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Correlation Between a Simple Tool for Evaluating Masticatory Function Value with Masticatory Performance by Sieve Method and Masticatory Ability by Questionnaire Among Older Adults

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Abstract

Objectives: This study aimed to find the correlation between a simple tool for evaluating masti-catory function value with masticatory performance and masticatory ability among older adults and using masticatory function value for evaluating subjects with different mastication groups.

Methods: The sample was 100 older adults in the dental clinic of Lee Hospital, Lamphun, Thailand. The samples were interviewed with general information, dental examination, tooth number, and occlusal pair. The wax biting test was given to samples, compared with the masticatory performance by sieve method and the masticatory ability by questionnaire. Data were analyzed using descriptive and analytical statistics.

Results: A high positive correlation between a simple tool for evaluating masticatory function value with masticatory performance by sieve method (correlation coefficient=0.54) and masticatory ability by questionnaire (correlation coefficient=0.64). The difference in the number of teeth, Occlusal pairs, and Eichner index classification have different masticatory function values (p<0.05). The number of teeth, occlusal pair, and masticatory ability can predict masticatory function values (R=0.83; R2=0.68; F=68.12; p<0.05). Masticatory groups divided by masticatory function value are related to masticatory groups divided by masticatory performance. (Chi-Square=8.24, p<0.05)

Conclusions: The simple tool created for evaluating masticatory function value by wax biting test can used to measure masticatory function. It is a reliable tool, easy to use in the clinic, convenient, and not complicated. It can differentiate masticatory function values in people with different mastication.

Keywords: masticatory ability, masticatory function value, masticatory performance, oral hypofunction

Introduction

The aging process involves various degenerative changes across multiple systems. In the oral cavity, this manifests as a decline in function[1] known as oral hypofunction. This condition can lead to decreased food intake, resulting in inadequate nutrient intake which affects the digestive system and overall health, ultimately leading to malnutrition and declining quality of life. Diagnosis at an early stage, with appropriate treatment and care, can prevent the progression of oral dysfunction in older adults. Reduced masticatory function, a component of oral hypofunction, can be assessed using various methods. These include counting the number of occlusal pairs[2], measuring particle size, utilizing the sieve method[3] or colorimetric analysis[4], applying the mixing ability index[5] to evaluate masticatory performance, measuring bite force[6], and administering questionnaires to evaluate masticatory ability.[7] Each method requires specialized equipment, which can be complicated, time consuming, and expensive.[7] Consequently, these methods are often unsuitable for clinical use in rural areas. Given these limitations, we aimed to develop a simple method which can be applied in hospital or dental clinic settings. Previous studies have not evaluated masticatory function using the wax biting test, despite the fact that dental wax sheets are readily available at dental clinics, inexpensive, and easy to use for creating bite marks. Therefore, we are interested in developing this method for assessing masticatory function. In this study, we define the masticatory function value as the measurement of wax thickness resulting from biting in the maximum habitual intercuspation position.

This study aimed to examine the correlation between a simplified assessment tool for evaluating masticatory function and established measures of masticatory performance as determined by the sieve method. Self-reported masticatory ability was assessed through a standardized questionnaire among older adults. Additionally, this study sought to use masticatory function values to evaluate older adult participants across different mastication groups and classify masticatory groups based on masticatory function values.

Materials and Methods

The study sample comprised 100 older adults who attended the dental clinic at Lee Hospital in Lamphun, Thailand. The sample size was calculated using the formula: $n=\left[\frac{z_{\alpha}+z_{\beta}}{z}\right]+3$. Data were collected between October 2022 and September 2023. The inclusion criteria were: (i) age 60 years or older, (ii) at least one occlusal pair, (iii) occlusion stability (stable contact on all teeth with equal intensity in the centric relationship), and (iv) the ability to understand written and spoken Thai and respond to the point range used in questionnaires. The exclusion criteria were as follows: (i) systemic disease which could influence jaw movement, for example Parkinson's disease, (ii) symptomatic temporomandibular disorders (pain and effect on chewing ability), (iii) severe pain effect of mastication, for example toothache and trigeminal neuralgia, and (iv) hyposalivation. All participants provided written informed consent after receiving a full explanation of the study's objectives and procedures. The study protocol was independently reviewed and approved by the Ethics Committee of the Faculty of Dentistry, Chiang Mai University (No.18/2022).

