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Comparison between self-estimated and clinical oral malodor

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Abstract

Objectives. The aims were to evaluate the validity of patients' self-estimation and clinical diagnosis of oral malodor and to examine the relationship of oral malodor with oral health status. ***Methods.*** The subjects were 252 patients (mean age 43.7 ± 10.7 years) who complained of oral malodor. Oral malodor was assessed by patients' self-estimation, organoleptic test and Oral Chroma. Oral health status, including dental and periodontal conditions, oral hygiene status and flow rate of saliva, was examined. The N-benzoyl-DL-arginine-2-napthilamide (BANA) positive bacteria in tongue coating were evaluated by BANA test. A Spearman's correlation coefficient was used to test correlation between self-perceived and clinical oral malodor. The stepwise multiple regression analysis was used to assess predictors of patients' self-estimated and clinical oral malodor. ***Results.*** The percentage of patients who were diagnosed with pseudo-halitosis was 38.5%. Patients' self-estimated oral malodor was significantly correlated with organoleptic test ($r = 0.61$), H_2S ($r = 0.50$) and CH_3SH ($r = 0.46$). There were 47.1% of patients who estimated correctly their oral malodor's scores with those by examiner. The highest correspondence was found in patients without oral malodor (52.6%), followed by in those with moderate or strong oral malodor (46.7%) and in those with slight oral malodor (33.3%). The significant predictors of patients' self-estimated and clinical oral malodor were bleeding on probing, tongue coating, BANA test and flow rate of saliva. ***Conclusion.*** Patients' self-estimated oral malodor was found to correspond significantly with clinical oral malodor and be associated with oral health status. Current findings suggest that self-estimation can be used to judge one's own oral malodor.

Key Words: *oral malodor, periodontal diseases, tongue coating, bacteria*

Introduction

Halitosis which is also called oral malodor is a very unpleasant symptom, frequently causing restriction of social interaction and decreasing quality-of-life. Most individuals experience personal discomfort and social embarrassment leading to emotional distress [1–3]. The condition is multifactorial in etiology but most of the causes are related to the oral cavity [4]. Many Gram-negative anaerobic bacteria, mainly periodontal pathologen such as *Treponema denticola*, *Porphyromonas gingivalis* and *Tannerrella forsythia*, produce a diverse array of malodorous compounds including VSCs, short chain organic acids, diamines and phenyl compounds from their metabolism [5-7]. Volatile sulfur compounds (VSCs) are considered to be the most significant products as regards oral malodor with hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH) as the main contributors [8].

The prevalence of oral malodor varies in different parts of the world. The true prevalence of oral malodor is unknown and it is quite difficult to compare among studies because the researchers use different methods to assess oral malodor. Currently available epidemiological researches have been shown the prevalence of self-perceived/self-reported oral malodor up to 32% in the general population [9–11] and to 47% in dental patients [12,13]. However, self-perception is known to be limited by inaccuracy and low sensitivity. It is considered as the invalid method to judge one's own oral malodor because the degree of self-perceived oral malodor very often does not correspond to its clinical diagnosis [9,13]. Many people complain that they occasionally or continually have halitosis and that the condition interferes with their quality-of-life. However, some patients do not have any clinical evidence of genuine halitosis. These patients stubbornly complain of having halitosis although it is obviously not perceived by others and

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this condition is defined as pseudo-halitosis. In previous studies, we found that a majority of dental patients did not have appropriate knowledge about halitosis etiology [14] and that some patients who perceived their oral malodor had clinical oral malodor while most of them did not and their perception of oral malodor often related to cigarette smoke or alcohol smell [13]. Therefore, raising the accuracy of patient's evaluation of oral malodor by providing halitosis education from professionals may help in determining their actual condition, which is considered to be useful not only in patients concerning halitosis but also in community levels.

Clinically, organoleptic test and specific devices such as Gas Chromatography, Oral Chroma, Breathtron and Halimeter have been reliable to measure oral malodor. However, these measurement methods are not very easily implemented because they require trained examiners, consume time and cost money. A previous study reported that self-estimation of oral malodor has been reliable and correlated with the objective assessment of the persons who were not concerned about oral malodor [15]. To date, on the other hand, few studies are available in the literature regarding the reliability of self-estimation of oral malodor in patients who complained of the condition. Hence, the aims of the study were to evaluate the patients' self-estimation of oral malodor, in comparison with clinical diagnosis based on organoleptic score and VSCs concentrations; and to examine the relationship of oral malodor and oral health status.

