ORIGINAL ARTICLE

Evaluation of the Masticatory Part and the Habitual Chewing Side by Wax Cube and Bite Force Measuring System (Dental Prescale®)

Mutsumi Takahashi, DDS, Fumi Takahashi, DDS, PhD, and Osami Morita, DDS, PhD

Department of Complete Denture, The Nippon Dental University School of Life Dentistry at Niigata, Japan

Clinical significance

The results of this study suggest that the determination of the masticatory part by clenching the test food and the evaluation of the occlusal contact area, occlusal force, and the center of the occlusal balance by Dental Prescale were useful to determine the habitual chewing side.

Abstract

Purpose: This study evaluated the masticatory side as well as which side was the habitual chewing side by the use of wax cubes and a bite force measuring system in normal dentate subjects (ND) and complete denture wearers (CD).

Methods: Forty two ND subjects (29 males, 13 females; mean age, 24.8 ± 2.4 years), and 11 CD subjects (4 males, 7 females; mean age, 72.8 ± 7.0 years) participated in the study. The test food used in this study was wax cubes to determine the masticatory side. The difference in the occlusal contact area and occlusal force between the masticatory side and the opposite side was investigated using Dental Prescale®. ND was classified into 2 groups: those whose agreement on the masticatory part was high (ND-H) or low (ND-L). The distribution of the center of the occlusal balance was analyzed by Dental Prescale® in ND-H, ND-L, and CD.

Results: The occlusal contact area and occlusal force of the masticatory side was greater than the opposite one, and the center of the occlusal balance was wide in ND-H. In ND-L and CD, the occlusal contact area and occlusal force did not differ between the masticatory side and the opposite one, and the center of the occlusal balance developed a tendency to gather in the center.

Conclusion: The results of this study suggested that the evaluation of the masticatory side and the use of Dental Prescale were helpful in determining the habitual chewing side.

Key words: masticatory part, habitual chewing side,

bite force measuring system, wax cube

Introduction

Mastication is a series of the process of chewing food for swallowing and digestion. There have been many methods to examine the functions of ingestion, crunching, comminution, mixing, formation of bolus, and swallowing.

There are two types of methods to examine the ability of mastication. One of the methods to examine the ability of mastication is to masticate a test food directly. The test food differs according to the type of ability of mastication that would be evaluated. Regarding the ability of comminution, the test foods include peanuts, raw rice etc.^{1–4} Concerning the ability of mixing, the test foods include chewing gum, gummy jelly etc.^{5–10} Also, the test food included a temporary stopping to evaluate the relationship between the occlusal contact area and the main occluding area.^{11–13} Other methods examined the ability of mastication from other factors involved, such as muscle activity during mastication, jaw movement, food intake questionnaire method, occlusal contact area, and occlusal force. A pressure sensitive film, inspection of gnathic function, etc have also been used to examine the ability of mastication.^{2, 14–20}

It has been reported that the ability of mastication is influenced by the intraoral environment as well as other physiological alterations such as the growth process. The habit to masticate at more useful side to crunch is developed through repeated adaptation.²¹ There have been various studies that reported the relating factors to the habitual chewing side, that is, the habitual chewing side was related to the path of masticatory movement, masticatory rhythm, occlusion, and the dominant hand.^{22–30}

In general, the method to investigate the habitual chewing side is through a medical interview,^{31–33} however, there are some cases when the subjects

Corresponding to: Dr Mutsumi Takahashi
Department of Complete Denture, The Nippon Dental University School of Life Dentistry at Niigata
1-8 Hamaura-cho, Chuo-ku, Niigata 951-8580, Japan
Tel: +81-25-267-1500, Fax: +81-25-267-8906
E-mail: mutsumit@ngt.ndu.ac.jp

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cannot recognize the chewing side. In these cases, there are some methods to evaluate the chewing side objectively and easily in clinic, using a cotton roll,^{28,33,34} wax,³⁵⁻⁴¹ and temporary stopping.¹¹⁻¹³ The part that these test foods were clenched was defined as the masticatory part, and the side of the masticatory part was decided to be the habitual chewing side. However, the condition of the test food such as the size or the hardness to decide the masticatory side in normal dentate subjects and complete denture wearers has not been investigated.