The mean participant age was 66.19 years (range: 60-81; standard deviation: 4.66). All participants underwent a structured interview and a standardized oral examination which included the following components: 1. Counting the number of teeth and occlusal pairs, 2. Determining masticatory function values using the wax biting test, 3. Measuring masticatory performance using the sieve method, and 4. Evaluating masticatory ability by questionnaire.

Number of teeth and occlusal pairs

The functional remaining teeth, including dental prostheses, were counted. The number of occlusal pairs was clinically determined by counting the antagonist teeth in occlusion and categorizing them according to Eichner's index of tooth loss, with particular emphasis on the molars and premolars. The three classifications are Class A: four occlusal support zones; Class B: one to three occlusal support zones; and Class C: no occlusal support zones.[8] Figure 1 shows four occlusal pairs of antagonist teeth in occlusion.

Masticatory function values by the wax biting test

The masticatory function value was determined using a wax bite test. Pink dental wax sheets (CAVEX, Cavex Holland BV Co., the Netherlands) with dimensions of 60×90×1.5 mm were kept at 23±2°C. Participants were instructed to chew a 5 mm cotton between both jaws for

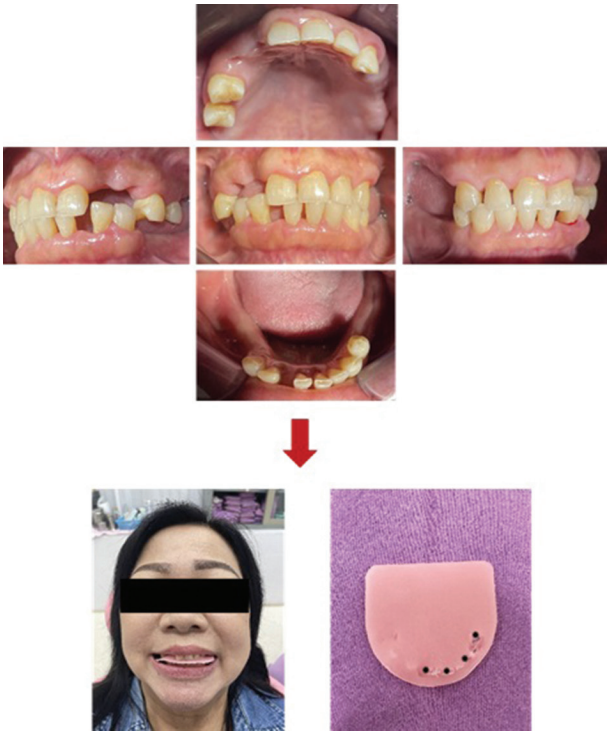

Figure 1: Wax biting test by a participant.

30 seconds to develop familiarity with the procedure, then bite each wax sheet using the habitual intercuspation bite pattern. The intercuspation bite patterns were replicated thrice to calculate the average change in wax thickness. Wax sheets were applied with the curved top facing upward to identify each occlusal pair. A dental wax gauge caliper was used to assess the thickness at the thinnest point of each occlusal pair, ensuring that the caliper was held perpendicular to the wax surface at the measurement point. The average thickness (C) was calculated from these values.

The change in wax thickness (D) can be calculated using the formula (Figure 2): $D = N - C$

Where: N = 1.5 mm (initial thickness of the wax sheet before biting)

C = Average thinnest thickness of the wax sheet at all occlusal points (mm)

Thus, the change in wax thickness (D) (mm) is: $D = 1.5 - C$

The change in wax thickness (D) was used to calculate the masticatory function value. The masticatory function value formula is based on the concepts of Hooke's law and Young's modulus, in which force (F) varies directly with displacement (x). The calculation of the chewing function was as follows:

Masticatory function value = Number of occlusal pairs (B) × Changed wax thickness (D)

The masticatory function value (Figure 1) calculated from the thickness of the wax sheets after biting on all three sheets, was then averaged to obtain the final result (Table 1).

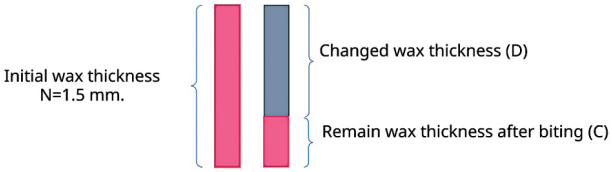

Figure 2: The calculation of the wax thickness change (D).

