Diagnostics of Halitosis Complaints by a Multidisciplinary Team

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Abstract

Aim: The study objective was to collect diagnostic data, to explore correlations between diagnostic variables, to provide an accurate initial diagnosis, and to provide appropriate management in consecutive subjects consulting with a multidisciplinary halitosis team because of a halitosis complaint.

Method: Nine hundred and fifty-four subjects with halitosis complaints applied for consultation. Subjects' history data were collected and organoleptic measurements and a physical examination were performed. Finally, genuine halitosis or pseudo-halitosis/ halitophobia was diagnosed initially and management was provided.

Result: Genuine oral halitosis was diagnosed initially in 93% of cases. Using oral cleaning materials, performing mechanical tongue cleaning, and periodical dentist consultation were over-represented in women, whereas men were more likely to have observable biofilm and carious lesions than women. Female gender was associated with tongue coating. Positive associations were found between age and performing mechanical tongue cleaning, organoleptic measurement scores as well as poor oral health. Educational level was positively associated with oral self care behaviours. Performing mechanical tongue cleaning was not associated with periodical dentist consultation.

Conclusion: In nearly all subjects complaining of halitosis, an oral cause could be detected.

Key words: Halitosis, Diagnostics, Management, Multidisciplinary

Introduction

Discomfort and (psycho-) social embarrassment are reasons for seeking professional care for halitosis. Halitosis is multifactorial and may involve both oral and non-oral conditions. In approximately 85-90% of all cases halitosis is caused by oral conditions, defined as oral malodour. Oral malodour arises from microbial degradation of organic substrates, such as glucose, mucins, peptides, and proteins present in saliva, crevicular fluid, oral soft tissues, and retained debris. Proteins containing the sulphurous amino acids cysteine and methionine, as well as tryptophan and lysine are causative substrates. Some microbial degradation products are volatile sulphur-containing compounds. Hydrogen sulphide (H_2S), methyl mercaptan (CH_3SH), and dimethyl sulphide ($(CH_3)_2S$) contribute to the malodour. In addition to volatile sulphur-containing compounds, a contribution has been demonstrated or suggested from short-chain fatty acids (butyrate, propionate, valerate), diamines (cadaverine, putrescine), alcohols, phenyl compounds (indole, skatole, pyridiene), alkines, ketones, and nitrogen-containing compounds (urea, ammonia). Organisms responsible for the hydrolysis of peptides and proteins, and the production of volatile sulphur-containing compounds include proteolytic obligate anaerobes, especially the Gram-negative species, mainly retained in tongue coating and periodontal pockets [1,2]. Non-oral aetiologies of halitosis may include disturbances of the upper respiratory tract and the pharynx, disorders of the gastrointestinal tract, some systemic diseases, metabolic disorders, and carcinomas. Contrary to the assumptions of several medical and oral health care providers, halitosis seldom or never originates within the stomach [3].

Before halitosis may be managed effectively, an accurate initial diagnosis based on analysis of data collected from subject history and physical examination, must be achieved. After analysis of these data, the halitosis complaint can be classified as oral or non-oral genuine halitosis, pseudo-halitosis, or halitophobia (monosymptomatic hypochondriasis; self-halitosis). Pseudo-halitosis is obviously not perceived by others, although the subject stubbornly complains of its existence. Halitophobia is diagnosed if no physical or social evidence exists suggesting that halitosis is present, whereas the subject persists in believing that he or she has halitosis and fails to recognize his psychological condition [2,4].

The 3 primary measurement methods of genuine halitosis are organoleptic measurement, gas chromatography, and sulphide monitoring. The use of organoleptic measurement is suggested as the 'gold standard'. Gas chromatography is the preferable method if precise measurements of specific gases are required. Sulphide monitoring is an easily used method, but has the limitation that important odours are not detected [1,2].

