Effectiveness of a Mouth Rinsing Function Test for Evaluating the Oral Function of Children

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Abstract

Aim: There has been an increase in consultations related to eating and oral function of children, such as not chewing food properly and swallow without chewing; however, there have been few studies about oral function evaluation. We have devised a mouth rinsing function test (MRFT) to evaluate the oral function of children by grading mouth rinsing function into five stages. We aimed to investigate the effectiveness of MRFT for evaluating the oral function of children and to investigate factors relating to the MRFT scores.

Methods: The participants were 182 children (age 3–6 years; 98 boys and 84 girls) attending nursery school, who underwent an oral examination and evaluation of MRFT and occlusal force. Data on growth history and eating behavior were collected from parents through a questionnaire.

Results: The MRFT score significantly correlated with age and if breastfeeding or bottle-feeding was stopped earlier. Children whose parents worried about their eating habits tended to have lower MRFT scores. There was no significant correlation with occlusal force or the thickness and length of the masseter.

Conclusions: MRFT is effective for evaluating the oral function of children because the MRFT score increases with age. The MRFT score is related to eating behavior; hence,
children with low MRFT scores should be supported appropriately. MRFT was not correlated with occlusal force or the thickness and length of the masseter muscle; therefore, it is necessary to examine the oral dexterity, using MRFT, when evaluating the oral function of children.

Keywords: oral function, mouth rinsing, eating behavior, occlusal force, masseter muscle
1. Introduction

During childhood, eating behaviors are established through a variety of experiences with food. These behaviors can be affected by oral function, being overweight, and socioeconomic factors and can further affect the life of an individual [1,2]; therefore, it is important to establish desirable eating behavior in childhood. Recently, however, Japan has seen an increase in consultations regarding eating problems in children, such as picky eating, quick eating, and slow eating [3]. Problems of eating behavior can be related to oral function, such as not chewing or swallow without chewing. To address this problem of eating behavior in children, it is necessary for medical personnel and caregivers to focus on oral function, but as yet there is no simple evaluation of oral function in children.

Studies have reported oral function evaluations in adults and the elderly were based on the occlusal force [4-6], diadochokinesis [7], and color changeable gum tests [8]. In addition, Sumi et al. reported an oral function evaluation test based on gargling and related this to a range of factors, such as cognitive function, activities of daily living, and body mass index [9].

At our division, we have devised a mouth rinsing function test (MRFT) to evaluate oral function by grading mouth rinsing function into five steps. In this study, we assessed the
usefulness of MRFT for oral function evaluation and investigated the relationship between eating behavior and oral function evaluated using MRFT.

2. Materials and Methods

Ethical approval for this study was obtained from the Ethics Committee of Showa University School of Dentistry (Issue #2014-015 in 2014). This study protocol was in compliance with the Code of Ethics of the World Medical Association (Declaration of Helsinki). A written consent was obtained from parents as well as assent from the child participants themselves.

2.1 Study design

The study was cross-sectional in design. Data were obtained in February 2016.

2.2 Participants

The participants were children aged 3–6 years from four nursery schools in Kashima city, Ibaraki Prefecture, Japan. The school staff distributed 500 letters about this study to the respective parents and collected the completed consent forms; parents were invited to talk in person with the researchers if they had any questions. The response rate was 54.0%. Of the 270 children for whom a completed consent form was received, 23 were absent from the nursery school on the test day, questionnaires were unavailable for 11,
and 54 with an occlusal force below 100 N or whose tongue pressure could not be measured were excluded from the analysis (Fig. 1). Therefore, only 182 participants were included; 98 boys and 84 girls. None had any illness or a known medical history of orthopedic dysfunctions that could affect the tests.

2.3 Basic information

Data regarding the participants’ age, sex, height, weight, growth history, and eating behavior were collected from the parents via a written questionnaire. This included the following questions: “1) When your child eats, does he/she chew well?” and “2) Have you worried about his/her eating?” The second question was divided into four categories: a) oral function (e.g., not chewing well, letting food out of the mouth, or cramming); b) picky eating; c) eating behavior and manners (e.g., eating while playing, or slow eating); and d) willingness to eat (e.g., overeating or undereating). An oral examination was performed on each child beforehand and all the information was recorded on a data collection form.

