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Short Communication

Assessment of newly developed tongue sulfide probe for detecting oral malodor

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Abstract

Aim: The present study examined the relationship between sulfide levels on tongue dorsum surfaces (pS levels) and oral malodor.

Method: The pS levels of 20 systemically healthy volunteers were evaluated using an industrial device equipped with a newly-developed tongue sulfide probe. The pS levels on 3 parts of the tongue – anterior, middle and posterior along the median groove of the tongue dorsum – were determined for each subject.

Results: The device reported the pS level in a digital score ranging from 0.0 ($<10^{-7}$ M of sulfide) to 5.0 ($\geqslant 10^{-2}$ M of sulfide) in increments of 0.5. Oral malodor was assessed by measuring the level of volatile sulfur compounds in mouth air, as well as by the organoleptic method. The pS levels were 0.03 ± 0.11, 0.20 ± 0.41 and 0.88 ± 0.76 for the anterior, middle and posterior parts, respectively. This difference was significant ($p<0.001$). Both oral malodor measurements showed significant correlation ($p<0.05$) with the pS levels of middle and posterior parts of tongue.

Conclusion: It was concluded that the tongue sulfide probe might be useful in management of subjects with oral malodor.

Key words: oral malodor; sulcular sulfide level; tongue dorsum; malodor test

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Volatile sulfur compounds (VSC), such as hydrogen sulfide, methyl mercaptan and dimethyl sulfide, cause oral malodor (Tonzetich & Richter 1964, Tonzetich 1971, 1977). These compounds are byproducts of bacterial metabolites (Kleinberg & Westbay 1990, Persson et al. 1990). The surface of the tongue dorsum is one of the main loci associated with VSC formation (Yaegaki & Sanada 1992, Bosy et al. 1994, De Boever & Loesche 1995). However, the quantitative measurement of VSC on the tongue dorsum has not yet been established.

Past studies have assessed oral malodor by scraping the tongue dorsum and smelling it immediately, or by having the subjects lick their wrist with their tongue and smelling the odor from the wrist (Bosy et al. 1994, Rosenberg & Leib 1995, Kozlovsky et al. 1996). Such organoleptic measurement raises several problems, such as inconsistent results among judges (Schmidt et al. 1978, Rosenberg & McCulloch 1992).

Recently, a new probe was developed that has simple and objective characteristics for sulfide measurement on the tongue dorsum. Using this tongue probe, we assessed the relationship between the sulfide level on the tongue dorsum and oral malodor.

The subject group consisted of 20 systemically healthy volunteers (5 female and 15 male; 27 to 69 years of age, mean 49.9 years) who agreed to participate in this study. Subjects taking any antibiotics within the last 3 months, or subjects with evidence of systemic diseases (e.g., diabetes mellitus, chronic renal failure, cirrhosis of the liver, gastrointestinal disorder, respiratory dysfunction, various carcinomas, etc.) that may influence oral malodor (Preti et al. 1992) were excluded from the study. The subjects were asked to refrain from oral activities (e.g., eating, drinking, chewing, brushing, and mouth rinsing) for 2 h prior to data collection. They were also asked not to use any commercial mouth rinse for a period of 24 hours prior to their visit.

The sulfide level on the tongue dorsum (pS level) was determined using the tongue sulfide probe (Diamond General Development Corp., Ann Arbor, MI, USA). The probe was applied on either the anterior, the middle, or the posterior part of the tongue along the median groove of the tongue dorsum with a light pressure for 30 s by the principal investigator (MM). This probe is com-

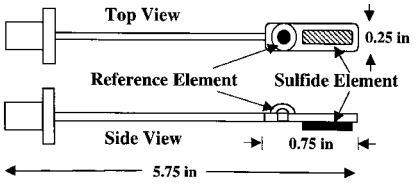

Fig. 1. Diagram of tongue sulfide probe. The sulfide-sensing element generates an electrochemical voltage proportional to the concentration of sulfide ions present. This voltage is measured relative to the operating point of the reference element.

posed of an active sulfide-sensing element and a stable reference element. The sulfide-sensing element generates an electrochemical voltage proportional to the concentration of sulfide ions present. This voltage is measured relative to the operating point of the reference element (Fig. 1). The electrochemical voltages generated by sulfide ions were measured by the electronic unit, and were displayed in a digital score ranging from 0.0 (undetectable pS; less than 10^{-7} M of sulfide) to 5.0 (more than or equal to 10^{-2} M of sulfide) in increments of 0.5. This digital score, *pS*, is defined by $pS=(7+\log S)$, where S is the molar concentration of sulfide in an "equivalent model sulcus fluid".