The available methods leading to lowering of oral malodour level can be divided into: usage of masking products (counteractives), mechanical reduction of micro-organisms and their substrates, chemical reduction of micro-organisms, and chemical neutralization of odorous compounds, including volatile sulphur-containing compounds [2,4-7].

The aim of the study was to collect diagnostic data, to explore correlations between the several diagnostic variables, to provide an accurate initial diagnosis, and to provide appropriate individual halitosis management in a cohort of

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consecutive subjects consulting with a multidisciplinary halitosis team because of a halitosis complaint.

Material and Methods

A multidisciplinary halitosis team, including a dentist, a dental hygienist, and an ear-, nose-, throat-surgeon (ENT-surgeon), was established to provide professional care for subjects complaining of halitosis in The Netherlands. One short press release regarding the establishment of the halitosis team and the halitosis management programme was provided to the Dutch national press centre. Everybody could apply for consultation. No inclusion or exclusion criteria were performed. From every consulting subject, data on history, organoleptic measurements, and physical intraoral condition were collected using a structured registration form, fed to a personal computer. At the end of the consultation, an initial diagnosis of the halitosis complaint was provided. The study was approved by the Medical Ethics Committee of the Erasmus University Medical Centre in Rotterdam, the Netherlands.

Subject history

History taking included questions concerning gender, age, education, wearing removable dentures, previous halitosis consultations and treatments, oral self care habits, and periodical consultations with oral health care providers.

Organoleptic measurements

For diagnosing halitosis initially, the subjects underwent 3 organoleptic measurement methods simultaneously by the 3 trained and calibrated members of the halitosis team: normal breath, licked wrist, and spoon test. Normal breath was examined by smelling while the relaxed seated subject was exhaling slowly and powerfully. Next, the subject was requested to lick 3 times a wrist with the full tongue dorsum. The thereby moistened wrist was left drying before examining the smell. For the spoon test, the tongue dorsum was scraped using a dental mirror and the scraped material was smelled [8-10]. Organoleptic measurements were recorded as: 0=no malodour, 1=slight but not objectionable odour, 2=definite objectionable odour and 3=very strong objectionable odour [11]. The organoleptic measurement scores of the 3 halitosis team members were averaged.

Physical examination

Physical examination by the ENT-surgeon included pharyngeal and lingual tonsils and upper respiratory tract (pharynx, maxillary sinus, posterior larynx). Physical examination by the dentist and the dental hygienist included observable oral biofilm (0=not present; 1=few; 2=moderate; 3=many), carious lesions (0=not present; 1=minor number; 2=moderate number; 3=many), and periodontal disease (0=not present; 1=minor; 2=present in one jaw; 3=present in both jaws), assessment of periodontal disease, and assessment of tongue coating.

Thorough upper respiratory tract examination using a flexible endoscope was only performed by the ENT-surgeon when this examination seemed mandatory by details of the medical history or the physical examination.

Periodontal disease was assessed by the dental hygienist using the Dutch Periodontal Screening Index (DPSI), a periodontal tool modified from the Community Periodontal Index of Treatment Needs (CPITN) [12,13]. The CPITN is an epidemiologic tool in population surveys and it can be used to recommend the kind of treatment needed to prevent or treat periodontal disease. Indicators used for the assessment of the DPSI are gingival recession, periodontal pockets subdivided in shallow (4-5 mm) and deep (6 mm or more) pockets, calculus, overhang of dental restoration, and gingival bleeding. The dentition is subdivided in sextants: the upper and lower frontal sextants, and the right and left upper and lower lateral sextants. A periodontal probe with a 0.5-mm ball tip is used to evaluate the health condition of the gingival sulcus. The probe is bearing a band between 2.0 and 7.0 mm from the ball tip. Scores in ascending order of severity are: 0=healthy, 1=bleeding on probing, 2=calculus and/or overhang of dental restorations, 3-=pockets of 4-5 mm without gingival recession, 3+=pockets of 4-5 mm with gingival recession, 4=pockets of 6 mm or more. Per sextant, the highest score is recorded. The highest score of the sextants was the overall DPSI score.