2.4 The mouth rinsing function test

Oral function was evaluated using MRFT. Each child was examined in the sitting position in a school chair with the neck in anteflexion and was instructed to do the following actions, which were demonstrated for the child to imitate: a) Take water
(10 ml) from the cup into the mouth. b) Close the mouth, keeping the water in it. c) Move both cheeks symmetrically. d) Move the cheeks alternately. The child was observed and evaluated from taking in the water to spitting it out. MRFT was scored as follows (Table 1): 1, water cannot be taken into the mouth; 2, water can be taken into the mouth, but is swallowed or water spills out of the mouth; 3, water can be held in the mouth, but can only be rinsed around symmetrically; 4, water can be rinsed around asymmetrically, but it spills outside the mouth, or can it be rinsed around asymmetrically but slowly; 5, water can be asymmetrically rinsed around well. The children were divided into two groups according to their MRFT score: those with a score of 1–3 were defined as the “symmetry” group, and those with a score of 4–5 as the “asymmetry” group.

2.5 Thickness of the masseter muscle and fat mass

The thickness of masseter muscle and fat mass were measured using ultrasonography (Miru-Cube®, 6 MHz linear array transducer; Global Health Co, Tokyo, Japan) (Fig. 2). Ultrasound images taken at the right side of the masseter muscle were obtained using a real-time scanner. The child sat on a height-adjustable chair with the head upright. Prior to the scan, the child was asked to clench the jaw so that the examiner could palpate the origin to estimate the thickest part of the masseter [10]. The evaluation criteria were
calibrated to account for inter-investigator differences. The muscles were measured when both relaxed and when contracted.

2.6 Length of the masseter muscle

The length of masseter muscle was measured by linear measurement of the skin surface using a ruler (which is not dangerous even when placed on the skin). The child sat on a chair with the head upright. After palpation of the masseter muscle and zygomatic arch, the distance from the zygomatic arch lower edge to mandible angle was measured perpendicular to the mandible lower edge [11,12].

2.7 Occlusal force and tongue pressure

The maximum occlusal force was measured using a pressure-sensitive film (Dental Prescale® 50H SS or S size, FUJIFILM, Tokyo, Japan). The occlusal force was analyzed using the Occluzer® (GC, Tokyo, Japan) [13]. Tongue pressure was measured using a tongue pressure measurement device® (JMS Co. Ltd., Hiroshima, Japan) [14,15].

2.8 Statistical analysis

The data were analyzed using the SPSS Statistics (version 22.0, IBM Japan, Tokyo, Japan). Correlations were tested using Spearman’s rank correlation coefficients, and comparisons between groups were done using the Mann–Whitney U-test and Pearson’s chi-square test. A P value <0.05 was considered to be statistically significant.
3. Results

3.1 Excluded children

Table 2 shows the excluded children. A total of 54 children (median age, 48.5 months; range, 41.8–59.3 months) were excluded. The proportion of young children was high: 24 children were 3 years old, 16 were 4 years, 12 were 5 years, and 2 were 6 years. Among them, 28 children had occlusal force less than 100 N, and we were unable to measure tongue pressure in 18 children due to the following: a) introduction was not well understood, b) rejection, c) could not properly use the instrument with their tongue. Moreover, 8 children had occlusal force below 100 N, and their tongue pressure could not be measured. (Table 2)

3.2 Characteristics of the children

In total, 182 nursery school children were included in the analysis, 98 boys and 84 girls, with a median age of 65 months (range, 52–73 months) (Table 3). Table 4 presents the mean measures according to age; the older children were taller and heavier. The mean height and body weight of these children were almost the same as those for all Japanese children of the same age [16]. This was an average group in terms of general development.
3.3 Questionnaire data

The median age at which the children stopped breastfeeding or bottle-feeding was 14 months (range, 12–18 months), similar to that for the whole of Japan (estimates of the median, 12–15 months) [17]. When questioned about eating behavior, 160 parents (88%) answered “Yes” to the question “When your child eats, does he/she chew well?” and 97 (53%) answered “Yes” to the question “Have you worried about his or her eating?” Of the parents who answered “Yes” to the second question, 15 included oral function among their worries (Table 3).

