Behavioral dental science: The relationship between tooth-brushing angle and plaque removal at the lingual surfaces of the posterior teeth in the mandible

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Abstract: The aim of this study was to investigate the relationship between tooth-brushing angle and efficacy of plaque removal. The subjects in this study were 72 students (18-21 yrs.) from paramedical schools. They answered the questionnaire of the Hiroshima University - Dental Behavioral Inventory (HU-DBI) to assess dental health behavior, and then received examinations of tooth-brushing angle, efficacy of plaque removal and gingival condition. The examination sites of tooth-brushing angle and the efficacy of plaque removal were the lingual surfaces of the posterior teeth in the mandible. The tooth-brushing angle, efficacy of plaque removal, gingival condition and dental health behavior were significantly associated with each other. The subjects who directed the bristles of the toothbrush vertically toward the tooth surfaces had a high efficacy of plaque removal, good gingival condition and good dental health behavior. Thus, it is important to direct the bristles vertically toward the tooth surfaces for effective plaque removal. In addition, knowledge related to good dental health might be necessary to carry out effective tooth brushing. (J. Oral Sci. 42, 79-82, 2000)

Key words: behavioral dental science; tooth-brushing; dental plaque prevention and control; dental health education.

Introduction

These days, most Japanese have a great interest in oral hygiene. Although a national survey in 1993 showed that 95% of Japanese brush their teeth every day, about two thirds of Japanese had gingivitis or periodontitis (1). Thus, it appears difficult to remove dental plaque on proximal surfaces by only tooth brushing (2).

Previous studies have reported that the efficacy of plaque removal was dependent on the type of brush (3), the force applied by the brush (4), and the number of brushing strokes used (5). Many methods of brushing have been presented and each brushing method has particular target areas and toothbrush movements. For example, Bass (6) proposed that the bristles should be forced directly into the gingival crevices and sulci between teeth, at about a 45° angle to the long direction of the teeth. Gottlieb (7) indicated that brushing of the teeth vertically from the gingival margin to the tooth tip appeared to be the only reasonable direction and in order to remove foreign material from proximal surfaces, the bristles should be inserted into the spaces between the teeth. Charters (8) suggested that the brush on the tooth be at a 45° angle with the bristles pointed toward the crown.

In the current study, the relationship between tooth-brushing angle and efficacy of plaque removal was investigated.

Methods

The subjects in this study were 72 students (18-21 yrs.) of the paramedical schools, Hiroshima University. All subjects were female. No information about their academic record was gathered, and participation was voluntary. Subjects answered a questionnaire, the Hiroshima University - Dental Behavioral Inventory (HU-DBI), and were examined for gingival condition, tooth-brushing
angle, and oral hygiene performance using the Patient Hygiene Performance index (PHP, Podshadly & Haley) (9). The standard examination of the PHP is performed on six particular teeth, but in this study the lingual surfaces of the second premolar and the first molar were examined and the mean value for the two teeth reported for each subject (Fig. 1).

The HU-DBI is comprised of 20 items to assess perceptions and oral health behavior. All items of the HU-DBI have a dichotomous response format (agree-disagree). The maximum score is 12 (Cronbach's alpha = 0.76) (10), and higher scores signify better oral health behavior.

All examinations of gingival condition were carried out by the same examiner. The gingival condition was measured against the Oral Rating Index (ORI) which categorized gingival condition according to an ordinal scale from -2 through to +2 (-2, very poor; -1, poor; 0, questionable; +1, good; +2, excellent) (11). The ORI uses a set of standard photographs of each level of the scale in order to maintain consistent standards. A previous study has shown that the ORI was highly associated with the Gingival Index (Löe & Silness; r = -0.839), the Plaque Index (Silness & Löe; r = -0.721), the Calculus Index (Greene & Vermillion; r = -0.741) and Probing Depth (r = -0.640) (10).

The examination of tooth-brushing angle, oral hygiene performance and gingival bleeding on brushing was carried out by a second examiner between three to four o'clock in the afternoon on weekdays, where the subjects had not received dietary controls in advance of the examination. The examination site was the lingual surfaces of the second premolar and the first molar in one side of the mandible. All subjects had no attachment loss in this part of the mouth. The left side was examined for right-handed subjects (n = 71), and the right side was examined for a left-handed subject (n = 1). The line connecting right and left angles of lip was considered the standard line of 90°.

Under the pretense of brushing, the tooth-brushing angle was defined as an angle between the vertical line to the standard line and the bristles of the toothbrush (Fig. 2) (4). The tooth-brushing angle of each subject was measured twice, and the mean value for each subject was recorded. The subjects then brushed their own site for 15 seconds using their own routine method. Immediately after the brushing, the presence of gingival bleeding was checked, and oral hygiene performance was evaluated by the PHP. Then the first examiner brushed the examined teeth of the subjects with the tooth-brushing angle of more than 90°, and the presence of gingival bleeding was checked once again.

Data were analyzed using StatView (Abacus Concepts, Inc., Berkeley, CA, USA). Relationships between tooth-brushing angle and other oral indices were analyzed by Pearson's correlation coefficient.

Results

The mean values of tooth-brushing angle, PHP, ORI, and HU-DBI were 56.4 (s.d. 21.3), 1.08 (s.d. 0.96), 0.99 (s.d. 0.78) and 7.78 (s.d. 2.66), respectively.

Table 1 shows a matrix of the correlation coefficients between tooth-brushing angle and the other oral indices. Pearson's correlation coefficient between the tooth-brushing angle and the PHP was -0.562 (p < 0.001). As the tooth-brushing angle increased, less dental plaque remained. The tooth-brushing angle was positively associated with the ORI (r = 0.564, p < 0.001) and the HU-DBI (r = 0.651, p < 0.001). The subjects with greater tooth-brushing angles had higher ORI, and higher HU-DBI. The PHP was negatively associated with the ORI (r = -0.602, p < 0.001) and the HU-DBI (r = -0.637, p < 0.001). The students who retained more dental plaque had worse gingival conditions and lower levels of dental health behavior.