Tongue coating was assessed by the dentist according to a previously used method [14]. Assessment criteria referred to the surface of the tongue dorsum coated by biofilm: 0=not present, 1=thin coating on one third, 2=thin coating on two thirds or thick coating on one third, 3=thick coating on more than two thirds.

Initial diagnosis

After data collection, the 3 halitosis team members classified the halitosis complaint into genuine halitosis or pseudo-halitosis/halitophobia. Pseudo-halitosis/halitophobia was determined when a subject had a score 0 on normal breath as well as on licked wrist and spoon test. Subsequently, the halitosis team members informed the subject, explained the findings, and recommended an appropriate management procedure. When genuine halitosis was diagnosed initially, appropriate halitosis management was provided.

Statistical analysis

Statistical analyses were carried out using SAS 9.2 (SAS Institute Inc., Cary, NC). For multi-item examinations, the internal consistency reliability was evaluated by calculating the Cronbach's alpha. In cases of Cronbach's alpha > 0.70, compound variables were constructed. Construct validity of compound variables was determined by explanatory factor analysis, using Pearson's correlation coefficient. Group effects of class variables were tested by the chi-square test and for two kinds of classification by the Fisher's exact test. For testing effects of continuous variables, Student-t-test and ANOVA models were used. Spearman's rank correlation coefficient was used for not-linear relationships.

Results

Subjects and history

During a period of 18 months, 954 subjects consulted with the halitosis team consecutively. Their data on gender and age are shown in *Table 1*. One per cent of the consulting subjects were school children; 16% had primary (and some occupational) education, 43% were secondary school graduates and 40% had education at college or university level. *Table 2* displays the subjects' data on wearing removable complete and/or partial dentures.

Many subjects (n=830; 87%) had previously consulted one or more health care providers. Thirty-four per cent had consulted two distinct care providers, 20% three, and 7% even four. Despite the lack of an adequate diagnosis and probable origin of the halitosis, several subjects had undergone treatments (*Table 3*).

The oral self-care habits of the dentate subjects and the periodical consultations with oral health care providers of all subjects are displayed in *Tables 4 and 5*, respectively.

Organoleptic measurements

Table 6 presents the results of the organoleptic measurements. The results of the measurement methods were very consistent and strongly correlated (Cronbach's alpha: 0.87). Subsequently, a compound variable 'organoleptics' was established by summating the scores of the 3 measurement methods, presenting a mean score of 4.3 ± 2.2.

Physical examination

Pharyngeal tonsilcrypts were diagnosed in 38 (4%) subjects, lingual tonsillitis in 74 (8%), pharyngitis in 360 (38%), sinusitis in 64 (7%), and laryngitis in 158 (17%).

In 584 (61%) subjects oral biofilm was observed clinically, in 72 (8%) carious lesions, and in 521 (55%) periodontal disease. The DPSI scores of the dentate subjects are shown in *Table 7*. The diagnostic variables 'observable oral biofilm', 'observable periodontal disease', and 'DPSI' were internal consistent and had a strong correlation (Cronbach's alpha: 0.79).

Only 62 (6%) subjects had no tongue coating, 216 (23%) displayed score 1,477 (50%) score 2 and 199 (21%) score 3.

Correlations between diagnostic variables

Several variables of the subject history, the organoleptic measurements, and the physical examination showed statistically significant correlations with gender, age, and educational level (*Table 8*). Male gender was correlated with having observable oral biofilm and observable carious lesions, whereas female gender was correlated with using floss, tooth pick, and interdental brush, performing mechanical tongue cleaning, periodical dentist consultation, and having tongue coating.

Age was positively correlated with performing mechanical tongue cleaning, the compound variable 'organoleptics', having observable oral biofilm, carious lesions, and periodontal disease, and with DPSI.