3.4 Mouth rinsing function test

Figure 3 shows the median and age range for each MRFT score: score 3, median 45 months (range, 41-54 months); score 4, median 57 months (range, 51-69 months); and score 5, median 71 months (range, 64-76 months). The 90 percentile age was 65 months for score 3, 78 months for score 4, and 79 months for score 5. Older children had significantly higher MRFT scores ($p < 0.01$). Two children (aged 70 and 81 months) with MRFT score 3 and one child (age 41 months) with score 5 were considered to be outliers (Fig. 3).

3.5 Masseter muscle and occlusal force

Table 4 presents the mean values at each age for maximum occlusal force, thickness
fat mass, thickness of masseter muscle (at rest and in contraction), and the length of the masseter muscle. The maximum occlusal force tended to increase with age; however, the correlation was not statistically significant (Table 5). No difference related to age was found in the thickness of masseter fat and muscle; however, the mean length of the masseter muscle increased with age ($p < 0.01$) (Table 4, Fig. 4).

3.6 Relationships between MRFT scores and other factors

Table 45 presents the correlation coefficients for relationships between MRFT scores and other factors. There was a significant correlation between the MRFT score and age ($p < 0.01$), and a significant negative correlation between the MRFT score and the age when breastfeeding or bottle-feeding was stopped ($p < 0.05$). The MRFT score was not significantly correlated with occlusal force or the thickness of the masseter muscle; however, there was a significant correlation between the MRFT score and the length of masseter muscle, but no significant correlation when controlled for age (Table 5).

3.7 Comparison of the “symmetry” and “asymmetry” groups

The “symmetry” group included the children with MRFT scores 1–3 ($n = 30$; median age 45.5 (41.8–53.5) months) and the “asymmetry” group included those with scores 4–5 ($n = 152$; median age 69.0 (55.0–74.0) months). The “asymmetry” group was significantly older ($p < 0.01$). In addition, more parents of “symmetry” group children
than “asymmetry” group children answered “No” to the question “When your child eats, does he/she chew well?” ($p < 0.05$). Furthermore, a greater number of the “symmetry” group children had problems with oral function. (Table 6)

4. Discussion

4.1 Oral function of the children

Recently, various methods have been used for evaluating the oral function of children, such as those involving gummy jellies [18,19] or occlusal force [13,20,21]; however, these methods were costly and it was not easy to source the food and equipment. Furthermore, using food in the evaluation runs the risk of triggering allergies and may not be agreed by the children’s parents. In contrast, evaluation using mouth rinsing is simple, safe, and low cost, but few studies have reported using this for the oral function evaluation of children. For this reason, we devised MRFT at our division for evaluating the oral function of children, and in this study we examined whether it was effective for this purpose.

The movement of mouth rinsing requires the perioral muscles (including the buccinator and orbicularis oris muscles) to inflate the cheeks [22,23] and oral dexterity to move the mouth asymmetrically [24]. It was presumed that all of this could be
evaluated by MRFT. A previous study reported that mouth rinsing related to the ability to imitate [25]. In this study, we investigated the relationship between MRFT and occlusal force, which has previously been used in oral function evaluation. We also investigated the relationship between MRFT and eating behavior through the use of a questionnaire.

4.2 Effectiveness of MRFT for evaluating oral function

The participants in this study were of normal development and of similar height and body weight compared with the Japanese average.

The purpose of this study was to investigate the usefulness of the MRFT oral function evaluation. Therefore, it was necessary to examine the MRFT scores in children who can understand the directions and cooperate. For the occlusal force measurement, we considered that excessively small occlusal force results (<100 N) may have happened by an error, such as double bite. Moreover, for children in whom we were unable to measure tongue pressure, this may have been caused by rejection, not understanding directions, or not being well used by the instrument with their tongue; we intend to study tongue pressure separately. In this study, we consider that these children may not understand the instructions or may not cooperate. Therefore, we excluded children who had an occlusal force below 100 N or in whom we were unable to measure tongue pressure.
pressure. Hence, we consider that the results of this study may be used as standards for the oral function evaluation of children.