Materials and methods

Subjects

Two hundred and sixty-three dentate patients who complained of having oral malodor visited the Periodontal Department, the National Hospital of Odonto-Stomatology in Ho Chi Minh city, Vietnam in 2009. Eleven subjects who had medical disorders, who were taking antibiotics or antibacterial substances or who were pregnant or lactating women were excluded. Two hundred and fifty-two patients (155 males and 97 females) aged from 19–60 years (mean age 43.7 ± 10.7) were finally recruited for this study. Consent was sought and ethical clearance for the study was obtained from the National Hospital of Odonto-Stomatology in Ho Chi Minh city, Vietnam.

Questionnaire

The subjects completed a self-administered questionnaire before the oral malodor assessment and oral examination. The first section of questionnaire inquired about socio-demographic information including age, gender and level of education. The second section was a set of information on oral malodor including duration of oral malodor (year), who complained of oral malodor (patient, patient and others or others). The last section consisted of questions related to psychosomatic tendencies including the problems caused by oral malodor ('I am uneasy whenever someone is nearby', 'I hate to talk to other persons', 'I do not like to meet other persons', 'I do not concentrate on my work', 'I cannot to be close to people socially' and 'Other persons avoid me'); the interference of oral malodor with family life in the last month (yes or no); and the interference of oral malodor with ability to function at workplace or social life in the last month (yes or no) [16].

Provision of the information on halitosis

One examiner provided the information on halitosis by using the pictures and explanation to each subject after the subject completed the questionnaire. The information consisted of: (1) the classification of halitosis (genuine halitosis including physiologic halitosis and pathologic halitosis, pseudo-halitosis and halitophobia), (2) the intra- or extra-causes of genuine halitosis (periodontal diseases, bad oral hygiene conditions, xerostomia, diabetes mellitus, hepatic cirrhosis, uremia, internal bleeding . . .), assessment of halitosis (by using specific devices and organoleptic test) and appropriate management of halitosis (improvement of oral hygiene, treatment of intra- and extra-oral diseases involved the condition for genuine halitosis; and explanation, counselling or treatment of psychological disorders for pseudo-halitosis or halitophobia). The subjects were informed that habitual halitosis, which is caused provisionally by tobacco, cigars, spices or foods, is not involved in halitosis classification. They were then given the oral malodor and oral health status examinations.

Oral malodor assessment

Oral malodor assessment was performed in the morning between 7:30 am and 11:30 am. Subjects were asked not to (1) consume food such as onions and garlic for 48 h before the measurement, (2) drink alcohol, use mouth rinse and smoke for the previous 12 h, (3) perform oral hygiene (tooth brushing, interdental and tongue cleaning) for the previous 2 h, (4) eat and drink for the previous 2 h and (5) use perfume or cosmetic fragrance in the morning of examination.

Self-estimation of oral malodor: Patients were instructed to close their mouth for 3 min and then smell the odor emanating from their entire mouth by cupping their hands over the mouth and nose, exhaling through the mouth and breathing in through the nose [1]. They were asked to score their own oral malodor intensity level on a 0–5 point scale as follows: 0, no odor; 1, questionable odor; 2, slight but clearly noticeable odor; 3, moderate odor; 4, strong odor; and 5, extremely foul odor [17].

Clinical diagnosis of oral malodor was based on organoleptic test using the aforementioned 0–5 point scale. One well-trained and experienced examiner who was blinded to other data evaluated for all subjects. Subjects closed their mouth for 3 min and released the air slowly by mouth through a paper tube with a 10 cm distance from the examiner's nose. Subjects were diagnosed as having clinical oral malodor when their organoleptic score was 2 or greater [18].