The aim of this study was to investigate the influence of the temperature conditions or the size of the wax cube as the test food to determine the masticatory part. Additionally, the relations among the masticatory part, the habitual chewing side, and occlusion was investigated using a bite force measuring system.

Materials and Methods

1. Experiment 1

1) Subjects

The subjects of this study were 12 healthy adults (6 males, 6 females; mean age, 26.5 ± 2.5 years), who had normal occlusion. The study was performed with the approval of the ethics committee of The Nippon Dental University School of Life Dentistry at Niigata (#119), and informed consent was obtained from all of the subjects before the start of the study.

2) Determining the masticatory part and method of analysis

In this study, we used a wax cube (Inoue Attachment, Co., Tokyo, Japan) as the test food to evaluate the masticatory part. The size of the test food was a 3.5-mm cube (about 0.04 g) and a 5.0-mm cube (about 0.10 g), and the temperature conditions were 16, 26, and 36°C.

To investigate the masticatory part, the wax cube was positioned on the center of the tongue. Subsequently, the subjects were instructed to clench the test food in 1 stroke where the subjects felt the easiest to clench the wax cube. The test was repeated 3 times on each size and each temperature condition. The clenched test food was fitted into a plaster cast that was prepared before the test (Fig. 1). The masticatory part was determined with a plaster cast with the conformed test food.

Fig. 1 a: The test food positioned on the tongue, b: Clenching the test food in 1 stroke, c: Clenched test food fitted into a plaster cast.

Then, the number of times that each subject clenched the test food at the same cusp and same marginal ridge was counted, and used for analysis. The part that the subject clenched the test food most was decided as the masticatory part. The difference in the number of agreements of the masticatory part according to the temperature conditions was analyzed by the Kruskal-Wallis test.

2. Experiment 2

1) Subjects

The subjects were 42 healthy adults (29 males, 13 females; mean age, 24.8 ± 2.4 years), who had normal occlusion (ND), and 11 healthy adults (4 males, 7 females; mean age, 72.8 ± 7.0 years), and who visited Niigata Hospital and wore complete dentures with no detriment (CD). The study was performed with the approval of the ethics committee of The Nippon Dental University School of Life Dentistry at Niigata (#119), and informed consent was obtained from all of the subjects before the start of the study.

2) Determination of the masticatory part and method of analysis

In experiment 2, we also used wax cubes as the test food. The size of the test cube was 3.5 mm and 5.0 mm in ND, and 3.5 mm, 5.0 mm, and 8.0 mm (about 0.22 g) in CD (Fig. 2), at room temperature.

The subjects clenched the test food in 1 stroke where the subjects felt the easiest to clench the cube. The test was repeated 5 times in ND, and 3 times in CD. The clenched test food was fitted into a plaster cast that was previously prepared. The masticatory part was determined with a plaster cast with the conformed test food. Then, the number of times that each subject clenched the test food

Fig. 2 Wax cubes.

at the same cusp and same marginal ridge was counted, and used for analysis. The part that the subject clenched the test food most was decided as the masticatory part. The difference in the number of agreements of the masticatory part according to the size was analyzed by the Wilcoxon signed-ranks test and Kruskal-Wallis test.

3) Evaluation of the habitual chewing side

The habitual chewing side was determined according to the subjectivity of each subject that was found at the time of the medical interview before mastication. The rate of agreement between the habitual chewing side and the side containing the masticatory part was calculated.

4) Measurement of the occlusal contact area and occlusal force

The occlusal contact area and occlusal force were measured using pressure sensitive film (Dental Prescale® 50H-R type, Scimolex, Co., Yamanashi, Japan), and evaluated using an Occluzar® (Fuji Film, Co., Tokyo, Japan).