In this study, the MRFT score correlated significantly with age. Yamane et al. [26] reported that 90% of children can voluntarily inflate both cheeks by 3 years 3 months and inflate the cheeks alternately left and right by 5 years 9 months. Inflating both cheeks was equivalent to the MRFT score 3 in our study, and voluntarily inflating the cheeks alternately left and right was equivalent to MRFT scores 4–5. In the present study, the median of age of the children according to MRFT score was 45 months (3 years 9 months) for score 3, 57 months (4 years 9 months) for score 4, and 71 months (5 years 11 months) for score 5, increasing with age in the same way as in the report of Yamane et al; however, it was considered that the 90 percentile age in that study were lower than those in the present study, perhaps because MRFT becomes more difficult with the requirement to hold water in the mouth. We suggest that MRFT is useful for the evaluation of the oral function of children, because the MRFT score increases with age.

In this study, one child had high score and two children had a low score for their age. These scores did not seem to be related to any survey items, such as age, stop breastfeeding or bottle-feeding and eating behavior for the three children. We would like to use MRFT not only for the evaluation of oral function in individuals but also as a
4.3 Relationship between the MRFT score and eating behavior

In this study, the children who stopped breastfeeding or bottle-feeding at an earlier age tended to have higher MRFT scores. However, the correlation coefficient showed a very weak correlation (r = 0.168) in this study. Therefore, it is necessary to investigate other groups or increase the number of study participants.

Compared with the “asymmetry” group children (the children with higher MRFT scores), significantly more parents of the “symmetry” group children responded that their child was not chewing well or that they were worried about their child’s eating habits. Masticatory movement is complex, involving a plurality of organs such as the tongue, cheek, and lips moving in cooperation, and requiring asymmetrical movement of the mouth [27-29]. Children with low MRFT scores were less able to move their mouths asymmetrically, and this may affect their masticatory movement. This might explain why children who had a problem with eating according to the questionnaire response had low MRFT scores. Therefore, it is suggested that the MRFT score is related to eating behavior based on oral function. Encouraging children since an early screening test for the wider population. Further investigation is required, such as observing daily meal practice, when a child’s MRFT score differs greatly from the mean for that age group.
age for the development of oral function by appropriately supporting them with low MRFT scores could help to solve the problem of eating behavior that has been increasing recently.

4.4 Relationship between the MRFT score and the other oral function

Several studies have reported that oral function and swallowing function of adult and elderly people declines with age, and is associated with a variety of factors such as sex, the number of remaining teeth, and the amount of saliva produced [4-6,9,30-33]. Moreover, it has also been reported that occlusal force decreases with aging through reductions in the amount of saliva, the remaining teeth, and the masseter muscle fibers [4,5,30]. Furthermore, reports suggest that the thickness of masseter muscle decreases with age after 60 years, and that this is related to occlusal force [5,6,31]. It has also been reported that chewing ability declines with aging, influenced by a reduction in the number of remaining teeth and by the use of dentures [32]. Furthermore, chewing ability is related to occlusal force [10] and diadochokinesis [7], which provide an indication of oral dexterity. This suggests that in adult and elderly people there is a relationship between muscle strength, the form of the masseter, and oral dexterity. The occlusal force is therefore measured and the other factors are predicted from this. Moreover, studies have reported that RSST and MWST were used as swallowing
function evaluation criteria [33], and there is a relationship between general condition and gargling in adults and the elderly [9].

In this study, we examined whether the MRFT score related to the development of occlusal force and the thickness and length of the masseter muscle in children. However, no children with problems with swallowing were included in our study to compare with healthy children. Therefore, we did not investigate the relationship between MRFT and swallowing function. We found that occlusal force tended to increase with age; however, this correlation was not statistically significant. The reason for this may be that occlusal has been closely and muscle strength has been increasing with age [13,34]. The thickness of the masseter muscle did not vary significantly with age. Previous studies have reported that the thickness of the masseter muscle increases with age 7-22 years [5,11,35], and that the length of the muscle was significantly correlated with age. As children became older, the masseter muscle lengthened. Thus, it is suggested that, with age, occlusal force tends to increase, the thickness of the masseter muscle remains constant, and the length of masseter muscle becomes longer.