Quantitative VSCs were measured with portable gas chromatography (Oral Chroma, Abimedical Coporation, Osaka, Japan). A disposable 1 mL syringe was inserted deep into the subject's oral cavity, positioned above the posterior part of the dorsum of the tongue without touching the oral mucosa or the tongue and held between the lips for 1 min. Then, the plunger was pulled slowly, pushed in again and pulled for a second time before being removed from the mouth. A 0.5 mL air sample aspirated was then injected into the inlet on the main unit of the measurement device. The VSCs gases were analyzed automatically in 8 min and their concentration values were displayed in ng/10 mL. The previous study suggested the threshold levels of oral malodor by using VSCs concentrations of $H_2S \geq 1.5$ ng/10 mL and $CH_3SH \geq 0.5$ ng/10 mL [19].

Oral examination

Following the oral malodor measurement, all subjects underwent a standard oral examination. Measurements of the dental and periodontal conditions were made on all the teeth excluding the third molars. Dental caries assessment was based on the WHO criteria. Pocket depths were assessed using a 1 mm scaled Williams periodontal probe and measured at six sites on each tooth. The deepest pocket was recorded for the tooth. Gingival bleeding on probing was recorded as presence or absence 30 s after pocket depth measurement [20]. Dental plaque and gingival index by Sillness were also accessed [21].

Tongue coating was examined on a scale of 0–3 by visual inspecting the areas of the tongue (the tongue dorsum was divided into three areas: anterior, middle and posterior) and scoring the coating as: 0, no coating apparent; 1, less than 1/3 of tongue dorsum coated; 2: between 1/3–2/3 of tongue dorsum covered; and 3, more than 2/3 of the surface coated [3].

The presence of periodontal pathogens such as *P. gingivalis*, *T. denticola* and *T. forsythia* on the surface of tongue dorsum was detected by BANA test (BANA Met LLC. Ann Arbor, MI). A tongue coating sample was collected using a cotton tip swab. The sample was placed on a BANA impregnated strip along the lowered border of a test card. An upper reagent strip containing Evan's black dye was activated by moistening with distilled water. Then, the lower strip was folded back to make contact with the upper strip and inserted into the incubator set at 35°C for 5 min [22]. Results of the BANA test were scored as: score 0 (negative reaction) when no blue color was visible, score 1 (weak positive reaction) when a faint blue color was detected and score 2 (positive reaction) when a distinct blue color appeared in the area contacted by the sample.

Resting saliva was obtained by requesting the subjects to spit into a pre-weighed paper cup for 5 min. Saliva flow rate was determined gravimetrically and calculated as milliliter per minute (mL/min).

Statistical analysis

The Chi-square test was used to examine distributional differences of gender and questionnaire variables. The independent sample *t*-test was used to test the differences between males and females for age, oral malodor status and oral health parameters. The Wilcoxon rank test was used to compare the patients' self-estimated and organoleptic scores. Correlations between self-estimated scores, organoleptic scores and VSCs concentrations; and between oral malodor and oral health parameters were tested by using a Spearman's correlation coefficient. The stepwise multiple regression analysis was used to further assess the predictors of each oral malodor. Statistical analysis was carried out using the SPSS 17.0 (Tokyo, Japan) and significance level used was $p < 0.05$.

Results

Characteristics of the subjects

Among study subjects, males accounted for more than 60% of the sample (61.5%) with a mean age and SD of 42.8 ± 10.8 years. Females (45.0 ± 10.8 years) were older than males but no significant difference in age was detected. Almost 40% of subjects (37.7%) had primary and secondary school level and 62.3% graduated from high school. The average duration of patients' oral malodor was 3.8 ± 2.7 years (range: 0.5–10 years). The majority of patients (44.0%) had complaints of oral malodor for from 1–5 years, 36.6% had complaints for more than 5 years, while almost 20% of patients (19.4%) had complaints for less than 1 year. About 47% of subjects (47.2%) noticed their oral malodor by themselves, 38.9% by themselves and others such as friends, family members or colleagues, while 13.9% were noted by others.

Regarding the psychosomatic problems caused by oral malodor, 61.9% of subjects were concerned with 1–3 problems and 19.6% with 4–6 problems, whereas 18.3% of subjects reported that they were not troubled by their oral malodor. In particular, 55.7% of subjects reported that they hesitated to talk to other persons,

Table I. Oral health status of the subjects.