Masticatory performance by the sieve method[3]

Each participant chewed 3 g portions of fresh, whole carrot (1×2×0.5 mm) 30 times. After chewing, carrots were expectorated into a container. The expectorated carrot particles were poured onto stacked US Standard No. 5-mesh (0.157-inch openings) and No. 100-mesh (0.0059-inch openings) sieves. Approximately 250 ml of water was used to wash the carrot through each sieve. The portions of carrot remaining on the No. 5-mesh and No. 100-mesh sieves were transferred to Whatmann No.1 filter paper. Each filter paper was allowed to dry for 24 hours at room temperature. After drying, the filter papers were weighed.

Table 1: The calculation of the masticatory function value from participants.

Wax	(A) Thickness at the thinnest point of each occlusal pair (mm)	(B) Occlusal pair	(C) Average thickness	(D) Changed wax thickness (D=1.5 - C)	Masticatory function value (B X D)
No. 1	0.10, 0.10, 0.20, 0.00	4	0.10	1.40	5.60
No. 2	0.20, 0.10, 0.20, 0.10	4	0.15	1.35	5.40
No. 3	0.10, 0.20, 0.20, 0.10	4	0.15	1.35	5.40
Average masticatory function value of 3 sheets					5.47

Masticatory performance was calculated by dividing the weight of the carrot passing through the No.5 mesh sieve by the total weight of the separated feed (particles collected from the No.5 and No.100 mesh sieves), then multiplying this fraction by 100 and expressing it as a percentage.

Masticatory ability by questionnaire

Masticatory ability was measured using a food intake questionnaire consisting of 14 frequently consumed food items adapted from a previously validated study.[9] Participants were asked to rate their chewing ability for each food type on a 4 point scale, ranging from "could not chew at all" (0 points) to "could chew well" (3 points). The total score for the 14 food items, ranging from 0-42, was calculated as each participant's "perceived chewing ability score." Higher scores indicated better chewing ability.

Statistical analyses

Data analysis was conducted using SPSS Version 29.0 for Windows. The correlation between a simple tool for evaluating masticatory function value with masticatory performance by the sieve method, and masticatory ability by questionnaire was analyzed using the Pearson correlation coefficient. Different mastication groups were compared using an independent t-test. Logistic regression analysis was used to predict the masticatory function values. The relationships between masticatory groups divided by masticatory function value and those divided by masticatory performance were analyzed using the chi-squared test. A p-value of less than 0.05 was considered statistically significant.

Results

Of the participants, 41% had fewer than 20 teeth, and 59% had 20 or more teeth. The means and standard deviations of the numbers of residual teeth, occlusal pairs, and posterior occlusal pairs were 20.56±6.17, 8.10±3.91, and 3.56±2.72, respectively. In total, 57% of participants had fewer than 10 occlusal pairs, while 43% had 10 or more occlusal pairs. Notably, 93% of participants did not wear dentures (Table 2).

The distribution of participants according to Eichner's index of tooth loss was as follows: 74% in Group A, 26% in Group B, and 0% in Group C. The means and standard deviations for masticatory performance, masticatory ability, and the masticatory function value were 37.61±36.23, 27.46±8.40, and 7.55±3.94, respectively.

The intraclass reliability of the measurement was assessed using Cronbach's Alpha Coefficient (α), which yielded a value of α=0.97, indicating high reliability. The Pearson Product-Moment Correlation was employed, along with the test–retest reliability method, resulting in a coefficient of stability of 0.96, further demonstrating high reliability.

The results showed a strong positive correlation[10] between a simple tool for evaluating the masticatory function value with masticatory performance by the sieve method (correlation coefficient=0.54) and masticatory ability by questionnaire (correlation coefficient=0.64) (Table 3).

The difference in the number of teeth (groups with fewer than 20 teeth and groups with 20 or more teeth), occlusal pairs (groups with fewer than 10 occlusal pairs and groups with 10 or more occlusal pairs), and Eichner index classification were associated with significantly different masticatory function values (p<0.05) (Table 4). The results of the logistic regression analysis revealed that the number of teeth, occlusal pairs, and masticatory ability can predict masticatory function values (R=0.83; R2=0.68; F=68.13; p<0.05) (Table 5). Prediction of the masticatory function value was calculated by the following formula (Equation 1):

Masticatory function value
= -1.92+(0.15) number of teeth
+(0.50) occlusal pairs+(0.09) masticatory ability

There was a significant association between masticatory groups divided by masticatory function value and masticatory groups divided by masticatory performance (chi-square=8.24, p<0.05) (Table 6).