Oral malodor was measured by the principal investigator (MM) in two ways: detection of VSC in mouth air and organoleptic assessment (Bosy et al. 1994). The VSC measurement in mouth air (VSC) was determined using the Halimeter® (Interescan Corp., Chatsworth City, CA, USA). Prior to VSC detection, each subject was asked to sit quietly without talking for 2 min. Participants were instructed to place their mouths slightly opened over the straw, which was attached to the air inlet of the monitor. The straw extended into the oral cavity approximately 4 cm. Subjects were then instructed to breathe through the nose during the entire measurement. The Halimeter contains a pump that pulls air through the plastic straw. When the sample of mouth air passed through an electrolytic sensor, the level of VSC was assessed. The peak VSC level was recorded in parts per billion (ppb) sulfur. This is equivalent to the direct reading from the digital scale of the monitor.

In the organoleptic measurement, subjects remained quiet with lips closed for a period of 2 min. They were then asked to exhale through the mouth briefly with moderate force at a distance of appropriately 10 cm from the principal investigator (MM). Organoleptic malodor rating (OR) was estimated on a scale of 0 to 5 as follows: 0=no odor, 1=barely noticeable, 2=slight but clearly noticeable, 3=moderate, 4=strong, and 5=extremely strong (Bosy et al. 1994).

The VSC level (ppb) in mouth air was 205±136 (mean±standard deviation {SD}) and the OR was 2.1±1.4. Significant correlation was observed between VSC in mouth air and OR ($r=0.796$, $p<0.001$). Table 1 represents the mean±SD and range of tongue sulfide (*pS*) level on the 3 parts of the tongue and the Spearman rank correlation coefficients between *pS* levels and oral malodor measurements. The posterior part of the tongue showed the highest *pS* level (0.88±0.76), followed by the middle (0.20±0.41). There was a significant difference in *pS* levels among the 3 parts of the tongue ($p<0.001$ by the Kruskal-Wallis test). The highest *pS* level was 2.0 on the posterior part of the tongue, which corresponded to 1×10^{-5} to 3×10^{-5} M of sulfide.

The *pS* levels on the middle and posterior parts of the tongue showed significant correlation with the VSC levels in mouth air ($r=0.712$ for middle, $r=0.628$ for posterior) and OR ($r=0.646$ for middle, $r=0.768$ for posterior). However, no significant correlation was observed between the *pS* level on the anterior part of the tongue and OR and VSC (Table 1).

In this pilot study, the localization of tongue odor was quantitatively assessed using this newly developed tongue probe in a chairside setting. The tongue sulfide levels obtained with this probe were significantly correlated with whole mouth odor. As demonstrated in past studies (Yaegaki & Sanada 1992, Bosy et al. 1994, De Boever & Loesche 1995), the surface of the tongue dorsum is most responsible for VSC formation. This newly developed tongue probe appears to be a simple, reliable, and clinically user-friendly tool for assessing oral malodor generated from the tongue dorsum.

The *pS* level on the posterior tongue dorsum was the highest of the three parts of the tongue examined. This is in agreement with Rosenberg & Leib (1995), who also reported that the posterior part was a primary source of tongue odor assessed by organoleptic rating. This observation can be explained by the absence of a cleansing function in the dorsal one-third of the tongue due to its close contact with the soft palate. This often results in more soft deposits, higher accumulation of bacteria, debris and nasal drip (Rosenberg 1996, Spielman et al. 1996). Conversely, in the anterior two-thirds of the tongue, cleaning ability is greatly improved because the tongue is in constant friction with the hard palate. This results in only a minimum of plaque deposition and significantly reduces the source of oral malodor.

The *pS* levels on the middle and posterior parts of the tongue dorsum were significantly correlated with oral malodor. This implies that the posterior two-thirds of the tongue is a possible source/cause of oral malodor. This finding further confirms the previous studies that have demonstrated that the surface of the tongue dorsum is most responsible for oral malodor (Yaegaki & Sanada 1992, Bosy et al. 1994, De Boever & Loesche 1995). Nonetheless, oral malodor is not caused by only one factor, but by a combination of various factors such as the periodontal condition (Miyazaki et al. 1995) and salivary components (Tonzetich et al. 1967). Multifactorial analysis including the *pS* level on the tongue dorsum allows us to better understand the true etiology of oral malodor.