Oral health parameters	Male	Female	Total	*p*
Number of teeth present	24.92 ± 3.84	25.47 ± 3.63	25.13 ± 3.76	0.252
Number of decayed teeth	2.74 ± 2.80	2.95 ± 2.88	2.82 ± 2.83	0.564
Number of teeth with 5 mm or greater pockets	2.35 ± 4.01	2.58 ± 4.09	2.44 ± 4.03	0.672
Number of teeth with bleeding sites	5.17 ± 5.26	5.81 ± 5.54	5.42 ± 5.37	0.364
Plaque Index	2.78 ± 1.53	2.70 ± 1.49	2.75 ± 1.51	0.671
Gingival Index	1.34 ± 1.09	1.18 ± 1.07	1.28 ± 1.08	0.267
Flow rate of saliva (mL/min)	0.26 ± 0.19	0.29 ± 0.23	0.27 ± 0.21	0.215
Tongue coating score	2.01 ± 0.77	2.02 ± 0.80	2.02 ± 0.78	0.941
BANA test score	1.03 ± 0.67	1.04 ± 0.66	1.03 ± 0.67	0.858

Data are presented as Mean ± SD; *p*, *p*-value.

49.5% were uneasy whenever someone was nearby, 27.8% did not want to meet other persons, 18.6% could not concentrate on their work, 12.4% reported that they were avoided by other persons and 1.0% could not to be close to people socially. More than 60% of subjects (61.5%) reported that their breath interfered with their family life and more than half of subjects (53.2%) were concerned with their activities at the workplace or social life in the last month. There was no significant difference between males and females in terms of psychosomatic problems.

Oral health status

Oral health status of the subjects is revealed in Table I. All subjects were dentate. The mean numbers of teeth present and decayed were 25.1 ± 3.8 and 2.8 ± 2.8, respectively. Almost 37% of the subjects (36.9%) had at least one 5 mm or greater pocket and ~ 70% of subjects (68.3%) had at least one tooth with bleeding sites. The mean values of gingival index and plaque index were 1.3 ± 1.1 and 2.8 ± 1.5, respectively. A low percentage of subjects had no tongue coating (2.4%). Almost a quarter of subjects had a score of 1 (22.6%). The highest percentage (46.0%) was observed in subjects with a score of 2 and 29.0% had a score of 3. Regarding the BANA test, about one-fifth of subjects (20.6%) had a score of 0. More than half of the subjects (55.6%) had a score of 1 and almost a quarter of subjects had a score of 2 (23.8%). The average flow rate of saliva was 0.3 ± 0.2 mL/min. Males and females did not differ significantly in any of the oral health parameters.

Oral malodor status

For self-estimation of oral malodor, the patients obtained the following scores estimates for their oral malodor levels: score 0, 46 (18.2%); score 1, 73 (29.0%); score 2, 46 (18.3%); score 3, 74 (29.4%); score 4, 13 (5.1%); and score 5, 0 (0%). For organoleptic test, the examiner obtained the following score of the patients: score 0, 3 (1.2%); score 1, 94 (37.3%); score 2, 33 (13.1%); score 3, 111 (44.0%); score 4, 11 (4.4%); and score 5, 0 (0%).

Based on the organoleptic test, 33 patients (13.1%) were diagnosed with slight malodor, 122 patients (48.4%) had moderate or strong oral malodour, whereas 97 subjects (38.5%) did not (pseudohalitosis). No significant difference in self-estimated or clinical oral malodor was detected by age or gender (Table II).

The correlation between self-estimated and clinical oral malodor is shown in Figure 1. For subjects who had no clinical oral malodor (score 0 and 1), 51 of those (52.6%) scored correctly with examiner's evaluation. Thirty-seven subjects (38.1%) estimated their breath (score 0) better than examiner's evaluation

Table II. Self-estimated and clinical oral malodor.

	Self-estimated oral malodor			Clinical oral malodor		
Score	Male	Female	Total	Male	Female	Total
0 and 1	71 (45.8)	48 (49.5)	119 (47.2)	60 (38.7)	37 (38.1)	97 (38.5)
2	32 (20.6)	14 (14.4)	46 (18.3)	16 (10.3)	17 (17.5)	33 (13.1)
3 and 4	52 (33.6)	35 (36.1)	87 (34.5)	79 (51.0)	43 (44.3)	122 (48.4)

Data are presented as Number (%).

