EFFECT OF ACUTE NASAL OBSTRUCTION ON MASTICATORY FUNCTION

Mika SUGAWARA, Isao OOTA*, Nariko SAKAGUCHI, Megumi ASAKA, Seiji IGARASHI and Koshiro INOMATA*
Department of Pediatric Dentistry and *Department of Oral Physiology, School of Dentistry, Health Sciences University of Hokkaido,

Abstract

The present study was undertaken to examine how masticatory function is affected by an acute nasal obstruction. Nasal obstruction was performed by pinching the nose of each subject with a nose clip. We measured the chewing time, water content of food bolus and the volume of saliva secreted during the mastication of peanuts. In addition, the chewing cycle time, burst duration time and the interval time were also analyzed from the results obtained electromyographically. Comparisons were made between the normal and the nasal obstructed condition in the same subject. The chewing time under nasal obstructed condition was significantly prolonged compared to control condition, whereas the water content of food bolus and volume of saliva secreted during mastication was unchanged. The chewing cycle time tended to be prolonged by nasal obstruction. The interval time was significantly prolonged by nasal obstruction, while the burst discharge time was not significantly changed. These results indicate that the water content of food bolus as an important factor for the determination of the chewing time under a nasal obstructed condition as well as in a normal condition. Therefore, the prolongation of chewing time under a nasal obstructed condition is possibly attributed to a compensatory action for getting an equivalent water content of food bolus under normal condition.

Key word: Acute nasal obstruction, Water content of food, EMG, Masticatory function.

Introduction

Numerous investigators have reported that masticatory function is affected by various factors. The chewing force, the number of chewing strokes and the time until swallowing vary according to the texture of food, such as its hardness, shape and stickiness (Shiere and Manly, 1952; Kawamura and Nobuhara, 1957; Thexton et al., 1980; Liao et al., 1990). The volume of saliva secreted during mastication depends on the water and taste substances containing food (Watanabe and Dawes, 1988; Watanabe et al., 1993a; Watanabe et al., 1998). However, most of these studies have been carried out on healthy subjects. There is little information about the effect of acute nasal obstruction on masticatory function. The conryzal type of cold easily gives rise to the acute nasal obstruction.

The present study was undertaken to examine how masticatory function is affected by an acute nasal obstruction. Based on the results, we have reported the effect of acute nasal obstruction on masticatory function, especially the effect on chewing time.

Materials and Methods

1. Subjects

The experiments were carried out in 5 subjects with a mean age of 28.8 ± 6.5 (mean ± SD.) years. All subjects were students or teaching staff of our university. They were free
from any clinical signs and symptoms of the stomatognathic system and had no history of nasal disease. Informed consent was obtained from each subject prior to the experiments.

2. Procedure for acute nasal obstruction

The nose of each subject was pinched by a nose clip and this situation was refereed to as a nasal obstructed condition. The completeness of nasal obstruction was checked by no leakage of expired air from the nasal cavity.

3. Measurements of chewing time, water content of food bolus and volume of saliva secreted during mastication.

Peanuts was used as the test food. The water content and the volume of saliva secreted during mastication were calculated by the chewing-spit method described by Richardson and Feldman (1986). That is, each subject took a 3g portion of peanuts and chewed until such time as the subject would normally swallow. Just before the occurrence of swallowing, the food bolus was spit out into a previously weighted container. The volume of saliva secreted during that time was calculated by subtracting the initial weight of food from that of the food-saliva mixture. The time required to the point before swallowing was measured as the chewing time.

4. Recording and analyzing of electromyogram

Electromyograms (EMG) of the working side of the masseter muscle were recorded from a pair Ag·AgCl surface disc electrodes placed on the facial skin over the middle portion of the muscle and stored on DAT tape.

The data stored on DAT tape were analyzed by a personal computer. The chewing cycle time, the burst duration time and the interval time were measured by an analysis program (QP-110J, NIHON KOHDEN).

The significance of the difference between values under the normal condition and those under the nasal obstructed condition in the same subject was tested by the paired t-test.

Results

1. Chewing time

Chewing time under the normal and the nasal obstructed condition is shown in Table 1. Under the normal condition, the chewing time was individually variable, ranging from 19.0 ± 3.2 (mean ± SD.) sec in subject 3 to 48.2 ± 4.3 sec in subject 4, while it was a narrow variation in the same subject. The chewing time in all subjects was prolonged by nasal obstruction. The maximum and the minimum values in the nasal obstructed condition was 29.3 ± 2.4sec in subject 3 and 79.0 ± 4.9sec in subject 4, respectively. The chewing time of subjects 1, 3 and 4 under the nasal obstructed condition showed a significant prolongation compared with that under the control condition (P<0.001).