It was suggested that the MRFT score is not related to occlusal force in children or to the thickness and length of the masseter muscle; however, as oral motor skill increases, the occlusal force tends to increase while the thickness of the masseter muscle remains
constant and the length of masseter muscle increases with age during childhood. Therefore, it is necessary to evaluate not only occlusal force but also oral motor skill, such as that evaluated by MRFT, when assessing the general oral function of children. A limitation of this study was that it was a cross-sectional study. Longitudinal studies are warranted in the future for more detailed effectiveness of MRFT. In addition, our study group contained only children. Therefore, we did not investigate chewing ability because of the many other investigation items and the increase of burden to the children. In the future, if these parameters can be added, the benefits of the MRFT tests to evaluate oral function may be more obvious.

4.5 Conclusions

The purpose of this study was to investigate the effectiveness of MRFT for oral function evaluation in children, and to investigate factors that relate to MRFT scores. The results suggest that MRFT is useful for the evaluation of oral function in children, because MRFT scores increase with age. MRFT scores may be related to eating behavior, because an increasing number of the parents of children with MRFT scores thought that their child had an eating behavior problem. Evaluating oral motor skill using MRFT in addition using occlusal force may be useful for the evaluation of oral function in children because MRFT scores were not related to occlusal force.
Conflicts of interest

The authors declare no conflict of interest.

Acknowledgement

We are very grateful to the children, parents, and staff in the nursery schools who participated and supported our survey. We also thank our colleagues of the division of hygiene and oral health, Showa University, Tokyo. This work was supported by JSPS KAKENHI Grant Number JP15K20649, JP16K11869.
Figure captions

Fig. 1 Flow diagram of participation

Fig. 2 Ultrasonography (Miru-Cube®)

Fig. 3 Age ranges associated with each mouth rinsing function test (MRFT) score. The vertical lines indicate median values, the boxes the 25–75 percentiles, and the whiskers the overall range. The circles denote outliers.

Fig. 4 Thickness and length of the masseter muscle by age
References


500 participants were invited

230 No response

Response rate: 54.0%

270 parents accepted
Asked to complete the questionnaire

23 children absent at time of testing

247 participated in the measurement

Survey items

- Mouth Rinsing Function Test (MRFT)
- Thickness and length of the masseter muscle (Miru-cube®)
- Occlusal Force (DENTAL PRESCALE®)
- Tongue pressure (JMS tongue pressure measurement device®)

11 No questionnaire received

54 participants were excluded
(Occlusal force <100 N or tongue pressure unmeasurable)

182 Provided complete data

Fig.1
a. Miru-Cube® & PC for image processing

b. Measurement point

c. Ultrasonography image
   in the clinical condition of rest

d. Ultrasonography image
   in the clinical condition of maximal voluntary contraction

※The image is of an adult volunteer.
Table 1 The mouth rinsing function test

<table>
<thead>
<tr>
<th>Score</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water cannot be held in the mouth.</td>
</tr>
<tr>
<td>2</td>
<td>Water can be held in the mouth, but it is swallowed or spilled outside the mouth.</td>
</tr>
<tr>
<td>3</td>
<td>Water can be held in the mouth without swallowing or spilling. Water can be rinsed around symmetrically.</td>
</tr>
<tr>
<td>4</td>
<td>Water can be rinsed around asymmetrically but is spilled outside of the mouth. Water can be rinsed around asymmetrically but slowly.</td>
</tr>
<tr>
<td>5</td>
<td>Water can be rinsed around asymmetrically well.</td>
</tr>
</tbody>
</table>

Method
a) Take the water (10 ml) from the cup into the mouth.
b) Close the mouth and retain the water.
c) Move both cheeks symmetrically.
d) Move the cheeks alternately.
Table 2 Excluded Children