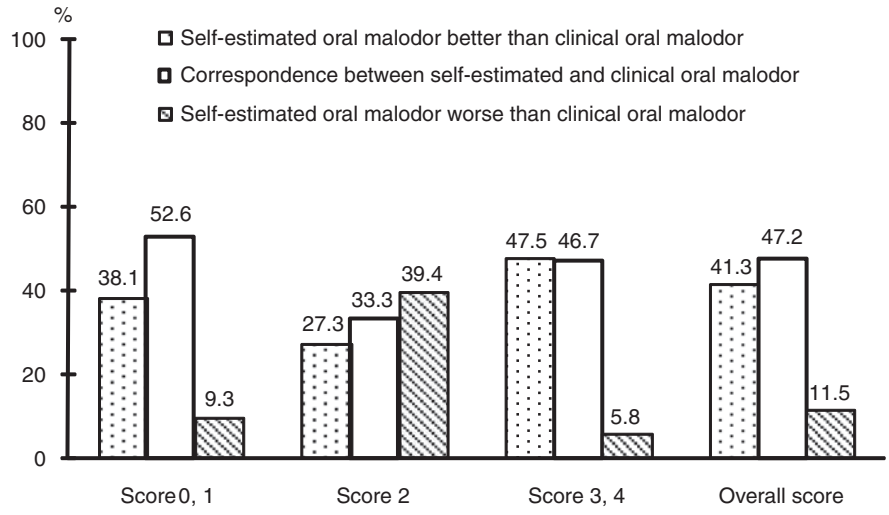

Figure 1. The correlation between self-estimated and clinical oral malodor.

(score 1) and nine subjects (9.3%) estimated their breath worse than examiner's evaluation. For patients with slight oral malodor (score 2), 11 of those (33.3%) scored correctly, nine patients (27.3%) estimated their breath better and 13 subjects (39.4%) estimated their breath worse than examiner's evaluation. For patients with moderate or strong oral malodor (score 3 and 4), 57 of those (46.7%) scored correctly, 58 patients (47.5%) estimated their breath better and seven patients (5.8%) estimated their breath worse than examiner's evaluation. In overall score, 119 patients (47.2%) scored correctly, 104 patients (41.3%) estimated their breath better and 29 patients (11.5%) estimated their breath worse than those of examiner's evaluation. No difference in correlation between patients' self-estimated and clinical oral malodor was detected by gender. By Spearman's correlation analysis of patients' self-estimated and clinical oral malodor, a high correlation coefficient was found ($r = 0.61$, $p < 0.001$).

By Oral Chroma measurement, the mean H_2S and CH_3SH concentrations of subjects were 4.6 ± 4.1 ng/10 mL and 3.6 ± 4.3 ng/10 mL, respectively. Self-estimated oral malodor was significantly correlated with H_2S ($r = 0.50$) and with CH_3SH ($r = 0.46$). Compared to self-estimated oral malodor, clinical oral malodor was also significantly correlated with H_2S and CH_3SH, but displayed with higher correlation coefficients ($r = 0.87$ and $r = 0.79$, respectively).

Association between oral malodor and oral health status

As shown in Table III, self-estimated oral malodor was positively associated with number of teeth with 5 mm or greater pockets ($r = 0.19$), number of teeth with bleeding sites ($r = 0.26$), gingival index ($r = 0.18$), plaque index ($r = 0.17$), tongue coating ($r = 0.33$) and BANA test ($r = 0.29$); and negatively associated with flow rate of saliva ($r = -0.31$), $p < 0.01$. Clinical oral malodor was also positively associated with number of

Table III. Association of oral malodor and oral health status.

