Low salivary flow and volatile sulfur compounds in mouth air

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Objective. The purpose of this study was to determine whether a reduction of salivary flow would influence the production of methylmercaptan (CH₃SH) and hydrogen sulfide (H₂S), which are volatile sulfur compounds (VSCs) known to cause oral malodor.

Study design. The VSCs in mouth air were measured by means of gas chromatography. Spitting and masticatory (stimulated) methods were used to determine the salivary flow rates of 174 patients.

Results. There was no significant correlation between the level of VSCs and salivary flow rate. However, subjects with extremely low resting salivary flow rates had significantly higher CH₃SH and H₂S concentrations and tongue-coating scores than those with higher resting salivary flow rates. Moreover, logistic analyses revealed that extremely low resting salivary flow, the increase in tongue coating, and a probing pocket depth greater than 4 mm were strong explanatory factors for the generation of VSCs, which could have caused oral malodor.

Conclusions. These findings suggested that an extreme reduction in resting saliva influenced the generation of CH₃SH and H₂S in mouth air.


Volatile sulfur compounds (VSCs) such as hydrogen sulfide (H₂S) and methylmercaptan (CH₃SH) are the main causes of oral malodor, which is a common complaint in different populations. VSCs originate from the bacterial metabolism of amino acids in materials such as food debris, desquamated cells from oral mucosa, and leukocytes that accumulate in the oral cavity. The intensity of clinical bad breath is significantly correlated with the level of the intraoral VSCs. The generation of oral VSCs is influenced by various factors in the oral cavity. The tongue coating and the periodontal pocket are the main sources of VSC production with respect to the bacterial profile. It is evident that an increase in the amount of tongue coating and the number of periodontal pockets significantly correlates with an increase in the concentration of VSCs in mouth air.

Dry mouth is generally regarded as another of the major contributory factors in the production of oral malodor because decreased salivary flow weakens the normal cleansing mechanism of the mouth and predisposes the oral flora toward gram-negative organisms responsible for the malodor. The malodor called morning breath is one of the phenomena caused by reduced salivary flow during sleep. However, previous studies have shown no evidence that a reduction in the salivary flow rate significantly correlates with increases in oral malodor or concentration of VSCs in mouth air. Thus, the general view that a reduction of salivary flow is linked to the production of oral malodor is merely a hypothesis.

The purpose of this study was to determine whether a reduction in salivary flow would influence the production of oral malodor, so we evaluated the relationship between the salivary flow rate and the level of VSCs in mouth air and between salivary flow rate and other parameters that are related to oral malodor, such as tongue coating and periodontal health.

SUBJECTS AND METHODS

The subjects were adult individuals who were selected at random from patients visiting for care at the Preventive Dentistry and Breath Odor Clinic of Kyushu Dental College (Kitakyushu, Japan). The procedures were explained to the subjects, and their informed consent was obtained before the investigation. Because systemic diseases and a decrease in the number of remaining teeth might influence the correlation between the generation of VSCs and the salivary flow rate, the subjects who were undergoing treatment for systemic were excluded.

All subjects were evaluated for the presence of oral malodor (BOP), and probing was performed on all surfaces of the teeth.

Gas chromatographic evaluation was performed using a 34-mm glass column (DMCS-60) that was 6 feet long, 60° photometric flow, 1.0 kg/cm² CH₃SH at a concentration of mL and 1 tonable.

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Table I. Profiles of the subjects in this study (means ± SDs)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Total (N = 174)</th>
<th>Men (n = 52)</th>
<th>Women (n = 122)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>48.6 ± 13.7</td>
<td>50.1 ± 13.3</td>
<td>48.0 ± 13.9</td>
</tr>
<tr>
<td>No. of teeth</td>
<td>26.5 ± 2.9</td>
<td>26.7 ± 3.1</td>
<td>26.4 ± 2.8</td>
</tr>
<tr>
<td>Resting salivary flow rate (mL/min)</td>
<td>0.3 ± 0.2</td>
<td>0.4 ± 0.3</td>
<td>0.3 ± 0.2</td>
</tr>
<tr>
<td>Stimulated salivary flow rate (mL/min)</td>
<td>1.4 ± 0.8</td>
<td>1.6 ± 0.8</td>
<td>1.4 ± 0.8</td>
</tr>
<tr>
<td>Concentration of CH₃SH (ng/10 mL)</td>
<td>5.6 ± 18.1</td>
<td>9.0 ± 26.7</td>
<td>4.2 ± 12.7</td>
</tr>
<tr>
<td>Concentration of H₂S (ng/10 mL)</td>
<td>9.4 ± 31.3</td>
<td>18.8 ± 53.1</td>
<td>5.5 ± 13.1</td>
</tr>
<tr>
<td>No. of PD4 (sites)</td>
<td>10.2 ± 16.9</td>
<td>16.3 ± 22.7*</td>
<td>7.7 ± 13.1</td>
</tr>
<tr>
<td>No. of BOP (sites)</td>
<td>15.5 ± 17.7</td>
<td>17.1 ± 19.3</td>
<td>14.8 ± 16.9</td>
</tr>
<tr>
<td>Tongue-coating score (%)</td>
<td>1.2 ± 0.6</td>
<td>1.4 ± 0.7*</td>
<td>1.1 ± 0.6</td>
</tr>
<tr>
<td>PCR (%)</td>
<td>46.2 ± 30.5</td>
<td>49.7 ± 19.2</td>
<td>44.7 ± 30.9</td>
</tr>
</tbody>
</table>