2. Water content of food bolus

Table 2 shows the water content of food bolus under the normal and the nasal obstructed conditions. Under the normal condition, the maximum value of water content of food bolus was 66.1 ± 20 % in subject 2 and the minimum value of that was 32.8 ± 5.6 % in subject 4 under the nasal obstructed condition, the maximum and the minimum values were 66.1 ± 2.4 % in subject 2 and 34.1 ± 4.9 % in subject 4, respectively. In all subjects, except for subject 1, there were no significant differences under

<table>
<thead>
<tr>
<th>subject</th>
<th>normal condition (sec)</th>
<th>nasal obstructed condition (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33.0±2.9</td>
<td>46.0±3.0*</td>
</tr>
<tr>
<td>2</td>
<td>28.0±1.4</td>
<td>30.7±4.4</td>
</tr>
<tr>
<td>3</td>
<td>19.0±3.2</td>
<td>29.3±2.4*</td>
</tr>
<tr>
<td>4</td>
<td>48.2±4.3</td>
<td>79.0±4.9*</td>
</tr>
<tr>
<td>5</td>
<td>46.0±14.0</td>
<td>55.0±6.1</td>
</tr>
</tbody>
</table>

Values are mean ± SD. Number of trials in each subject is 7. * indicates significant difference from the control condition at p<0.001.
the water content of food bolus between the normal condition and the nasal obstructed condition.

3. Volume of saliva secreted during mastication
   The volume of saliva secreted during mastication of peanuts is shown in Table 3. Subject 2 exhibited the maximum value both under the normal and the nasal obstructed conditions. The respective values were 5.8 ± 0.6g under the normal condition and 5.8 ± 0.3g under the nasal obstructed condition. The minimum values under the normal and the nasal obstructed conditions were obtained from subject 4, and they were 1.5 ± 0.4g and 1.5 ± 0.4g, respectively.

Table 2. The water content of food bolus in normal and nasal obstructed conditions.

<table>
<thead>
<tr>
<th>subject</th>
<th>normal condition (%)</th>
<th>nasal obstructed condition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>53.8 ± 1.8</td>
<td>58.2 ± 2.1</td>
</tr>
<tr>
<td>2</td>
<td>66.1 ± 2.0</td>
<td>66.1 ± 2.4</td>
</tr>
<tr>
<td>3</td>
<td>51.8 ± 2.0</td>
<td>54.9 ± 2.7</td>
</tr>
<tr>
<td>4</td>
<td>32.8 ± 5.6</td>
<td>34.1 ± 4.9</td>
</tr>
<tr>
<td>5</td>
<td>56.9 ± 1.9</td>
<td>51.0 ± 4.9</td>
</tr>
</tbody>
</table>

Values are mean ± SD. Number of trials in each subject is 7. * indicates significant difference from the control condition at p<0.001.

Table 3. Volume of saliva secreted during mastication in normal and nasal obstructed conditions.

<table>
<thead>
<tr>
<th>subject</th>
<th>normal condition (g)</th>
<th>nasal obstructed condition (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.4 ± 0.2</td>
<td>4.1 ± 0.3</td>
</tr>
<tr>
<td>2</td>
<td>5.8 ± 0.6</td>
<td>5.8 ± 0.3</td>
</tr>
<tr>
<td>3</td>
<td>3.2 ± 0.3</td>
<td>3.6 ± 0.4</td>
</tr>
<tr>
<td>4</td>
<td>1.5 ± 0.4</td>
<td>1.5 ± 0.4</td>
</tr>
<tr>
<td>5</td>
<td>3.9 ± 0.3</td>
<td>3.2 ± 0.6</td>
</tr>
</tbody>
</table>

Values are mean ± SD. Number of trials in each subject is 7. * indicates significant difference from the control condition at p<0.001.

There were no significant differences in the volume of saliva secreted during mastication between the normal and the nasal obstructed conditions.

4. Chewing Cycle time, burst duration time and interval time.
   Typical electromyograms recorded from the same subject under the normal and the nasal obstructed conditions are shown in Fig. 1. Under the normal condition, burst discharge were repeated with a somewhat constant interval. In contrast to this, burst discharge was considerably longer compared to the normal condition.