	Self-estimated oral malodor		Clinical oral malodor	
Oral health parameters	*r*	*p*	*r*	*p*
Number of teeth present	0.02	0.804	0.01	0.849
Number of decayed teeth	–0.05	0.451	–0.07	0.303
Number of teeth with 5 mm or greater pockets	0.19	0.003	0.45	< 0.001
Number of teeth with bleeding sites	0.26	< 0.001	0.36	< 0.001
Gingival Index	0.18	0.005	0.41	< 0.001
Plaque Index	0.17	0.006	0.32	< 0.001
Tongue coating score	0.33	< 0.001	0.65	< 0.001
BANA test score	0.29	< 0.001	0.45	< 0.001
Flow rate of saliva	–0.31	< 0.001	–0.28	< 0.001

r, correlation coefficient; *p*, *p*-value.

teeth with 5 mm or greater pockets ($r = 0.45$), number of teeth with bleeding sites ($r = 0.36$), gingival index ($r = 0.41$), plaque index ($r = 0.32$), tongue coating ($r = 0.65$) and BANA test ($r = 0.45$); and negatively associated with flow rate of saliva ($r = -0.28$), $p < 0.001$. Numbers of teeth present and decayed were not associated with self-estimated or clinical oral malodor.

Stepwise multiple regression analysis of oral malodor

The stepwise regression analyses of association between the oral malodor and oral health status are presented in Table IV. Adjusted by age, gender, level of education and psychosomatic problems, the results showed that both self-estimated and clinical oral malodor were significantly associated with number of teeth with bleeding sites, tongue coating, BANA test and flow rate of saliva. Number of teeth with 5 mm or greater pockets, gingival index and plaque index were not extracted as strong factors associated with self-estimated or clinical oral malodor.

Discussion

Characteristics of the subjects

Current findings demonstrated the significant correspondence between self-estimated and clinical oral malodor. Thus, self-estimation can be used as a possible method to judge one's own oral malodor. In addition, this study indicated that oral health status including periodontal condition, oral hygiene status and flow rate of saliva associated with oral malodor. Bleeding on probing, tongue coating, BANA-positive bacteria and flow rate of saliva were further determined as main predictors of self-estimated or clinical oral malodor in this study.

The subjects in this study were patients who complained of oral malodor and sought treatment in the dental hospital. The results showed that 61.5% of subjects suffered from the real condition while 38.5% were pseudo-halitosis patients. For the effective management of halitosis, an accurate diagnosis that depends on analysis of data collected from patient history and clinical examination should be achieved. So it is important to classify clearly halitosis prior to diagnosis for halitosis patients to avoid mismanagement of psychosomatic halitosis. Yaegaki and Coil [23] reported that the classification and management of halitosis patients are very useful for general practitioners, especially with regards to patients with pseudo-halitosis.

A high percentage of subjects with pseudo-halitosis was observed in the study. This result is in agreement with the previous studies which reported the prevalence of pseudo-halitosis ranging between 25–50% [3,24]. In the present study, more male subjects complained of oral malodor than females, which is not consistent with what was reported as the characteristic feature of psychological halitosis by the previous finding [3]. The current study showed that the majority of subjects perceived oral malodor by themselves and through others. In addition, a high prevalence of subjects who were concerned by at least one problem caused by oral malodor and more than half of subjects admitted that oral malodor interfered with their family and social life. Oral malodor when perceived by the subjects and others could disturb their social lives and make them lack confidence in communicating with other people. Current findings reflected the negative impact of oral malodor in patients' lives.

Comparison between self-estimated and clinical oral malodor

The primary reference standard for the detection of oral malodor is the organoleptic test. The organoleptic test is believed to be the most reliable and practical method for clinical oral malodor diagnosis [18,25]. In this study, organoleptic test was performed by the same examiner and the good correlations between organoleptic test and measured H_2S and CH_3SH concentrations were obtained. Self-estimated oral malodor also

Table IV. Stepwise multiple regression analysis of oral malodor.

Oral malodor	Independent variables	β	*p*
Self-estimated oral malodor	Number of teeth with bleeding sites	0.03	0.025
	Tongue coating	0.22	0.048
	BANA test	0.29	0.023
	Flow rate of saliva	–1.73	< 0.001
Clinical oral malodor	Number of teeth with bleeding sites	0.03	0.001
	Tongue coating	0.63	< 0.001
	BANA test	0.17	0.045
	Flow rate of saliva	–1.31	< 0.001

Adjusted by age, gender, level of education and psychosomatic problems; β, standardized regression coefficient; *p*, *p* -value.

showed significant correlations with both measured H_2S and CH_3SH concentrations in this study.