Using floss, tooth pick, and interdental brush, performing mechanical tongue cleaning, and periodical dentist consultation were correlated positively with educational level.

Using floss, tooth pick, and interdental brush was

Table 1. *Subjects' data on gender and age in years.*

	Men	Women	Total
Gender	414 (43%)	540 (57%)	954 (100%)
Mean age (range 5-88)	41.5 ± 15.0*	43.0 ± 13.4*	42.3 ± 14.1

**Student-t-test; P = 0.01*

Table 2. *Number and percentages of subjects wearing removable complete and/or partial dentures.*

Removable denture	Number and percentage of subjects
Complete maxillary denture	45 (5%)
Partial maxillary denture	39 (4%)
Complete mandibular denture	28 (3%)
Partial mandibular denture	30 (3%)

Table 3. *Subjects' data on previous halitosis consultations and treatments.*

Health care provider	Consultation	Treatment
General medical practitioner	673 (71%)	116 (12%)
General dental practitioner	664 (70%)	87 (9%)
ENT-surgeon	245 (26%)	74 (8%)
Gastro-enterologist	167 (17%)	137 (14%)

Table 4. *Oral self-care habits of the dentate subjects during the day.*

Self-care	Never	Morning	Evening	Post each meal
Toothbrush	10 (1%)	721 (76%)	315 (33%)	90 (9%)
Dental floss	608 (64%)	286 (30%)	63 (7%)	8 (1%)
Tooth pick	691 (73%)	205 (21%)	31 (3%)	30 (3%)
Interdental brush	845 (89%)	87 (9%)	16 (2%)	8 (1%)
Mouth rinse	548 (58%)	374 (39%)	50 (5%)	20 (2%)
Tongue cleaning	406 (43%)	500 (52%)	79 (8%)	23 (2%)

Table 5. *Data on the subjects' periodical consultations with oral health care providers*

Periodical consultation	Oral health care provider	
	Dentist	Dental hygienist
Never	46 (5%)	752 (79%)
Once a year	180 (19%)	60 (6%)
More than once a year	724 (76%)	136 (14%)
Missing value	4 (0%)	6 (1%)
Total	954 (100%)	954 (100%)

Table 6. *Prevalences, percentages, mean scores and standard deviations (s.d.) of normal breath, licked wrist, and spoon test organoleptic scores.*

	Organoleptic method		
Score	**Normal breath**	**Licked wrist**	**Spoon test**
0 (no)	181 (19%)	215 (23%)	71 (7%)
1 (slight)	375 (40%)	518 (54%)	154 (16%)
2 (definite)	317 (33%)	200 (21%)	493 (52%)
3 (very strong)	78 (8%)	20 (2%)	236 (25%)
Total	954 (100%)		954 (100%)
Mean score (s.d.)	1.3 (0.9)	1.0 (0.7)	1.9 (0.8)

Table 7. *DPSI scores of the 909 subjects with a dentate maxilla and the 926 subjects with a dentate mandible, overall as well as separately for the right maxillary (1), frontal maxillary (2), left maxillary (3), left mandibular (4), frontal mandibular (5), and right mandibular (6) sextants.*

	Sextant						
DPSI score	**1**	**2**	**3**	**4**	**5**	**6**	**Overall**
0	171 (19%)	239 (26%)	147 (16%)	165 (18%)	133 (14%)	181 (20%)	70 (8%)
1	47 (5%)	101 (11%)	42 (5%)	36 (4%)	41 (5%)	53 (6%)	31 (3%)
2	172 (19%)	299 (33%)	170 (19%)	173 (19%)	467 (50%)	221 (24%)	161 (17%)
3-	266 (29%)	159 (18%)	312 (34%)	334 (36%)	165 (18%)	279 (30%)	304 (33%)
3+	78 (9%)	46 (5%)	46 (5%)	65 (7%)	59 (6%)	72 (7%)	79 (9%)
4	175 (19%)	65 (7%)	169 (18%)	153 (16%)	61 (7%)	120 (13%)	281 (30%)
Total	909 (100%)	909 (100%)	909 (100%)	926 (100%)	926 (100%)	926 (100%)	926 (100%)