In order to observe the changes in the chewing cycle time, the burst duration time and the interval time according to the nasal obstruction, these parameters were measured in all strokes during mastication of peanuts.

As shown in Fig. 2, the chewing cycle time of all subjects was prolonged by the nasal obstruction. Under the normal condition, respective values of the maximum and the
minimum of the chewing cycle time were 875.8 ± 180.5 msec in subject 4 and 571.4 ± 62.9 msec in subject 1. Under the nasal obstructed condition, the maximum value was 1073.8 ± 505.4 msec in subject 4 and the minimum value was 642.2 ± 112.7 msec in subject 1. In subjects 1, 3 and 4, the chewing cycle time under the nasal obstructed condition was significantly different from that under the normal condition (P<0.001).

Figure 3 shows the burst duration time under the normal and the nasal obstructed conditions. In all subjects, the interval time under the nasal obstructed condition was longer than that under the normal condition. Subject 4 showed the maximum value under both the normal and the nasal obstructed conditions. The value was 529.5 ± 100.0 msec under the normal condition and 535.6 ± 135.4 msec under the nasal obstructed condition. On the other hand, subject 1 showed the minimum value under both conditions. The values under the normal condition and that under the nasal obstructed condition were 370.0 ± 69.7 msec and 326.3 ± 69.7 msec, respectively. There was no significant difference between the burst duration time under the normal and the nasal obstructed conditions.

The interval time under the normal and the nasal obstructed conditions is shown in Fig. 4. In all subjects, the interval time under the nasal obstructed condition was longer than that under the normal condition. Subject 4 showed the maximum value under both normal and nasal obstructed conditions. The values were 345.9 ± 173.0 msec under the normal condition and 535.4 ± 171.6 msec under the nasal obstructed condition, respectively. The minimum value under the normal condition was 205.1 ± 64.7 msec in subject 1, and that under the nasal obstructed condition was 294.4 ± 155.7 msec in subject 2. There was a significant difference between the interval time under the
Table 4. Coefficient of variation in normal and nasal obstructed conditions.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Normal condition (%)</th>
<th>Nasal obstructed condition (%)</th>
<th>Normal condition (%)</th>
<th>Nasal obstructed condition (%)</th>
<th>Normal condition (%)</th>
<th>Nasal obstructed condition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11.0</td>
<td>17.5</td>
<td>15.4</td>
<td>21.4</td>
<td>31.6</td>
<td>39.1</td>
</tr>
<tr>
<td>2</td>
<td>24.2</td>
<td>27.8</td>
<td>16.8</td>
<td>22.4</td>
<td>53.2</td>
<td>52.9</td>
</tr>
<tr>
<td>3</td>
<td>12.0</td>
<td>15.9</td>
<td>18.4</td>
<td>14.6</td>
<td>22.1</td>
<td>32.8</td>
</tr>
<tr>
<td>4</td>
<td>20.6</td>
<td>47.1</td>
<td>18.9</td>
<td>25.0</td>
<td>50.0</td>
<td>88.4</td>
</tr>
<tr>
<td>5</td>
<td>17.3</td>
<td>17.5</td>
<td>17.9</td>
<td>16.9</td>
<td>48.8</td>
<td>50.1</td>
</tr>
</tbody>
</table>

normal and the nasal obstructed conditions.

Table 4 shows the coefficient of variation in the chewing cycle time, the burst duration time and the interval time. Most of the coefficient of variation under the nasal obstructed condition increased compared with the control condition. In the burst duration time in subjects 3 and 5, and that of the interval time in subject 2, the coefficient of variation decreased slightly compared with the control condition.

Discussion

Earlier studies have shown that the chewing time is affected by various factors. Several investigators have reported that the water content of food bolus and the salivary flow rate serve as important factors for the determination of the chewing time (Watanabe et al., 1993; Ohnishi et al., 1994; Shiozawa et al., 1995). Watanabe et al. (1993b) and Ohnishi et al. (1994) reported that the water content of food bolus at the time just before swallowing is fairly constant in the same subject.

In this study, it was revealed that the chewing time under the nasal obstructed condition was significantly prolonged as compared to the control condition (Table 1). In contrast, there was no significant difference in the water content of food bolus and the volume of saliva secreted during mastication of peanuts between the control and the nasal obstructed conditions (Tables 2 and 3). These results indicate that the water content of food bolus serves as an important factor for the determination of the chewing time even under the nasal obstructed condition.

