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Assessment of Oral Malodor: A Comparison of the Organoleptic Method with Sulfide Monitoring

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Abstract

Aim: The purpose of the present study was to measure the oral malodor of volunteers by means of a subjective organoleptic method and a sulfide monitor as well as to evaluate the diagnostic value of the Halimeter® in the diagnosis of halitosis.

Methods and Materials: Sulfide monitoring and organoleptic oral malodor assessment methods were performed on 77 volunteers (51 females, 26 males) selected from academic staff, students, clerks, and patients of the Shaheed Beheshti University of Medical Sciences and Health Services, Dental School. The organoleptic method of assessment and sulphide monitoring were conducted by three calibrated judges. The Kendall's tau-b correlation analysis was used to calculate correlation coefficients between the sulfide monitor and organoleptic scores.

Results: The Kendall's correlation coefficient between sulfide monitoring and organoleptic scores was 0.493 ($p<0.001$). Sensitivity and specificity were assessed to be 61.1% and 87.8% respectively. The positive predictive value (PPV) and the negative predictive value (NPV) were 81.5% and 72%, respectively. The intra-class correlation coefficient for the three episodes of monitoring was calculated as 97%.

Conclusion: Use of a sulfide montoring device in conjunction with the organoleptic method is an effective strategy for diagnosing oral malodor.

Clinical Relevance: Because of its small size and simplicity of handling the Halimeter sulfide monitor is convenient to use. This method of evaluation of patients for oral malodor is capable of differentiating normal patients (such as with Pseudohalitosis and halitophobia) from the others and for halitosis screening along with other techniques such as the organoleptic method. However, when used alone, it may lead to a misdiagnosis of some cases in terms of intensity.

Keywords: Halitosis, organoleptic, sulfide monitoring, Halimeter®

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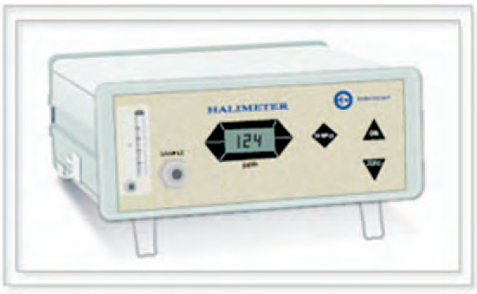
Introduction

Halitosis is a common problem affecting more than 50% of the general population.[1,2] Volatile sulfur compounds (VSCs) such as hydrogen sulfide, methyl mercaptan, and dimethyl sulfide are primarily produced by anaerobic bacteria and are considered to be the major gases associated with halitosis and have demonstrated a high correlation with breath malodor.[3,4] The role of general dentists as the most appropriate professionals to diagnose and manage this condition is essential since 50 to 90% of all bad breath problems emanate from the oral cavity.[3,5]



Several techniques for the evaluation of halitosis have been developed and assessed. They include the use of such devices as the Jerome 631- X H2S Analyzer (Arizona Instrument, Tempe, AZ, USA) and the Halimeter® (Interscan Corp., Chatsworth, CA, USA) as well as the use of analytical methods such as gas chromatography and use of the human nose or organoleptic evaluation based on the olfactory sensory system. The Halimeter is a portable gas monitor using an electrochemical sensor to detect the presence of VSCs in the air.[6,7]

Despite the popularity of organoleptic assessment, this method has several problems in terms of objectivity and reproducibility, contradiction among odor judges in reaching the same verdict, and the risk of transmission of respiratory diseases.[8-10] Regardless of these consequences, this method has remained the most reliable, sensitive, and practical procedure for halitosis evaluation.[6,10] Current monitoring devices for the evaluation of mouth air are simple, portable, highly sensitive, and reproducible. Furthermore, regarding patient evaluation and therapy, these devices have gained priority compared to other procedures.[2,11] However, concern remains because Halimeter ratings may be influenced noticeably by alcohol, strong mouthwashes, and acquired gases during gum chewing.[6]

According to Rosenberg et al.[8] organoleptic scores were highly correlated with sulfide monitor values. In 1996 and1997 Shimura et al.[10-11] achieved similar results; because of its simplicity of handling they recommended clinical application of the sulfide monitor in the diagnosis and management of halitosis. In 2000 Takahiko and coworkers[12] also determined a high correlation between sulfide monitor values and organoleptic scores. In addition, they estimated the sensitivity, specificity, and diagnostic accuracy of the sulfide monitor method.