Table 2 shows the oral hygiene performance by area of tooth surface and tooth-brushing angle. After 15 seconds of brushing, there were no subjects with dental plaque that
remained on the occlusal area. Plaque was retained in the middle area by only two subjects who brushed their teeth at an angle of 35 to 50°. All the subjects that brushed at an angle over 65° removed all dental plaque from the gingival area, though a few of them retained dental plaque on the proximal area. However, only half of the subjects with a brushing angle less than 65° removed all plaque from the gingival area, and in the proximal area few of them succeeded in plaque control.

When the subjects brushed their own teeth, there were few subjects with gingival bleeding (Table 3). In contrast, the examiner's brushing caused gingival bleeding in most subjects with a brushing angle less than 65°.

**Discussion**

Some studies on efficacy of plaque removal did not standardize the gingival condition of the subjects (5). Likewise, the subjects of this study were not standardized. However, subjects in the current study had rather good gingival condition and oral health behavior, judging from the ORI and HU-DBI (10).

In this study, the lingual surfaces of the posterior teeth in the mandible were chosen as the examination site because it has been reported that gingival inflammation is found more in this area (12). Macgregor (5) showed that plaque scores were greatest in this part of the mouth, but varied little between other areas. Therefore, it was considered better to evaluate these areas, if the subjects had a relatively good gingival condition.

All subjects used a back-and-forth vibratory motion when they brushed their own teeth. The first and second measured values of the tooth-brushing angle were almost identical (r = 0.974, maximum difference = 14°).

The subjects with a larger tooth-brushing angle had less plaque residue, better gingival condition and better dental health behavior. It was necessary to direct the bristles vertically toward the tooth surfaces for plaque removal and good gingival condition. The tooth-brushing angle might be one of the most important factors in plaque control. In addition, knowledge and perception of dental health issues might be necessary to carry out the effective tooth brushing.

Occlusal and middle areas were brushed well at any tooth-brushing angle in this sample. However, when the teeth were brushed at an angle less than 65° it was difficult to remove plaque on gingival areas and it was almost impossible to clean proximal areas. If the tooth surfaces were flat, brushing at any angle would be equally effective for cleaning all areas of the lingual surface. However, as the surfaces are curved and have undercuts, brushing at a right angle might be superior for reaching gingival areas and proximal areas.

Very few subjects had gingival bleeding when they brushed their own teeth, whereas 62% of the subjects had bleeding when the examiner brushed their teeth. It was suggested that they had inflamed gingiva with easy bleeding because the subjects may not have made the bristles reach the gingiva when they normally brush their teeth. When

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**Table 1** Correlation coefficients between the tooth-brushing angle and the other indices

<table>
<thead>
<tr>
<th></th>
<th>PHP*</th>
<th>ORI*</th>
<th>HU-DBI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brushing angle</td>
<td>-0.562*</td>
<td>0.564*</td>
<td>0.651*</td>
</tr>
<tr>
<td>PHP</td>
<td>-0.602*</td>
<td>-0.637*</td>
<td></td>
</tr>
<tr>
<td>ORI</td>
<td>0.565*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pearson's correlation coefficients *p < 0.001

- a: Patient Hygiene Performance (oral hygiene performance)
- b: Oral Rating Index (gingival condition)
- c: Hiroshima University - Dental Behavioral Inventory (oral health behavior)

**Table 2** Relationship between tooth-brushing angle and plaque retention

<table>
<thead>
<tr>
<th>Area of tooth surface</th>
<th>Proximal Plaque</th>
<th>Marginal</th>
<th>Middle</th>
<th>Occlusal</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°-35°</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>~50°</td>
<td>22</td>
<td>8</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>~65°</td>
<td>24</td>
<td>11</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>~80°</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>~95°</td>
<td>7</td>
<td>9</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>~110°</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>51</td>
<td>28</td>
<td>90</td>
</tr>
</tbody>
</table>

a: The number of subjects who remained no dental plaque
b: The number of subjects with some dental plaque

discussion

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**Table 3** Gingival bleeding on brushing by tooth-brushing angle

<table>
<thead>
<tr>
<th>Brushing angle</th>
<th>Bleeding</th>
<th>Brushing by subject</th>
<th>Brushing by examiner</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°-35°</td>
<td>10</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>~50°</td>
<td>22</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>~65°</td>
<td>15</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>~80°</td>
<td>6</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>~95°</td>
<td>9</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>~110°</td>
<td>4</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>6</td>
<td>27</td>
</tr>
</tbody>
</table>

a: The number of subjects without gingival bleeding
b: The number of subjects with some gingival bleeding
the brush was placed on the tooth at about a 45° angle with the bristles pointed toward the root (like the Bass method), the bristles appeared to not reach the gingiva. Unexpectedly, it was not sufficient to set bristles at a 45° angle for plaque control of gingival sulci. Young women without deep gingival pockets do not need to clean gingival pockets. It would be sufficient for them to clean all areas of the tooth surfaces, including gingival and proximal areas. Cleaning the tooth surface using a toothbrush is the most fundamental part of plaque control.

The results of the present study suggest that toothbrushing angle is a very important factor in cleaning both gingival and proximal areas. It is important to provide proper tooth brushing instruction as a part of dental health education before encouraging the use of dental floss or interdental brushes.

Acknowledgments
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References
8. Charters, W.J. (1932) Eliminating mouth infections with the toothbrush and other stimulating instruments. Dent. Dig. 38, 130-136