Table 8. *Diagnostic variables significantly correlated with gender (♂ = in favour of men; ♀ = in favour of women), age, educational level, the compound variable 'organoleptics', and tongue coating (+ = positively correlated; - = negatively correlated) respectively, statistical tests used, and P-values.*

Variable	**In favour of/**	**Statistical test**	**P-value**
	+/-		
Gender			
Using floss, tooth pick, interdental brush	♀	ANOVA	0.02
Mechanical tongue cleaning	♀	Fisher's exact test	0.06
Periodical dentist consultation	♀	Fisher's exact test	0.001
Observable oral biofilm	♂	Student-t-test	0.02
Observable carious lesions	♂	Student-t-test	< 0.0001
Tongue coating	♀	chi-square test	< 0.0001
Age			
Mechanical tongue cleaning	+	ANOVA	< 0.0001
'Organoleptics'	+	Pearson's correlation	< 0.0001
Observable oral biofilm	+	Pearson's correlation	< 0.0004
Observable carious lesions	+	Pearson's correlation	0.02
Observable periodontal disease	+	Pearson's correlation	Pearson's correlation
DPSI	+	Spearman's rank correlation	< 0.0001
Educational level			
Using floss, tooth pick, interdental brush	+	chi-square test	0.05
Mechanical tongue cleaning	+	chi-square test	0.05
Periodical dentist consultation	+	chi-square test	0.06
'Organoleptics'			
Observable oral biofilm	+	Pearson's correlation	< 0.0001
Observable periodontal disease	+	Pearson's correlation	< 0.0001
DPSI	+	Spearman's rank correlation	0.03
Tongue coating	+	ANOVA	ANOVA
Tongue coating			
Mechanical tongue cleaning	-	chi-square test	chi-square test

positively correlated with periodical dentist consultation, and negatively with observable oral biofilm as well as observable periodontal disease.

The compound variable 'organoleptics' was positively correlated with observable oral biofilm, observable periodontal disease, DPSI, and tongue coating.

Initial diagnosis

Sixty-four (7%) subjects received a score 0 for normal breath as well as for licked wrist and spoon test, demonstrating that genuine halitosis could not be diagnosed initially. The remaining 890 subjects had a score of 1 or higher for at least one organoleptic test as well as a score 1 or higher for overall DPSI or tongue coating. Therefore, these subjects got the initial diagnosis genuine oral halitosis.

Management

The 890 subjects with the initial diagnosis genuine oral halitosis were recommended to consult the dental hygienist of the halitosis team for professional oral cleaning and self care instructions and follow-up appointments.

In case subjects diagnosed with pharyngeal tonsilcrypts,

lingual tonsillitis, pharyngitis, sinusitis or laryngitis had persisting halitosis at the final follow-up consultation with the dental hygienist, additional consultation and follow-up was scheduled with the ENT-surgeon of the halitosis team.