It is natural that the water content of food bolus is the total amount of the water content of peanuts itself and the saliva secreted during mastication. As mentioned above, the water content of food bolus and the volume of saliva during mastication under the nasal obstructed condition are almost the same as those in under the control condition. These results indicate that the flow rate of saliva during mastication is decreased under the nasal obstructed condition. Therefore, it is concluded that the prolongation of chewing time under the nasal obstructed condition may possibly be attributed to a compensatory action for getting the equivalent water content of food bolus under the control condition.

Electromyographical studies indicate clearly that the chewing cycle time consists of two components; the burst discharge time and the interval time (Amano et al., 1989). In our results, the chewing cycle time under the nasal obstructed condition tended to be longer than that under the control condition (Figs. 1 and 2). Moreover, there was no significant difference in the burst discharge time under the nasal obstructed and the control conditions (Fig. 3), whereas the interval time was significantly prolonged under the nasal obstructed condition (Fig. 4). These results indicate that if the same number of chewing strokes occur under both
conditions, the prolongation of chewing time under the nasal obstructed condition is mainly due to a prolongation of the interval time. According to Shiere and Manly (1952), the chewing time is also determined by the number of chewing strokes. To better understand the prolongation of the chewing time under the nasal obstructed condition, it is necessary to investigate further the chewing strokes under the nasal obstructed condition.

It is well established that the masticatory movements occur regularly (Nakaya et al.; 1997). Thus, several investigators applied this masticatory rhythm to the diagnosis of the temporomandibular joint dysfunction (Hirai et al., 1985). On the other hand, it is generally accepted that the coefficient of variation is one index for the regularity of a given phenomenon (Alvarado et al.; 1989). In our results, values of the coefficient of variation on the chewing cycle time, the burst discharge time and the interval time under the nasal obstructed condition are markedly increased compared to those under the normal condition (Table 4). These results indicate that the regularity of chewing rhythm will decrease under the nasal obstructed condition.

As mentioned above, our results revealed that the interval time is significantly prolonged under the nasal obstructed condition. Under the nasal obstructed condition the nose breathing will be transformed into the mouth breathing. It is speculated that the masticatory movements are stopped transiently, in order to have breathing spells under the nasal obstructed condition. Therefore, it is considered that the mouth breathing may be performed during a prolonged interval time under the nasal obstructed condition. Further investigations on the relationship between mastication and respiration are required.

**Conclusion**

The present study was undertaken to examine how the masticatory function is affected by the acute nasal obstruction and obtained the following results. 1. The chewing time under nasal obstructed condition was significantly prolonged compared to the control condition. However, no significant differences were found in the water content of food bolus and the volume of saliva secreted during mastication between the control and the nasal obstructed conditions. 2. The chewing cycle time tended to be prolonged by nasal obstruction. 3. The interval time was significantly prolonged by nasal obstruction, while the burst discharge time was not significantly altered. These findings suggest chewing time under nasal obstruction is possibly attributed to a compensatory action for getting an equivalent water content of food bolus under normal conditions. In addition, mouth breathing may be performed during the prolonged interval time under the nasal obstructed condition.

**References**


抄録
本研究の目的は、食物咀嚼に対する鼻閉の影響を明らかにすることである。被験者の鼻腔をノーズクリップで閉鎖した状態を鼻閉とした。咀嚼に関する実験ではビーナッツを咀嚼させ、その時の咀嚼時間、嚥下時食塊水分量ならびに唾液分泌量を測定した。筋電図に関する実験ではビーナッツ咀嚼時の咀嚼周期、筋放電持続時間ならびに筋放電間隔を求めた。以上の結果は、同被験者の正常時と鼻閉時について比較した。鼻閉時の咀嚼時間は正常時に比べ有意に延長した。一方、嚥下時食塊水分量ならびに唾液分泌量には両条件下で有意差を認めなかった。咀嚼周期時間は鼻閉時で延長する傾向を示した。鼻閉時における筋放電持続時間は有意な変化を示さなかったが、筋放電間隔は有意に延長した。以上の結果は、嚥下時食塊水分量は鼻閉時でも正常時と同様に咀嚼時間を判定に重要である。したがって、鼻閉時の咀嚼時間の延長は嚥下時食塊水分量を正常時と同程度にするための代償作用と考えられる。また、鼻閉時では咀嚼運動を一時的に停止し、口呼吸をするために筋放電間隔が延長すると推察される。