The purpose of the present study was to measure the oral malodor of volunteers by means of a subjective organoleptic method and a sulfide monitor as well as to evaluate the diagnostic value of the Halimeter® in halitosis diagnosis.

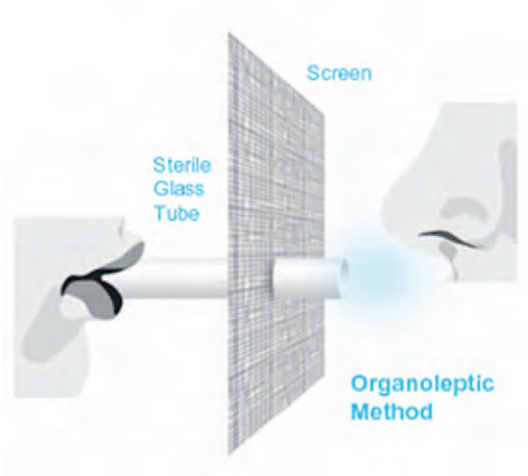
Methods and Materials

The study population included 77 volunteers (26 males, 51 females) among academic staff, students, staff personnel, and patients of the

Shaheed Beheshti University of Medical Sciences, Dental School in Tehran, Iran who responded to the local recall program and agreed to take part in this correlational study.

Individuals with self-reporting systemic diseases affecting breath odor such as uremia, hepatic cirrhosis, diabetes mellitus (Type 1), and sinusitis were excluded from the study. The 77 volunteers were required to refrain from eating and drinking eight hours prior to the test and to avoid eating garlic or onions within 24 hours before the assessment. They were also asked to abstain from tooth brushing, using toothpaste, mouthwash, breath fresheners, scented cosmetics, or grooming aids the morning of testing. All subjects were tested within a few consecutive days between 8:00 and 10:00 a.m.

On the morning of the test day, each patient was screened first using the organoleptic method and then by the sulfide monitor. The organoleptic evaluation panel consisted of three judges who were trained and calibrated with each other beforehand by sniffing the mouths of 15 individuals within three consecutive days. If at least two judges had the same opinion regarding the presence of mouth odor, the organoleptic score would be determined. If there was no agreement among judges, the volunteer would be referred to another day. Furthermore, the organoleptic test was conducted using a screen which concealed the judge from the individuals (to avoid the influence of individuals' appearance on the judgment) and a sterile glass tube (10 cm in length and 2 cm in diameter), which was fitted into a hole in the screen. Each volunteer was requested to close his/her mouth for one to two minutes prior to sampling and place about 4 cm of the glass tube into his/her mouth, then slowly exhale his/her mouth breath through the glass tube. This step was repeated three times during each test. One judge at a time smelled the mouth odor of the individuals until all three judges had evaluated the subjects. Organoleptic scores were then recorded independently by each judge on an ordinal scale as follows:



0: No malodor
1: Slight malodor
2: Clearly noticeable malodor
3: Strong malodor (strong intensity of mouth odor with entirely unacceptable or objectionable characteristics)

Each subject was also evaluated with a sulfide monitor (Halimeter) test. Patients were asked to keep their mouths closed for three minutes prior to testing while breathing through the nose. After three minutes, a disposable plastic straw was mounted at the mouthpiece of the Halimeter and was inserted into the subject's mouth (positioned at a place similar to that in the organoleptic test) and the subject was asked to exhale briefly through the straw for 30 seconds. These steps were repeated in three trials for each subject and in each turn the peak value was recorded by the Halimeter. Then the mean value of three peak recordings was calculated and the final value for each patient was recorded as parts per billion (ppb) sulfide equivalents.

According to the manufacturer Halimeter measurements were divided into three categories as follows:

- Normal = 80-160 ppb
- Weak = 160-250 ppb (malodor at a close distance)
- Strong = >250 ppb (malodor at a greater distance)

The statistical analysis was carried out using SPSS 9.0 software (SPSS, Inc., Chicago, IL, USA); Kendall's tau-b correlation coefficient was used to determine the level of correlation between the organoleptic scores and the sulfide monitor values. As α was set at 0.05, $p<0.05$ was considered statistically significant. The Tukey's post hoc test was used to compare the sulphide monitor scores and different organoleptic rankings (0, 1, 2, and 3), and the Mann-Whitney test was used to determine the difference between men and

women in terms of scores of the two methods. A Spearman correlation was not run, and the Kendall's tau-b correlation coefficient was used.