Discussion

The primary aim of this study was to provide an accurate initial diagnosis for a cohort of consecutive subjects consulting with a multidisciplinary halitosis team because of a halitosis complaint. In the cohort of 954 subjects, genuine oral halitosis was diagnosed initially in 890 (93%) cases. For the remaining 64 subjects, all organoleptic measurements were negative, suggesting pseudo-halitosis or halitophobia. Fifty-nine of them could be convinced easily that they had no symptoms of halitosis and left the clinic relieved and satisfied (pseudo-halitosis). Five of them were disgruntled by the diagnostic outcome and were disappointed with the team members because, after consultations with several health care providers previously, also this team could not solve their serious problem. Responding to the favourable message of not having symptoms of halitosis by refusing to accept or expressing disappointment is a potential symptom of halitophobia. Those subjects were invited for follow-up consultation with the dentist and, when indicated according to the opinion of the dentist, with a psychologist or a psychiatrist additionally. Halitophobia may be related to chemosensory dysfunction or can evolve to a complicated chronic olfactory reference syndrome when left untreated, which should not be neglected [15,16]. The prevalence of potential pseudohalitosis/halitophobia in the present survey was relatively low (7%) when compared to similar previous studies performed in several countries during the last ten years, which reported prevalences of 12.5, 27.9, 15.7, 6.1, and 17.3 chronologically [17-21]. The peak prevalence of 27.9 in the study by Seemann et al. (2006) could be due to the relatively 'friendly' organoleptic measurement method used, since the subjects had to count slowly from one to ten on nasal air exhaling through the nose. Consistent with similar previous studies, four of the five potential halitophobia subjects were women [18,19].

A second aim of the study was to explore correlations between the several relevant diagnostic variables. Generally, using oral health cleaning materials (floss, tooth pick, interdental brush), performing mechanical tongue cleaning, and periodical dentist consultation were over-represented in women, whereas men were more likely to have observable biofilm and observable carious lesions than women. These findings are in line with the results of previous studies which elucidated that a healthy lifestyle in general and oral self care behaviours in particular, such as tooth brushing, interdental cleaning, and periodical dentist consultation, are over-represented in women [22]. Contradictory to these correlations, female gender was associated with tongue coating, suggesting that women did not or did not sufficiently perform mechanical tongue cleaning, although they had rather good oral self care behaviours. This suggestion approves that performing mechanical tongue cleaning is not a standard oral health-related behaviour in the general population, even not in subjects who are suffering from halitosis and in subjects who are complaining of halitosis as shown in the present study [5,23].

The association found of both 'mechanical tongue cleaning' and the compound variable 'organoleptics' with 'age' is rather remarkable. It suggests that older people are more likely to perform mechanical tongue cleaning and, simultaneously, have higher organoleptic measurement scores than younger people. Previously, it has been suggested that older people, in particular dependent older people, have higher organoleptic measurement scores. This suggestion sounds reasonable, but has not yet been demonstrated scientifically [24-27]. However, performing mechanical tongue cleaning and having nevertheless high organoleptic measurement scores is rather contradictory, although there is no firm statement whether performing mechanical tongue cleaning contributes to a reduction of halitosis [28].

The association of the compound variable 'organoleptics' with 'observable oral biofilm', 'observable periodontal disease', 'DPSI', and 'tongue coating' confirms that halitosis results mainly and closely from oral conditions, such as oral biofilm, periodontal disease, and tongue coating [1]. Moreover, this association confirms that primary management of halitosis should focus on consultation with a dental hygienist for professional oral cleaning and self care instructions [4].

Using oral cleaning materials was associated with periodical dentist consultation, but performing mechanical tongue cleaning was not. Although it is not known if mechanical tongue cleaning is recommended widely by oral health care providers in The Netherlands, it was apparently not adequately practised in this group of halitosis patients. Either oral health care providers don't recommend mechanical tongue cleaning widely, or their patients don't adhere to the recommended preventive self care due to discomfort by the gagging reflex and/or lack of awareness of the importance. This lack of recommendation adherence is presumably also the reason that it was not possible to find scientific evidence for the effectiveness of mechanical tongue cleaning [28,29]. Maybe, the management method of tongue cleaning should shift from only mechanical cleaning to a combined management method using a mechanical tongue cleaner and gargling with a mouthrinse or only gargling with a mouthrinse [30,31].

The results of the present study confirmed the results of other halitosis consultations that for subjects with genuine halitosis generally an oral cause can be detected [14,18,19,21]. Consequently, it is recommended that the initial halitosis examination should be an oral malodour examination carried out by an experienced dentist or dental hygienist and that the management should focus on simple self care habits of removing oral biofilm and eliminating volatile sulphur compounds producing micro-organisms.