Discussion

In this study, a simple tool for evaluating the masticatory function value showed a strong positive correlation with masticatory performance as measured by the sieve method and masticatory ability as assessed by questionnaire, both of which are standard methods with high reliability in objective testing and subjective measurement.[11,12] The masticatory function value obtained through the wax biting test can be used to measure and differentiate masticatory function among participants belonging to different masticatory groups. Analysis of

Table 2: Demographics data.

Characteristics	Quantity	Percent
Sex		
Male	32	32
Female	68	68
Age		
Mean (S.D.)	66.19 (4.66)	
Min – Max	60-81	
Underlying disease		
No	65	65
Yes	35	35
Number of teeth		
Mean (S.D.)	20.56 (6.17)	
Min - Max	6-32	
Teeth number group		
< 20 teeth group	41	41
≥ 20 teeth group	59	59
Occlusal pairs		
Mean (S.D.)	8.10 (3.91)	
Min – Max	1-16	
Occlusal pairs group		
< 10 occlusal pairs group	57	57
≥ 10 occlusal pairs group	43	43
Denture		
No	93	93
Yes	7	7
Eichner classification		
A	26	26
B	74	74
C	0	0
Masticatory performance by sieve method	37.84 (36.32)	
Mean (S.D.)	0.01-99.91	
Min – Max		
Masticatory ability by questionnaire		
Mean (S.D.)	27.46 (8.40)	
Min – Max	5-42	
Masticatory function value by wax biting test		
Mean (S.D.)	7.55 (3.94)	
Min – Max	0.43- 16.91	

Table 3: The correlation between masticatory function value by the wax biting test with masticatory performance by sieve method and masticatory ability by questionnaire.

	Spearman correlation coefficient	*p*-value
Masticatory function value by wax biting test Masticatory performance by sieve method	0.54	<0.05**
Masticatory function value by wax biting test Masticatory ability by questionnaire	0.64	<0.05**

** Correlation is significant at the 0.05 level (2-tailed).

Table 4: Comparing of the masticatory function values for evaluating subjects in different mastication groups.

	Masticatory function value by wax biting test		t	x
	$\bar{x}$	S.D.		
Tooth number				
<20 teeth group	4.46	2.5	-9.07	<0.05*
≥ 20 teeth group	9.7	3.28		
Occlusal pairs				
<10 occlusal pairs group	4.8	2.38	0.07	<0.05*
≥10 occlusal pairs group	10.2	3.27		
Eichner classification				
Eichner A	10.75	3.61	5.49	<0.05*
Eichner B	6.42	3.1		

* Significant at the 0.05 level

Table 5: The Logistic regression analysis of the number of teeth, occlusal pairs, and masticatory ability by questionnaire for prediction masticatory function value.

	b	SEb	β	t	*p*-value
Number of teeth	0.15	0.06	0.23	2.47	<0.05*
Number of occlusal pairs	0.50	0.11	0.49	4.45	<0.05*
Masticatory ability by questionnaire	0.09	0.04	0.19	2.36	<0.05*
β_0 -1.92; SE_{est} = ±2.26 R=0.83; R^2=0.68; F=68.12; p<0.05					

* Significant at the 0.05 level

Table 6: The relationships between masticatory groups divided by masticatory function value and mastication group by masticatory performance by sieve method.

	Normal mastication divided by Masticatory function value (%)	Low mastication divided by Masticatory function value (%)	Total	Chi-square	*p*-value
Normal mastication divided by masticatory performance	12 (36.4%)	8 (11.9%)	20 (20%)	8.24	<0.05*
Low mastication divided by masticatory performance	21 (63.6%)	59 (88.1%)	80 (80%)		

* Significant at the 0.05 level

groups with varying numbers of teeth revealed that participants with 20 or more teeth exhibited higher masticatory function values than those with fewer than 20 teeth. The findings of this study are consistent with those of Miyaura *et al.,*[13] who observed a marked increase in biting pressure among individuals with at least 20 teeth. Similarly, Bates *et al.,*[14] found that a reduction in occlusal surface area may require individuals to chew for a longer duration in order to reach the swallowing threshold for food consistency.