The subjects bit down on the Dental Prescale for 3 seconds with maximum occlusal force. The measurement was repeated 3 times, and the average of the occlusal contact area and occlusal force was used for analysis.

5) Relationship between the masticatory part, the occlusal contact area, and occlusal force

The ND subjects were divided into 2 groups. The total number of clenching times of the wax cube in this study was 10 times (2 conditions by 5 times). One group consisted of 22 subjects, who had the same masticatory part more than 8 times (ND-H). The other group consisted of 20 subjects, who had the same masticatory part less than 7 times (ND-L). The side that contained the masticatory part was determined as the masticatory side, and the

Fig. 3 The number of agreements of the masticatory part (comparison by the temperature conditions of the test food).

other side was determined as the opposite side. The total of either side was set at 100%, and the percentage of the occlusal contact area and occlusal force on the masticatory side and the opposite side was calculated. The difference of the occlusal contact area and occlusal force between the masticatory side and the opposite side was analyzed by the t-test.

In the same way, the difference of the occlusal contact area and occlusal force between the masticatory side and opposite side was analyzed by the Wilcoxon signed-ranks test and t-test in CD.

6) The distribution of the center of the occlusal balance

The distribution of the center of the occlusal balance was analyzed by the results of the Dental Prescale test in ND-H, ND-L, and CD. The differences of the distribution between ND-H and ND-L were analyzed by the Mann-Whitney's U test.

Results

1. Experiment 1

The average of the number of agreements of the masticatory part at the temperature conditions of the wax cubes of 16, 26, and 36°C was 4.33 ± 1.43 times, 4.25 ± 2.00 times, and 4.33 ± 1.54 times, respectively. There was no statistically significant difference among the three temperature conditions of the wax cubes (Fig. 3).

2. Experiment 2

1) Comparison by the size of the test food

The average of the number of agreements of the masticatory part at the size of the wax cubes of 3.5 mm and 5.0 mm in ND was 3.79 ± 1.00 times and 3.91 ± 1.02 times, respectively. There was no statistically significant difference between the sizes

Fig. 4 a: The number of agreements of the masticatory part [comparison by the size of the test food in normal dentate subjects (ND)], b: The number of agreements of the masticatory part [comparison by the size of the test food in complete denture wearers (CD)].

Fig. 5 a: The percentage of the occlusal contact area in normal dentate subjects who had high agreement regarding the masticatory part (ND-H), b: The percentage of the occlusal contact area in normal dentate subjects who had low agreement regarding the masticatory part (ND-L), c: The percentage of the occlusal contact area in complete denture wearers (CD).

of the test food (Fig. 4-a). Also the average of the number of agreements of the masticatory part at the size of the wax cubes of 3.5 mm, 5.0 mm, and 8.0 mm in CD was 1.55 ± 1.29 times, 1.82 ± 1.25 times, and 1.91 ± 1.04 times, respectively. There was no statistically significant difference among the three sizes of the wax cubes (Fig. 4-b).

2) The rate of agreement of the habitual chewing side and the masticatory side

The percentage of agreement upon the habitual chewing side and the masticatory side was 95.2% (40/42 subjects) in ND and 90.9% (10/11 subjects) in CD.

3) Comparison of the occlusal contact area and occlusal force on the masticatory side and opposite side

(1) The occlusal contact area

The results of the evaluation by the Dental Prescale test was that the percentage of the occlusal

contact area of the masticatory side was greater than the opposite one in ND-H ($p < 0.05$), the average of the percentage of the occlusal contact area of the masticatory side and the opposite one was $55.2 \pm 8.5\%$ and $44.8 \pm 8.6\%$, respectively (Fig. 5-a). The average of the percentage of the occlusal contact area of the masticatory side and the opposite one in ND-L was $51.0 \pm 7.0\%$ and $49.0 \pm 7.0\%$, respectively. There was no significant difference between the masticatory side and the opposite one (Fig. 5-b). Also, the average of the percentage of the occlusal contact area of the masticatory side and the opposite one in CD was $50.4 \pm 9.6\%$ and $49.6 \pm 9.7\%$, respectively. There was no significant difference between the masticatory side and the opposite one (Fig. 5-c).