Results

The study population consisted of subjects with an average age of 26.4±7.4 (SD) and ranged from 19 to 58 years. The organoleptic scores among volunteers were judged as follows: 41 with score 0 (53.2%), 23 with score 1 (29.9%), 10 with score 2 (13.0%), and 3 with score 3 (3.9%).

The mean values of the three measurements during the sulfide monitor evaluation (±SD) were 170.3±108.0, 164±106.4, and 172.4±114.5 ppb. The intraclass correlation coefficient (ICC) was 0.975 with a 95% confidence interval: (CI) (0.963-0.983; p<0.001). In addition, there was no statistically significant difference among these analysis of variance (ANOVA) values for repeated measurements; F=1.353; p=0.265). The mean value was 169.2±107.0 ppb.

Inter-rater correlation coefficients were 0.546 for raters 1 and 2, 0.633 for raters 1 and 3, and 0.743 for raters 2 and 3 (Kendall's tau-b; p<0.001 in all cases). The correlation coefficient between approved organoleptic scores and sulfide monitor values was 0.493 (Kendall's tau-b; p<0.001). As shown in Figure 1, the mean values of sulfide monitor among individuals with different organoleptic scores were statistically different (ANOVA; F=38.600; p<0.001).

According to the manufacturer's guide, 50 subjects (64.9%) had a sulfide monitor value of normal range (80-160 ppb or below). Ten subjects (13.0%) had slight and 17 (22.1%) had strong halitosis (161-250 and >250ppb, respectively). The correlation coefficient between this grading and organoleptic score (Kendall's tau-b) was 0.616 (P<0.001) (Table 1).

The mean (±SD) of sulfide monitor values for males and females were 155.0±99.0 and 176.4±111.2 ppb, respectively (T test; t=0.828; p=0.410). Moreover, the organoleptic scores of males and females showed no statistically significant difference (Mann-Whitney test; mean ranks: 40.4 and 38.3, respectively; p=0.669).

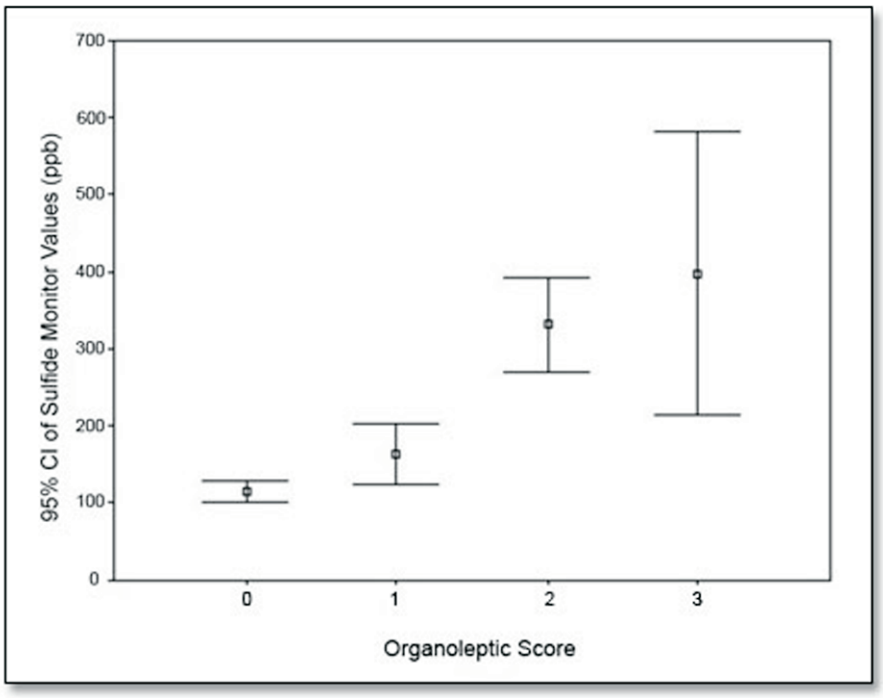


Figure 1. Mean (with 95% CI) of sulfide monitor values (ppb) for individuals with different organoleptic scores; Tukey's post hoc test showed all paired comparison was statistically significant (p<0.05) except organoleptic scores of 2 and 3 (p=0.452).