CH₃SH: Methylmercaptan; H₂S: hydrogen sulfide; PD4: probing pocket depth ≥4 mm; BOP: bleeding on probing; PCR: plaque control score.

* Mann-Whitney U test, P < .05.

Table II. Spearman correlation coefficients between VSC levels and salivary flow rates and between VSC and parameters of considerable oral malodor

<table>
<thead>
<tr>
<th>Parameters</th>
<th>CH₃SH concentration (ng/10 mL)</th>
<th>H₂S concentration (ng/10 mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>P</td>
<td>r</td>
</tr>
<tr>
<td>Resisting salivary flow rate (mL/min)</td>
<td>-0.103</td>
<td>.190</td>
</tr>
<tr>
<td>Stimulated salivary flow rate (mL/min)</td>
<td>0.055</td>
<td>.287</td>
</tr>
<tr>
<td>No. of PD4 (sites)</td>
<td>0.262</td>
<td>.001</td>
</tr>
<tr>
<td>No. of BOP (sites)</td>
<td>0.310</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Tongue-coating score (%)</td>
<td>0.386</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PCR (%)</td>
<td>0.052</td>
<td>.541</td>
</tr>
</tbody>
</table>

VSC: Volatile sulfur compound.
Table III. Comparison of parameters between groups on the basis of salivary flow rate

<table>
<thead>
<tr>
<th>Variables</th>
<th>RS rate (n = 24 [8/16])</th>
<th>RS2 rate (n = 44 [4/106])</th>
<th>SS1 rate (n = 25 [7/18])</th>
<th>SS2 rate (n = 149 [45/104])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>52.9 ± 14.5</td>
<td>47.9 ± 13.5</td>
<td>45.4 ± 17.3</td>
<td>49.1 ± 13.0</td>
</tr>
<tr>
<td>No. of teeth</td>
<td>25.4 ± 3.3</td>
<td>26.7 ± 2.8</td>
<td>26.8 ± 3.0</td>
<td>26.4 ± 2.9</td>
</tr>
<tr>
<td>Concentration of CH₃SH (ng/mL)</td>
<td>19.6 ± 3.10</td>
<td>3.2 ± 13.5</td>
<td>8.5 ± 25.1</td>
<td>5.1 ± 16.5</td>
</tr>
<tr>
<td>Concentration of H₂S (ng/mL)</td>
<td>18.4 ± 29.1</td>
<td>8.0 ± 31.6</td>
<td>8.0 ± 16.3</td>
<td>9.7 ± 33.3</td>
</tr>
<tr>
<td>No. of PD4 (sites)</td>
<td>6.3 ± 22.8</td>
<td>9.2 ± 15.7</td>
<td>8.2 ± 15.6</td>
<td>10.6 ± 17.1</td>
</tr>
<tr>
<td>No. of BOP (sites)</td>
<td>23.8 ± 25.7</td>
<td>14.2 ± 15.7</td>
<td>17.8 ± 18.1</td>
<td>15.1 ± 17.6</td>
</tr>
<tr>
<td>Tongue-coating score (%)</td>
<td>1.5 ± 0.7</td>
<td>1.1 ± 0.6</td>
<td>1.2 ± 0.7</td>
<td>1.1 ± 0.6</td>
</tr>
<tr>
<td>PCR (%)</td>
<td>50.3 ± 19.6</td>
<td>45.4 ± 20.6</td>
<td>52.5 ± 22.7</td>
<td>44.9 ± 19.8</td>
</tr>
</tbody>
</table>

RS: Resting saliva; RS1: resting saliva less than 0.1 ml/min; RS2: resting saliva greater than or equal to 0.1 ml/min; SS1: stimulated saliva less 0.7 ml/min; SS2: stimulated saliva greater than or equal to 0.7 ml/min; n, number of subjects (men/women).

*Mann Whitney U test, *P < .05.

Table IV. Odds ratios of parameters for producing high concentrations of CH₃SH and H₂S

<table>
<thead>
<tr>
<th>Parameters</th>
<th>CH₃SH ≥ 0.5 ng/10 mL. H₂S ≥ 1.5 ng/10 mL.</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS flow rate</td>
<td>4.0 (1.1-13.6)*</td>
<td>4.2 (1.2-14.8)*</td>
</tr>
<tr>
<td>Increase of 1 score in tongue coating</td>
<td>2.8 (1.4-5.8)*</td>
<td>2.0 (1.0-4.2)*</td>
</tr>
<tr>
<td>Increase of 1 site in no. of PD4</td>
<td>1.1 (1.0-1.1)*</td>
<td>1.1 (1.0-1.2)*</td>
</tr>
</tbody>
</table>

*P < .05, †P < .01.