(2) The occlusal force

The results of the evaluation by Dental Prescale was that the percentage of the occlusal force of the masticatory side was greater than the opposite one in ND-H ($p < 0.05$), the average of the percent-

Fig. 6 a: The percentage of the occlusal force in normal dentate subjects who had high agreement regarding the masticatory part (ND-H), b: The percentage of the occlusal force in normal dentate subjects who had low agreement regarding the masticatory part (ND-L), c: The percentage of the occlusal force in complete denture wearers (CD).

Fig. 7 a: The distribution of the center of the occlusal balance in normal dentate subjects who had high agreement regarding the masticatory part (ND-H), b: The distribution of the center of the occlusal balance in normal dentate subjects who had low agreement regarding the masticatory part (ND-L), c: The distribution of the center of the occlusal balance in complete denture wearers (CD).

age of the occlusal force of the masticatory side and the opposite one was $54.0 \pm 7.4\%$ and $46.0 \pm 7.2\%$, respectively (Fig. 6-a). The average of the percentage of the occlusal force of the masticatory side and the opposite one in ND-L was $50.7 \pm 6.8\%$ and $49.3 \pm 6.8\%$, respectively. There was no significant difference between the masticatory side and the opposite one (Fig. 6-b). Also, the average of the percentage of the occlusal force of the masticatory side and the opposite one in CD was $51.2 \pm 9.0\%$ and $48.8 \pm 9.0\%$, respectively. There was no significant difference between the masticatory side and the opposite one (Fig. 6-c).

4) The distribution of the center of the occlusal balance

The distribution of the center of the occlusal balance in ND-H, ND-L, and CD is shown in Fig. 7. The distribution of the center of the occlusal balance in ND-H was wider than ND-L in bilateral distribution ($p < 0.05$).

Discussion

1. The test food

In the present study, we selected wax cubes as the test food to evaluate the masticatory part. Kato et al.^{11,12} and Tokuda et al.¹³ used a temporary stopping for normal dentate subjects. However, the temporary stopping was too difficult to clench for complete denture wearers. Ichikawa et al.³⁷ used clearance wax (Syofu Inc., Kyoto, Japan) for complete denture wearers. The wax cube used in this study was made by mixing paraffin wax with Hi-Mic-1045 wax.^{35,36,38-41} It can be used widely for normal dentate subjects and complete denture wearers, because it does not stick to the teeth or dentures. The wax cube can be fabricated in any size and the temperature conditions can vary; therefore, the complete denture wearers probably clenched the wax cube easily. Therefore it can evaluate objective data in a short time, and the subjects were not burdened with this evaluation.

For these reasons, the wax cube was selected as the test food in this study.

In experiment 1, the proper temperature conditions of the test food to determine the masticatory part was investigated in normal dentate subjects. According to the results of questions to the subjects, the subjects could clench the test food the easiest at the temperature condition of 26°C. There was no relationship between the subjectivity of easily clenching and the determination of the masticatory part. This study suggested that the hardness of the test food did not influence the determination of the masticatory part, because there was no difference in the number of agreements of the masticatory part among the temperature conditions. Therefore, it was suggested that controlling the temperature conditions of the test food was not necessary.