Table 1. Organoleptic and sulfide monitor grades (according to the manufacturer) for 77 individuals.

Organoleptic Score	Sulfide Monitor Grades			
	Normal Range (≤160 ppb)	Slight Halitosis (161-250 ppb)	Severe Halitosis (>250 ppb)	Total
0	36 (46.8%)	4 (5.2%)	1 (1.3%)	41
1	14 (18.2%)	5 (6.5%)	4 (5.2%)	23
2	-	1 (1.3%)	9 (11.7%)	10
3	-	-	3 (3.9%)	3
Total	50	10	17	77

Table 2. Categorizing individuals by organoleptic score and sulfide monitor grades.

		Organoleptic Score	
		Normal	Halitosis
Sulfide Monitor Grade	Normal	36	14
	Halitosis	5	22

The subjects were divided into four groups (with and without halitosis) based on the organoleptic score (0 and ≥1), and the degree of halitosis estimated by sulfide monitor values (≤160 ppb as normal and >160 ppb and as abnormal is shown in Table 2.

Sensitivity and specificity of sulfide monitor values for detecting individuals with and without halitosis were 61.1% and 87.8%, respectively. Prediction value of a positive test (PPV) was 72.0% and of a negative test was 81.5%. A ratio of 75.3% of all subjects was differentiated accurately. The area under the ROC curve was 0.0.790 (95% CI: 0.678-0.894; R^2 = 0.819) and estimated curve was defined as Y= 0.5 Ln (X) + 0.77 (Figure 2).

Discussion

In this study the Kendall's correlation coefficient between the average of sulfide monitor values and organoleptic scores was 0.493 (P<0.001) which indicates an intermediate level of correlation. Hence, in the evaluation of a subject, for halitosis diagnosis or determination of halitosis intensity, different results might exist between the two evaluation methods. The Spearman correlation coefficient (r) between sulfide monitor values and organoleptic scores was 0.603 in Rosenberg's study,[8] 0.81 and 0.82 in Shimura's studies,[10,11] and 0.66 in Takahiko's study.[12]

Differences among these results may arise from variations in the conduct of the organoleptic method, inclusion criteria, and study populations. Differences in the organoleptic method include the number of judges, scoring methods, judge calibration, use of the bag sampling method or direct technique, or use of intervening screen, type of sulfide monitor, number of monitors in use, calibration of the monitor, and use of a filter.

In the present study sensitivity and specificity of the sulfide monitor test were calculated which established an indicator of the sulfide monitor's diagnostic ability in the population. The sulfide monitor's specificity and sensitivity were