Alarming is the discovery that almost 90% of the subjects had previously consulted one or more health care providers, mainly general medical and dental practitioners, who had not identified and managed the halitosis complaint successfully. Basic aspects of halitosis should be an integrated part of primary and postgraduate education of health care providers, particularly of general medical and dental practitioners, and dental hygienists.

The decision to use only organoleptic measurements may be considered as a weakness of the study because sulphide monitoring is an easily used and valuable objective measurement. The decisive argument for this decision was the practical reason that only one measurement method was desired and that organoleptic measurement is considered to be the 'gold standard'. Moreover, sulphide monitoring has the limitation that important odours are not detected and when used as the single measurement method may lead to a misdiagnosis of some cases in terms of intensity [1,2,32].

Conflict of interest

The authors declare that they have no conflict of interest.

References

1. van den Broek AMWT, Feenstra L, de Baat C. A review of the current literature on aetiology and measurement methods of halitosis. *Journal of Dentistry*. 2007; **35**: 627-635.
2. Scully C, Greenman J. Halitology. Breath odour: aetiopathogenesis and management. *Oral Diseases*. 2012; **18**: 333-345.
3. Tangerman A, Winkel EG, de Laat L, van Oijen AH, de Boer WA. Halitosis and Helicobacter pylori infection. *Journal of Breath Research*. 2012; **6**: 017102.
4. van den Broek AMWT, Feenstra L, de Baat C. A review of the current literature on management of halitosis. *Oral Diseases*. 2008; **14**: 30-39.
5. Pham TAV, Ueno M, Zaitsu T, Takehara S, Shinada K, Lam PH, et al. Clinical trial of oral malodour treatment in patients with periodontal diseases. *Journal of Periodontal Research*. 2011; **46**: 722-729.
6. Ademovski SE, Lingström P, Winkel E, Tangerman A, Persson GR, Renvert S. Comparison of different treatment modalities for oral halitosis. *Acta Odontologica Scandinavica*. 2012; **70**: 224-233.
7. Blom T, Slot DE, Quirynen M, van der Weijden GA. The effect of mouthrinses on oral malodor: a systematic review. *International Journal of Dental Hygiene*. 2012; **10**: 209-222.
8. Kozlovski A, Gordon D, Gelernter I, Loesche WJ, Rosenberg M. Correlation between the BANA test and oral malodor parameters. *Journal of Dental Research*. 1994; **73**: 1036-1042.
9. Rosenberg M. Clinical assessment of bad breath: current concepts. *The Journal of the American Dental Association*. 1996; **127**: 475-482.
10. Greenstein RB-N, Goldberg S, Marku-Cohen S, Sterer N, Rosenberg M. Reduction of oral malodor by oxidizing lozenges. *Journal of Periodontology*. 1997; **68**: 1176-1181.
11. Schmidt NF, Tarbet WJ. The effect of oral rinses on organoleptic mouth odor ratings and levels of volatile sulfur compounds. *Oral Surgery Oral Medicine Oral Pathology*. 1978; **45**: 876-883.
12. World Health Organization. Community periodontal index of treatment needs (CPITN). *Oral health surveys – basic methods* (3rd Edn.) Geneva: World Health Organization; 1987.
13. van der Velden U. The Dutch periodontal screening index validation and its application in The Netherlands. *Journal of Clinical Periodontology*. 2009; **36**: 1018-1024.
14. Delanghe G, Ghyselen J, Feenstra L, van Steenberghe D. Experiences of a Belgian multidisciplinary breath odor clinic. *Acta Otorhinolaryngologica Belgica*. 1997; **51**: 43-48.