2. The masticatory part

In experiment 2, the test was repeated 5 times in ND, and 3 times in CD, because the importance of one trial was large at the case of the comparison by 2 sizes of the test food on 3 trials in ND. The subjects clenched the test food with the size of 3.5 mm more easily than 5.0 mm in ND, but there was no relationship between the subjectivity of easily clenching and the determination of the masticatory part. On the other hand, the subjects felt that it was most difficult to clench the test food with the size of 3.5 mm in CD, and some of them clenched the test food using the anterior teeth or the test food fell from the occlusal surface. Therefore, it was suggested that the test food with the size of 3.5 mm was not suitable to determine the masticatory part in CD. According to the results of questions to the subjects, the subjects clenched the test food easily with the size of 5.0-mm and 8.0-mm cubes in CD, but there was no relationship between the subjectivity of easily clenching and determination of the masticatory part. These results suggested that the size of the test food did not influence the determination of the masticatory part.

3. Relationship between the subjectivity of the habitual chewing side and the masticatory side

Regarding the frequency of the subjectivity of the habitual chewing side, Ueda et al.⁴² reported that about half of the subjects were conscious of their habitual chewing side, and Kurachi et al.³¹ reported that about three-quarters of the subjects were conscious of their habitual chewing side, and this

was discovered at the medical interview. Ogimito et al.³³ compared the reliability of the subjectivity of the habitual chewing side before and after mastication, and the results suggested that the medical interview after mastication was more reliable and more detectable than the one before.

The habitual chewing side in this study was found at the time of the medical interview before mastication, and the rate of agreement with the masticatory side was 95.2% in ND and 90.9% in CD. These findings suggested that clenching the test food was a useful and easy method to determine the habitual chewing side.

4. The occlusal contact area and occlusal force

Concerning the evaluation of Dental Prescale, it was reported that the occlusal contact area and occlusal force at the habitual chewing side was greater than the opposite one.⁴³ In the present study, the number of agreements on the masticatory part was evaluated, and the ND were divided into ND-H and ND-L groups. CD was also examined. The occlusal contact area and occlusal force at the masticatory side was greater than the opposite one in ND-H, however, there were no differences in ND-L and CD. These results suggested that the subjects who did not have a regular masticatory part did not have a right or left difference regarding the occlusal contact area and occlusal force. And on the subjects who had a regular masticatory part, the occlusal contact area and occlusal force were greater than the opposite one.

5. The center of the occlusal balance

The center of the occlusal balance was calculated from the distribution of the occlusal contact area and occlusal force. In ND-H, the center of the occlusal balance tended to be toward the masticatory side. This finding was based on the idea that the chewing side would incline to the right or left, and the masticatory part could be easily decided in ND-H. On the other hand, the center of the occlusal balance converged toward the center in ND-L and CD. This finding indicated that it is difficult to determine whether the chewing side is on the right or left, and the masticatory part won't develop a tendency either way. Namely, these results suggested that there was a relationship among the number of agreements on the masticatory part, the center of the occlusal balance, the occlusal contact area, and occlusal force.

Conclusion

This study investigated the masticatory part and the habitual chewing side using a wax cube and Dental Prescale in normal dentate subjects and complete denture wearers, and the following conclusions were obtained:

1. The temperature conditions of the test food did not influence the determination of the masticatory part.
2. The size of the test food did not influence the determination of the masticatory part.
3. The percentage of agreement concerning the habitual chewing side and the masticatory part was 95.2% in normal dentate subjects and 90.9% in complete denture wearers.
4. The occlusal contact area and occlusal force of the masticatory side was greater than the opposite one in normal dentate subjects who had high agreement regarding the masticatory part ($p < 0.05$). The occlusal contact area and occlusal force did not differ between the masticatory side and the opposite one in normal dentate subjects who had low agreement concerning the masticatory part and complete denture wearers.
5. The center of the occlusal balance varied widely in normal dentate subjects who had high agreement regarding the masticatory part, and it converged toward the center in normal dentate subjects who had low agreement concerning the masticatory part and complete denture wearers.

In this study, it was suggested that the center of the occlusal balance was relevant to the habitual chewing side and the masticatory part. The determination of the masticatory part by clenching the test food and the evaluation of the occlusal contact area, occlusal force, and the center of the occlusal balance by Dental Prescale were useful to determine the habitual chewing side.

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