This study found that participants with 10 or more pairs of occluding teeth had higher masticatory function values than those with fewer than 10 pairs. This is consistent with the findings of Witter *et al.,*[15] who reported that masticatory ability becomes impaired when fewer than 10 occluding pairs of teeth are represented.

This study found that Eichner Group A had higher masticatory function values than Eichner Group B, consistent with Ikebe *et al.,*[8] who found that participants in Eichner Group A had the highest masticatory performance of the three groups.

The masticatory function value by wax biting test

among older adults can be used to measure masticatory function. A reliability tool, it is easy and convenient for use in clinics. The findings of this study revealed a strong positive correlation between this simple assessment tool and both masticatory performance and masticatory ability. However, when conducting a regression analysis to predict masticatory function values using the wax biting test along with all other factors, it was found that the number of teeth, the total number of occluding pairs, and masticatory ability assessed by questionnaires had a very strong correlation with masticatory function. The multiple correlation coefficient was 0.83, and the masticatory function could be predicted with 68% accuracy.

The grouping method for masticatory function (Table 6) was based on the cut-off point from previous studies which reported that biting pressure increased significantly in subjects with fewer than 20 teeth[13] and that having 10 occluding pairs, specifically arranged from premolar to premolar, should satisfy function at a suboptimal but acceptable level for older adults.[16,17] Mastication ability scores below 80% were considered low; scores above 80% were classified as normal.[18]

Based on these findings, masticatory function values obtained from the wax biting test were grouped by substituting numerical values into Equation 1. Values below 8.94 were classified as low, while values greater than 8.94 were considered normal. Masticatory performance was categorized according to previous studies, in which individuals with levels below 80% were identified as having low performance.[19]

While the finding that the total number of occluding pairs significantly impacts masticatory function values is consistent with previous studies[16,17], it is not consistent with the emphasis on the number of posterior occluding pairs, as referenced in the study by Sarita *et al.,*[2] They found that individuals with fewer than four posterior occluding pairs experienced chewing problems such as being unable to chew all types of food or needing to consume specially prepared meals. The results of the present study support the theory that the total number of occluding pairs has a greater impact on masticatory function than the number of posterior occluding pairs.

Of the group with dentures, six older adults wore removable dentures. The removable dentures were slightly worn, with good retention and effective chewing; however, their masticatory function values were lower than those of fixed dentures. This finding is consistent with the study by Liedberg *et al*.,[20] who reported that individuals with removable dentures have a reduced ability to chew hard foods compared with those with fixed dentures.

In this study, the recording of occlusion was performed at the position of maximum habitual intercuspation, which is the position where the opposing teeth achieve the greatest occlusal contact, depending on each individual's natural bite. The masticatory function value was measured at the position most frequently used by older adults, which reflects stable occlusion; if this position involved mobility of teeth or caused discomfort while chewing, older adults would avoid using those teeth for the occlusion. A previous study investigating the relationship between periodontal conditions and masticatory ability found that the average clinical attachment level was negatively correlated with bite force and occlusal contact area. This is because the loss of clinical attachment of periodontal structures can lead to tooth mobility, which affects the occlusal contact area.[21] Therefore, it is important to consider periodontal status when evaluating mastication.

A limitation of this study is the method used to measure the thickness of the wax bite, as only vertical force was evaluated. This method does not measure dynamic chewing efficiency or reflect neuromuscular adaptation in individuals with missing teeth, and lacks correlation with muscle activity. It is therefore suitable in local dental clinical settings to assess masticatory function and support research data collection.

Conclusions

The results of this study demonstrate that the wax biting test is a reliable and accurate method of measuring masticatory function, and can therefore be effectively utilized in dental clinics to evaluate masticatory function. It is a simple, precise, and dependable technique which aligns well with standard procedures. However, it should be noted that this study was limited in that it did not reflect dynamic chewing efficiency or muscle activity. The wax biting test can be used to evaluate masticatory function and identify oral hypofunction, thereby ensuring proper eating, adequate nutrition, and the maintenance of a healthy digestive system and overall well-being, leading to an improved quality of life.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

Consent

Written informed consent was obtained from the participants to publish this article.

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