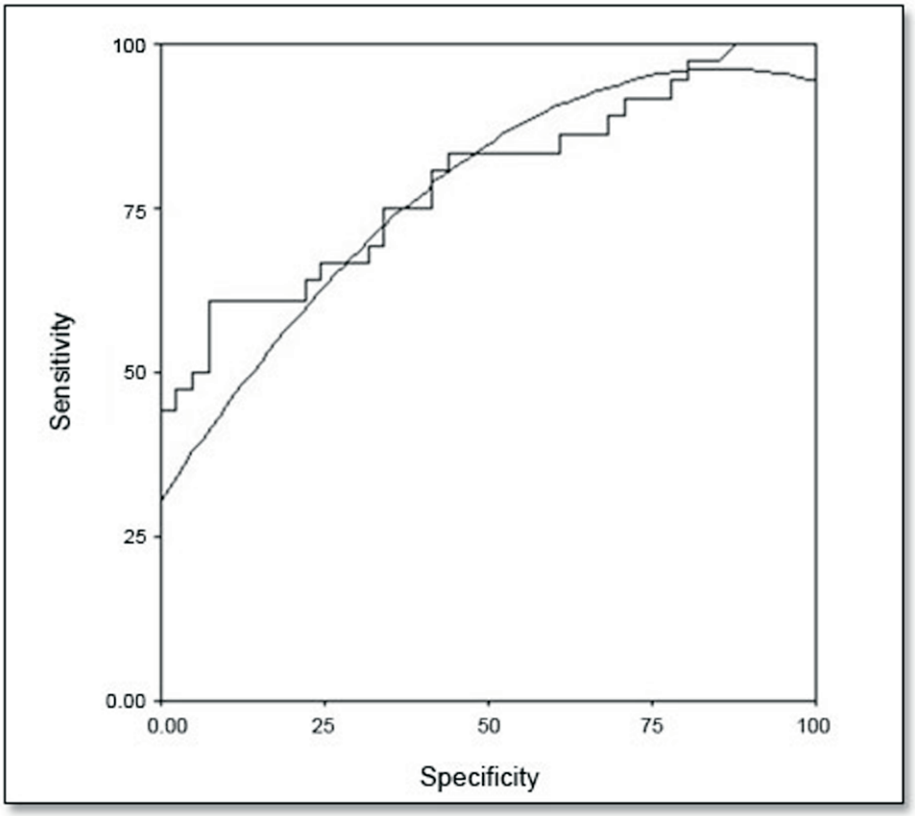


Figure 2. ROC curve to determine the diagnostic values of sulfide monitor grades to differentiate individuals with and without halitosis.

respectively lower and higher than values in the research by Takahiko et al.[12] The commercial brands of sulfide monitors and the manner in which the organoleptic method was conducted was similar in both studies, but the sample size of the present study was smaller. In addition, almost all of Takahiko's patients had some degree of oral malodor which was often objectionable, whereas in the present study a large number of participants were university students who had no objectionable breath malodor except for a few subjects which may affect the results. The PPV and NPV obtained in the present study were indicators the sulfide monitor is more accurate in diagnosis of subjects with halitosis than subjects without halitosis. The accuracy of a diagnosis of halitosis using a sulfide monitor is about 75%. In other words, the sulfide monitor might show false results in about one-fourth of the cases.

In this study both intra- and inter-rater reproducibility in the organoleptic method was strongly acceptable. It is noteworthy to mention that among all researches in these matters the highest obtained correlation coefficient belonged to Shimura's research in 1996 (r=0.84) in which judges had been calibrated already by a specific amount of gas. Among all studies on this topic the highest obtained correlation coefficient (r=0.84) was found by Shimura[10] in which judges were calibrated using a specific amount of odiferous gas. This finding suggests the importance of the method of judge calibration (i.e., by gas or subjective organoleptic examination by nasal sniffing). In addition, in our study the consistency of sulfide monitor values was statistically significant (ICC=0.97). This shows similar results will be obtained in repeated evaluations of a patient using a sulfide monitor

during different days if no intervention is done. This evaluation had been mentioned in the Shimura[10] study in a comment on the fairness of the acquired consistency level but did not mention the exact figure.

The correlation coefficient between intensity of halitosis by sulfide monitor and organoleptic method represented a high significant positive correlation (r= 0.616). Thus, it could be concluded the scoring method used for organoleptic evaluation was consistent with the grading method recommended by the Halimeter's manufacturer. As the organoleptic score moved from 0 to 3, the number of subjects with a value of ≤160 ppb decreased whereas the number of those with higher scores increased gradually.

Based on these findings, further studies should be conducted on smokers to determine the diagnostic ability of the sulfide monitor in these cases. Evaluation of diagnostic values of the sulfide monitor to detect and differentiate the patients with halitosis of oral or extra-oral origins and evaluation of sulfide monitor efficacy to follow up the patients after treatment are recommended.

Conclusion

Within the limits of this study it can be stated the use of a sulfide monitoring device in conjunction with the organoleptic method is an effective strategy for diagnosing oral malodor.

Clinical Relevance

Because of its small size and simplicity of handling the Halimeter sulfide monitor is convenient to use. This method of evaluation of patients for oral malodor is capable of differentiating normal patients (such as with Pseudohalitosis and halitophobia) from the others and for halitosis screening, along with other techniques such as the organoleptic method. However, when used alone, it may lead to a misdiagnosis of some cases in terms of intensity.

Based on the study results, the intra-class correlation coefficient was calculated which was representative of the high level of consistency of the monitor during three repeated trials of measurements. Further, among other findings was the relationship between the grouping of sulfide monitor scores (according to the manufacturer's recommendation) and organoleptic scores which was an indicator of a high correlation coefficient. Evaluation of sensitivity and specificity of the sulfide monitoring method and the authenticity of its diagnostic powers were also included as considerable findings.

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