In agreement with previous finding [26], this study also demonstrated the good correspondence between self-estimated and clinical oral malodor. The higher correspondence between self-estimation and organoleptic test was found in current subjects without oral malodor or in those with moderate/strong oral malodor compared to those with slight oral malodor. Patients who were without clinical oral malodor or with clear oral malodor could recognize their real condition. It may be because current subjects received the information and knowledge on etiology of intra- or extra-halitosis before their estimation of oral malodor. This was considered to have an impact on the accuracy of patients' perception about the condition since questionnaire data revealed that most of the patients did not have the appropriate knowledge about halitosis. Current subjects would become increasingly adept and objective in estimating and scoring their own malodor after absorbing necessary information.

On the other hand, the present results were not consistent with the previous studies which indicated that self-estimated oral malodor was not associated with clinical oral malodor and that subjects with a complaint of oral malodor remained largely unable to score their own bad breath in an objective fashion [1,15]. The apparently contradictory results can be explained, for example, cognitive, emotional and physiological factors can affect the perception of smell [27]. Level of education, occupation knowledge about halitosis and the unfamiliarity or sensitivity to one's own malodor may also be influences in the estimation of oral malodor. The individuals differ in their sensitivity to smells, so the way they perceived oral malodor is often complex [2]. Further, the difference in rating scales among studies is also thought to have an impact on the results. Previous studies used the continuous 10-cm visual analog scale marked on each end as 'no odor' and 'extremely foul odor', while a 0–5 point scale was used in this study.

Relationship between oral malodor and oral health status

This study demonstrated that severity of periodontal condition, poor oral hygiene status, high BANA-positive bacteria levels and low flow rate of saliva significantly associated with oral malodor production. The current results further showed the good correlation between self-estimated and clinical oral malodor by indicating that bleeding gum, tongue coating accumulation, high BANA-positive bacteria level in the tongue dorsum and reduced flow rate of saliva were the main predictors of each oral malodor. Bleeding gums is known as a common sign of periodontal disease. Blood decomposition products themselves can also produce sulfur-containing peptides and amino acids that are source of VSCs. Yaegaki and Sanada [28] also found that bleeding on probing positively correlated with VSCs production.

Supported by past studies [4,28,29], this study also demonstrated that tongue coating and BANA-positive bacteria in the tongue coating were significantly associated with oral malodor. These facts can be explained because the tongue has a large surface and its papillary structure represents an anaerobic niche in the oral cavity, favoring the accumulation of oral debris and micro-organisms responsible for VSC generation. Tongue coating is comprised of bacteria, large amounts of desquamated epithelial cells released from the oral mucosa, leukocytes from periodontal pockets, blood metabolites and different nutrients [28].

The current finding was consistent with previous studies which demonstrated the reduction in flow rate of saliva and oral malodor formation [14,30]. A reduction in flow rate of saliva influences the generation of VSC because it weakens the normal natural cleaning mechanism of the mouth, predisposing an accumulation of debris, plaque and bacteria shift. A reduced flow rate of saliva was also considered to be related to greater accumulation of tongue coating [30].

This study indicated that the severity of periodontal diseases, an increase in the amount of tongue coating and BANA-positive bacteria and a reduction in flow rate of saliva were the main causes for the higher oral malodor production. Hence, periodontal disease treatment and improvement of daily oral hygiene including tongue cleaning are effective measures for improving oral pathological halitosis.

This study also found the good correlation between patients' self-estimated and clinical oral malodor. Current findings suggested that self-estimation of oral malodor by using hand-on mouth technique may be useful in helping the assessment of risk factors and detection of one's own malodor. Increasing the accuracy of patient's estimation on their oral malodor requires provision of adequate information from the health professionals. Prediction of own oral malodor after receiving proper halitosis education is considered as a possible method of oral malodor assessment for future research, public health setting, health education or dental service provision. This study showed the importance of halitosis education in evaluation of the real condition by own patients. Thus, it is important to enhance the knowledge about etiology of intra- or extra-halitosis along with proper guidelines of oral malodor management, not only patients concerning halitosis but also in community levels. Further research in general populations should be needed to confirm the current findings.

Conclusion

Patients' self-estimated oral malodor was found to correspond significantly with clinical oral malodor

and be associated with oral health status such as bleeding on probing, flow rate of saliva, tongue coating and BANA-positive bacteria. The current findings suggest that self-estimation can be used to judge one's own oral malodor.

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