Table 1. Mean±SD of sulfide levels on three parts of tongue dorsum (pS level) and their correlation coefficients with oral malodor measurements

	Tongue sulfide (pS) level		Correlation coefficient with	
	mean±SD[+]	range	VSC[++]	OR[+++]
anterior	0.03±0.11	0–0.5	0.299	0.325
middle	0.20±0.41	0–1.5	0.712**	0.646*
posterior	0.88±0.76	0–2.0	0.628**	0.768**

[+] Significantly different among the three parts of tongue dorsum ($p<0.001$).
[++] Volatile sulfur compounds in mouth air (Mean±SD; 205±136 ppb).
[+++] Organoleptic rating (Mean±SD; 2.1±1.4).
Significant correlation (* $p<0.05$, ** $p<0.01$).

In addition, since the size of the probe was small (0.25×0.75 inches) in relation to the surface of the tongue, this new device allows clinicians to detect more specific information about odor distribution on the tongue dorsum, lateral and ventral surfaces. In summary, results from this limited pilot study suggest that this newly developed tongue probe has potential in the management of subjects with oral malodor.

Zusammenfassung

Beurteilung einer neu entwickelten Sulfidprobe von der Zunge zur Entdeckung schlechten Mundgeruches

Die vorliegende Studie prüft die Beziehung zwischen den Sulfidlevels auf der Oberfläche des Zungenrückens (pS Level) und dem schlechten Mundgeruch. Die pS Levels von 20 systemisch gesunden Probanden wurden unter Nutzung eines industriell gefertigten Gerätes mit einer neu entwickelten Sulfidanalyse von der Zunge evaluiert. Die pS Levels von 3 Stellen der Zunge – anterior, mittel und posterior entlang der mittleren Zungenfurche – wurden für jede Person bestimmt. Das Gerät zeigte den pS Level in einer digitalen Scoreskala von 0.0 ($<10^{-7}$ M Sulfid) bis 5.0 ($\geqslant 10^{-2}$ M Sulfid) in Einheiten von 0.5. Der schlechte Mundgeruch wurde durch Messung des Level von flüchtigen Schwefelbestandteilen in der Ausatmungsluft gemessen sowie durch eine organoleptische Methode. Die pS Level waren 0.03±0.11, 0.20±0.41 und 0.88±0.76 für die anterioren, mittleren und posterioren Anteile. Diese Differenz war signifikant ($p<0.001$). Beide oralen Mundgeruchmessungen zeigten signifikante Korrelationen ($p<0.05$) mit dem pS Level der mittleren und posterioren Anteile der Zunge. Es wurde geschlossen, daß die Sulfidmessung von der Zunge nützlich im Management von Personen mit schlechtem Mundgeruch sein könnte.

Résumé

Evaluation d'une nouvelle sonde linguale à sulfide pour détecter l'halitose

La relation existant entre les niveaux de sulfide sur les surfaces du dos de la langue (niveaux pS) et l'halitose a été examinée. Les niveaux pS de 20 volontaires en bonne santé ont été évalués en utilisant un système industriel équipé d'une nouvelle sonde linguale à sulfide. Les niveaux pS de 3 parties de la langue c.-à-d. antérieure, moyenne et postérieure le long de la fente médiane du dos de la langue, ont été déterminés. Ce système indiquait le niveau pS sur un score digital allant de 0.0 ($<10^{-7}$ M de sulfide) à 5.0 ($\geqslant 10^{-2}$ M de sulfide) avec des degrés de 0.5. L'halitose a été estimée en mesurant le niveau des composants volatiles de sulfure dans l'air buccal ainsi que par la méthode organoleptique. Les niveaux pS étaient respectivement de 0.03±0.11, 0.20±0.41 et 0.88±0.76 pour les parties antérieures, moyennes et postérieures du dos de la langue. Cette différence était significative ($p<0.001$). Les deux mesures de l'halitose montraient une corrélation significative ($p<0.05$) avec les niveaux pS des parties moyennes et postérieures de la langue. Cette sonde linguale à sulfide pourrait donc être utile dans le traitement des sujets souffrant d'halitose.

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