<table>
<thead>
<tr>
<th>Excluded Children (n)</th>
<th>3years</th>
<th>4years</th>
<th>5years</th>
<th>6years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>24 (44%)</td>
<td>16 (30%)</td>
<td>12 (22%)</td>
<td>2 (4%)</td>
<td>54 (100%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exclusion reason (n)</th>
<th>3years</th>
<th>4years</th>
<th>5years</th>
<th>6years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occlusal force &lt;100N</td>
<td>17</td>
<td>9</td>
<td>9</td>
<td>1</td>
<td>36</td>
</tr>
<tr>
<td>Tongue pressure could not be measured</td>
<td>11</td>
<td>11</td>
<td>3</td>
<td>1</td>
<td>26</td>
</tr>
<tr>
<td>a) Introduction was not well understood</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>b) Rejection</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>c) Could not properly use the instrument with their tongue</td>
<td>6</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>19</td>
</tr>
</tbody>
</table>
### Table 3 Questionnaire data

<table>
<thead>
<tr>
<th>Basic information</th>
<th>Median (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (month)</td>
<td>65 (52–73)</td>
</tr>
<tr>
<td>Sex (M:F)</td>
<td>98:84</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>108.0 (100.6–113.0)</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>18.0 (16.0–20.1)</td>
</tr>
<tr>
<td>Stop breastfeeding or bottle-feeding (month)</td>
<td>14 (12–18)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Eating behavior</th>
<th>Number (rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When your child eats, does he/she chew well? (Yes:No)</td>
<td>160 (88%):22 (12%)</td>
</tr>
<tr>
<td>Have you worried about his or her eating? (Yes:No)</td>
<td>97 (53%):85 (47%)</td>
</tr>
<tr>
<td>Categories</td>
<td>Rate</td>
</tr>
<tr>
<td>a) Oral function</td>
<td>15 (13%)</td>
</tr>
<tr>
<td>b) Picky eating</td>
<td>57 (50%)</td>
</tr>
<tr>
<td>c) Eating behavior and manners</td>
<td>30 (26%)</td>
</tr>
<tr>
<td>d) Willingness</td>
<td>13 (11%)</td>
</tr>
</tbody>
</table>

n = 182
Table 4 Mean measurements for each age

<table>
<thead>
<tr>
<th>Measurement</th>
<th>3 years (n = 31)</th>
<th>4 years (n = 44)</th>
<th>5 years (n = 49)</th>
<th>6 years (n = 58)</th>
<th>Total (n = 182)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>95.1 ± 3.4</td>
<td>103.2 ± 5.0</td>
<td>108.8 ± 4.4</td>
<td>114.2 ± 4.0</td>
<td>106.8 ± 7.9</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>14.3 ± 1.4</td>
<td>16.7 ± 1.9</td>
<td>18.6 ± 2.5</td>
<td>20.6 ± 2.6</td>
<td>18.0 ± 3.1</td>
</tr>
<tr>
<td>Maximum occlusal force (N)</td>
<td>191.7 ± 63.1</td>
<td>221.1 ± 88.4</td>
<td>220.7 ± 95.0</td>
<td>232.7 ± 98.6</td>
<td>219.7 ± 90.3</td>
</tr>
<tr>
<td>Thickness of masseter fat (mm)</td>
<td>6.1 ± 1.2</td>
<td>5.6 ± 1.1</td>
<td>5.4 ± 1.2</td>
<td>5.6 ± 0.9</td>
<td>5.6 ± 1.1</td>
</tr>
<tr>
<td>Thickness of masseter muscle (rest) (mm)</td>
<td>9.4 ± 1.5</td>
<td>9.7 ± 1.8</td>
<td>9.9 ± 2.0</td>
<td>9.7 ± 2.1</td>
<td>9.7 ± 1.9</td>
</tr>
<tr>
<td>Thickness of masseter muscle (contraction) (mm)</td>
<td>11.5 ± 1.6</td>
<td>12.0 ± 1.7</td>
<td>12.3 ± 2.4</td>
<td>12.2 ± 2.5</td>
<td>12.1 ± 2.2</td>
</tr>
<tr>
<td>Length of masseter muscle (cm)</td>
<td>4.6 ± 0.5</td>
<td>4.6 ± 0.4</td>
<td>5.1 ± 0.4</td>
<td>5.2 ± 0.4</td>
<td>4.9 ± 0.5</td>
</tr>
<tr>
<td>Age of stopping breastfeeding or bottle-feeding (month)</td>
<td>17.5 ± 8.5</td>
<td>17.1 ± 8.5</td>
<td>16.1 ± 8.0</td>
<td>14.9 ± 6.0</td>
<td>16.2 ± 7.7</td>
</tr>
</tbody>
</table>