15. Yaegaki K, Coil JM. Genuine halitosis, pseudo-halitosis, and halitophobia: classification, diagnosis, and treatment. *Compendium of Continuing Education in Dentistry*. 2002; **21**: 880-890.
16. Falcão DP, Vieira CN, Batista de Amorim RF. Breaking paradigms: a new definition for halitosis in the context of pseudo-halitosis and halitophobia. *Journal of Breath Research*. 2012; **6**: 017105.
17. Filippi A, Müller N. Echte und psychisch bedingte Halitosis – Befunde, Diagnosen und Ergebnisse einer Mundgeruch-Sprechstunde. *Schweizer Monatsschrift für Zahnmedizin*. 2006; **116**: 129-135.
18. Seemann R, Bizhang M, Djamchidi C, Kage A, Nachnani S. The proportion of pseudo-halitosis patients in a multidisciplinary breath malodour consultation. *International Dental Journal*. 2006; **56**: 77-81.
19. Quirynen M, Dadamio J, Van den Velde S, De Smit M, Dekeyser C, et al. Characteristics of 2000 patients who visited a halitosis clinic. *Journal of Clinical Periodontology*. 2009; **36**: 970-975.
20. Romano F, Pigella E, Guzzi N, Aimetti M. Patients' self-assessment of oral malodour and its relationship with organoleptic scores and oral conditions. *International Journal of Dental Hygiene*. 2010; **8**: 41-46.
21. Zürcher A, Filippi A. Findings, diagnoses and results of a halitosis clinic over a seven year period. *Schweizer Monatsschrift für Zahnmedizin*. 2012; **122**: 205-210.
22. Tseveenjav B, Suominen AL, Vehkalahti MM. Oral health-related behaviours among dentate adults in Finland: findings from the Finnish Health 2000 Survey. *European Journal of Oral Sciences*. 2012; **120**: 54-60.
23. Buunk-Werkhoven YAB, Dijkstra A, van der Schans CP. Determinants of oral hygiene behavior: a study based on the theory based of planned behavior. *Community Dentistry and Oral Epidemiology*. 2011; **39**: 250-259.
24. Durham TM, Malloy T, Hodges ED. Halitosis: knowing when 'bad breath' signals systemic disease. *Geriatrics*. 1993; **48**: 55-59.
25. Honda E. Oral microbial flora and oral malodour of the institutionalised elderly in Japan. *Gerodontology*. 2001; **18**: 65-72.
26. Ekanayake L, Perera I. The association between clinical oral health status and oral impacts experienced by older individuals in Sri Lanka. *Journal of Oral Rehabilitation*. 2004; **31**: 831-836.
27. Al-Ansari JM, Boodai H, Al-Sumait N, Al-Khabbaz AK, Al-Shammari KF, Salako N. Factors associated with self-reported halitosis in Kuwaiti patients. *Journal of Dentistry*. 2006; **34**: 444-449.
28. Van der Sleen MI, Slot DE, Van Trijffel E, Winkel EG, Van der Weijden GA. Effectiveness of mechanical tongue cleaning on breath odour and tongue coating: a systematic review. *International Journal of Dental Hygiene*. 2010; 8: 258-268.
29. Bordas A, McNab R, Staples AM, Bowman J, Kanapka J, et al. Impact of different tongue cleaning methods on the bacterial load of the tongue dorsum. *Archives of Oral Biology*. 2008; **53**: S13-S18.
30. Roldán S, Herrera D, O'Connor A, González I, Sanz M. A combined therapeutic approach to manage oral halitosis: a 3-month prospective case series. *Journal of Periodontology*. 2005; **76**: 1025-1033.
31. Fedorowicz Z, Aljufairi H, Nasser M, Outhouse TL, Pedrazzi V. Mouthrinses for the treatment of halitosis. *Cochrane Database of Systematic Reviews*. 2008; CD006701.
32. Baharvand M, Maleki Z, Mohammadi S, Alavi K, Moghaddam EJ. Assessment of oral malodor: A comparison of the organoleptic method with sulfide monitoring. *The Journal of Contemporary Dental Practice*. 2008; **9**: 76-83.