The mean values of parameters among groups classified in terms of the difference in the resting salivary flow rate or the stimulated salivary flow rate are summarized in Table III. The VSC concentrations and tongue-coating scores were significantly higher in the RS1 group than in the RS2 group, and the PCR score was significantly higher in the SS1 group than in the SS2 group. There was no significant difference between the groups with respect to other parameters. On the other hand, the 7 subjects with RS1 also had SS1.

Table IV shows the odds ratios calculated for stepwise logistic regression analyses to evaluate the associations between the high concentrations of CH₃SH and H₂S (CH₃SH ≥ 0.5 ng/10 mL. H₂S ≥ 1.5 ng/10 mL) and the resting salivary flow rate, the tongue-coating score, and the number of PD4. The odds ratios calculated from subjects with high concentrations of CH₃SH and H₂S in mouth air were significantly greater, by 4.0-fold and 4.2-fold (P < .05), respectively, if the resting salivary flow rate was extremely low (ie, <0.1 ml/min). The odds ratios calculated from subjects with high concentrations of CH₃SH and H₂S were significantly greater, by 2.8-fold and 2.0-fold (P < .01), respectively, in terms of a 1-point increase in the tongue-coating score. In addition, the odds ratios were greater, by 1.1-fold (P < .01), with an increase in the number of PD4 at 1 site. Other parameters (the stimulated salivary flow rate and the number of BOP sites and PCRs) were not extracted as strong factors related to the objectionable VSC concentrations.

RESULTS

The profiles of the subjects in this study are shown in Table I. The study population consisted of 52 men and 122 women with a mean age and SD of 48.6 ± 13.7 years. There was no significant difference between men and women in terms of the parameters, except for the number of PD4 and the tongue-coating score. That is, men had significantly greater number of PD4 and higher tongue-coating scores than did women.

Table II shows the correlations between the VSC levels and the salivary flow rate, in addition to the correlations between VSC levels and the parameters of considerable oral malodor. Significant correlations were found between the VSC (CH₃SH and H₂S) concentrations and the numbers of PD4 and BOP and between VSC concentrations and the tongue-coating score. The resting and stimulated salivary flow rates had no significant correlation with the VSCs.

DISCUSSION

Saliva plays an important role in the maintenance of oral health. Thus, reduced salivary flow predisposes individuals to oral disease and discomfort. Our results reveal that the proportions of subjects with a resting salivary flow rate of less than 0.1 ml/min and a stim-
ulated salivary flow rate of less than 0.7 mL/min each
totaled approximately 14% of all subjects. These results
were mostly in agreement with those of previous stud-
ies.38,39

CH₃SH and H₂S are the main substances that cause
oral malodor.13 This study has shown no significant
correlation between the CH₃SH and H₂S levels in
mouth air and the resting and stimulated salivary flow
rate; however, the results did reveal that subjects with a
resting salivary flow rate of less than 0.1 mL/min had
higher CH₃SH and H₂S levels in mouth air than those
with a flow rate greater than 0.1 mL/min. Therefore, it
was suggested that an extreme reduction in the RS flow
rate might be one of the risk factors for the generation
of oral malodor but that RS flow may not significantly
influence the intensity of the oral malodor if the rate is
within normal limits. In contrast, the VSC levels of
subjects with an extremely low stimulated salivary flow
rate of less than 0.7 mL/min did not significantly differ
from those of the other subjects; therefore, the reduc-
tion in the SS was not believed to be associated with the
generation of VSCs. This result is similar to the find-
ings of Miyazaki et al.29 who showed no correlation
between the VSC level and the SS. Thus, we suggest
that a reduction in the stimulated salivary might not be
a risk factor for oral malodor.

It was evident from a review of previous studies that
tongue coating was strongly related to VSC production,4,12
and that the VSC concentration was higher in
individuals with periodontitis than in those without
periodontitis.3,8-11 This study showed that the extreme
reduction in RS flow, in addition to the increase in the
amount of tongue coating and periodontal pockets,
was one of the main explanatory factors for the high-level
generation of VSCs (CH₃SH and H₂S) in mouth air. On
the other hand, subjects with an extremely low RS flow
rate had a significantly higher tongue-coating score
than the other subjects, and they tended to have poor
periodontal health compared with the others. Therefor,
it was suggested that a reduction of RS flow might
influence the production of tongue coating and the
periodontal health and that oral malodor was caused by
the interaction of multiple risk factors.

In conclusion, addition to tongue coating and peri-
donital health, a reduction in the RS flow rate influ-
enced the generation of the VSCs (CH₃SH and H₂S). This,
an extreme reduction in the RS flow rate is associated
with the generation of oral malodor.

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