(mean ± SD)
Fig. 3

- **MRFT score**

- 71 m (5 y 11 m) with a total of 88 participants
- 57 m (4 y 9 m) with a total of 64 participants
- 45 m (3 y 9 m) with a total of 29 participants
- 47 m (3 y 11 m) with a total of 1 participant

**Total = 182**
Fig. 4

Thickness of the masseter muscle (rest) (mm)

Length of the masseter muscle (cm)

$r = 0.519$

$n = 182$
Table 5 The results of correlation

<table>
<thead>
<tr>
<th></th>
<th>Age (month)</th>
<th>MRFT</th>
<th>Maximum Occlusal Force (N)</th>
<th>Thickness of masseter fat (mm)</th>
<th>Thickness of masseter muscle (rest) (mm)</th>
<th>Thickness of masseter muscle (contraction) (mm)</th>
<th>Length of masseter muscle (cm)</th>
<th>Stop breastfeeding or bottle-feeding (month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (month)</td>
<td>-</td>
<td>0.576**</td>
<td>0.143</td>
<td>-0.140</td>
<td>0.050</td>
<td>0.097</td>
<td>0.519**</td>
<td>-0.144</td>
</tr>
<tr>
<td>MRFT</td>
<td>-</td>
<td>0.130</td>
<td>-0.109</td>
<td>0.048</td>
<td>0.125</td>
<td>0.276**</td>
<td>-0.168*</td>
<td>-0.144</td>
</tr>
<tr>
<td>Maximum occlusal force (N)</td>
<td>-</td>
<td>-0.002</td>
<td>0.061</td>
<td>0.136</td>
<td>0.186*</td>
<td>-0.144</td>
<td>-0.144</td>
<td></td>
</tr>
<tr>
<td>Thickness of masseter fat (mm)</td>
<td>-</td>
<td>-0.186*</td>
<td>-0.163*</td>
<td>-0.115</td>
<td>-0.075</td>
<td>-0.144</td>
<td>-0.144</td>
<td></td>
</tr>
<tr>
<td>Thickness of masseter muscle (rest) (mm)</td>
<td>-</td>
<td>0.794**</td>
<td>0.098</td>
<td>0.029</td>
<td></td>
<td>-0.043</td>
<td>-0.043</td>
<td></td>
</tr>
<tr>
<td>Thickness of masseter muscle (contraction) (mm)</td>
<td>-</td>
<td></td>
<td></td>
<td>0.121</td>
<td></td>
<td>-0.490</td>
<td>-0.490</td>
<td></td>
</tr>
<tr>
<td>Length of masseter muscle (cm)</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of stopping breastfeeding or bottle-feeding (month)</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p < 0.01 *p < 0.05; MRFT, mouth rinsing function test

Spearman’s correlation coefficient n = 182
Table 6 Comparison of the “symmetry” and “asymmetry” groups

6-a. Age ranges associated with “symmetry” and “asymmetry”

<table>
<thead>
<tr>
<th></th>
<th>Median (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>symmetry</td>
<td>45.5 months (41.8-53.5)</td>
</tr>
<tr>
<td>asymmetry</td>
<td>69.0 months (55.0-74.0)</td>
</tr>
</tbody>
</table>

n=182
Mann-Whitney U-test **: p<0.01

6-b. When your child eats, does he/she chew well?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>symmetry</td>
<td>23</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>asymmetry</td>
<td>137</td>
<td>15</td>
<td>152</td>
</tr>
</tbody>
</table>

Total 160 (88%) 22 (12%) 182 (100%)

Pearson’s chi-square test *: p<0.05

6-c. Have you worried about his/her eating?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No or others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Oral function</td>
<td>5</td>
<td>25 (83%)</td>
<td>30</td>
</tr>
<tr>
<td>symmetry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>asymmetry</td>
<td>10</td>
<td>142 (93%)</td>
<td>152</td>
</tr>
</tbody>
</table>

Total 15 (8%) 167 (92%) 182 (100%)

not significantly
Pearson’s chi-square test