The Correlation between Masticatory Performance, Number of Occluding Teeth, and Cognitive Status in Older Adults

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Abstract

Chewing performance might depend on the number of occluding teeth and affect the cognitive status. However, the linkage among these factors is still not fully understood.

To investigate the possible correlation between masticatory performance, number of occluding teeth, and cognitive status in older adults.

192 older adult participants were first classified into 3 Eichner's groups (A, B, and C), and were further divided according to the number of occluding teeth into 6 modified groups. The peanut chewing and sieving method were used to evaluate masticatory performance while the Mini-Cog assessment was employed to classify the cognitive status as normal cognitive status or at-risk of cognitive impairment. Data were statistically analyzed using two-way ANOVA with multiple comparisons and Spearman's correlation.

Participants with normal cognitive status showed significantly higher masticatory performance scores than those at risk of cognitive impairment (P<.001). Participants with a greater number of occluding teeth also demonstrated significantly better masticatory performance than those with a smaller number of occluding teeth and edentulism (P<.001). A positive correlation was observed between masticatory performance and cognitive function scores. However, a negative correlation was observed between masticatory performance and the number of occluding teeth of the modified group.

The number of occluding teeth is a key determinant of masticatory performance and was shown to have a positive correlation with cognitive function scores. Among participants with a comparable number of occluding teeth, the normal cognitive status group showed better masticatory performance than the at-risk cognitive impairment status group.

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Introduction

The proportion of populations aged 60 years and older has been dramatically increasing, accounting for 32% of the global population. The incidence of dementia is also increasing in these populations, estimated to be 24.3 million in 2001 with the prevalence of new cases of approximately 3.9% or 4.6 million annually. In developing countries, this trend doubles every 20 years.[1] Mild cognitive impairment was proposed to be a pre-dementia stage and could progress to Alzheimer's disease (AD) by Petersen et al 1995.[2] Cognitive impairment, including dementia and AD, has a wide range of impacts including learning and memory, social functioning, language, visuospatial function, complex attention, and executive functions[3] that lead to an increase in the rate of disability, morbidity, and mortality.[4]

Several animal studies have shown that mastication and chewing ability could help improve brain functions, including cognitive performance.[5-7] A positron-emission tomography and magnetic resonance imaging study confirmed that mastication increased cerebral blood flow and activated several regions in the human brain.[8] A functional Magnetic Resonance Imaging study[9-11] also suggested that mastication induced neuronal activity as blood-oxygen-level-dependent signal increased in various regions of

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the brain, suggesting that chewing may help promote and maintain the learning and memory process. Conversely, the low number of teeth, especially fewer occluding teeth causing chewing difficulty, has been shown to lead to a higher incidence of dementia.[12] Moreover, research on secondary data from the Health Survey for England 2000 suggested that the lack of teeth was significantly associated with cognitive impairment.[13]

However, the linkage among mastication performance, number of occluding teeth using Eichner's index,[14]and cognitive status is not fully understood. It is possible that masticatory performance is dependent on the number of occluding teeth that is, in turn, related to cognitive status. This study aimed to investigate the possible correlation between masticatory performance, number of occluding teeth, and cognitive status of older adults.

Materials and methods

Healthy Thai adults over the age of 60 (n=192) were recruited with exclusion criteria of peanut allergies, uncontrolled systemic conditions, pain in the oral cavity, and the presence of dental prostheses. This study was approved by the Human Experimentation Committee of the Faculty of Dentistry, Chiang Mai University (Application No. 56/2019). All participants were informed of the objectives before giving their consent to attend the study.

The participants were first classified according to Eichner's criteria[15] into 3 main groups (A, B, and C); group A has 6-9 pairs of occluding teeth, group B have 1-5 pairs of occluding teeth, and group C have no occluding teeth or edentulism. Later the participants were further divided into 6 modified groups according to the number of occluding teeth; group I (8-9 pairs), II (6-7 pairs), III (4-5 pairs), IV (2-3 pairs), V (0 pair) and VI (edentulism) to amplify the differences in the results after the initial statistical analysis showed great different among groups. The comparison of the number of occluding teeth, Eichner's indexes, and modified groups are shown in Table 1.

Masticatory performance was evaluated using the peanut chewing and sieving method.[16,17] The participants were requested to chew a plastic bag filled with 3 grams of dried peanuts for 20 strokes without swallowing. The chewed peanut sample was transferred onto mesh no.10 (2 mm x 2 mm). The participant then rinsed their mouth with water onto the same mesh to ensure no residual sample remained. The crushed peanut sample that was smaller than the mesh was passed through. The remaining sample on the mesh was washed with water and transferred onto a filter paper (Whatman No.1, Cytiva, United States) and dried at 100°C in a hot air oven for 3 hours. Masticatory performance was calculated from the percentage of chewed peanuts that passed through the sieve compared with the initial weight.[18]

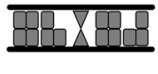
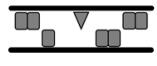
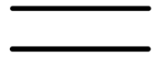
Eichner's index			Number of occluding teeth	Modified groups
A	A1		4 posterior occlusal contacts zone, occluding teeth in the molar and premolar zone, no missing teeth in both maxilla and mandible	I
	A2		4 posterior occlusal contacts zone, occluding teeth in the molar and premolar zone, at least one missing tooth at least in the maxilla and/or mandible	II
	A3			
B	B1		2 or 3 posterior occlusal contacts zone	III
	B2			
	B3		1 posterior occlusal contacts zone or anterior teeth contact only	IV
	B4			
C	C1		at least 1 tooth is present in the maxilla and/or mandible without any occlusal contacts zone	V
	C2			
	C3		Fully edentulous arch in maxilla and mandible	VI

Table 1. The comparison of the number of occluding teeth, Eichner's indexes, and modified groups.

The cognitive status of participants was evaluated using the Mini-Cog assessment tool (Thai version) which consists of a memory test and a clock drawing test.[19] Participants were classified as either normal cognitive status or at-risk of cognitive impairment. For the memory test, participants were asked to memorize three Thai words: house (Baan), cat (Maew), and the color green (Si-Kheiyw) by first repeating each word after the examiner and recalling those words after completing the clock drawing test. For the clock drawing test, the participants were requested to draw a circular clock with arms

showing 11:10 AM. One point was given for each correctly recalled word and two (all or none) points were given for correct clock drawing. The scoring 3 points and higher were classified as normal cognitive status while less than 3 points were categorized as at-risk of cognitive impairment. The masticatory performance from 6 modified groups and 2 cognitive statuses were analyzed using two-way ANOVA with Sidak's multiple comparison test. A *P* value of less than .05 defines a significant difference. The correlation between masticatory performance and modified group to cognitive score was tested with Spearman's technique.

Results

The mean±SD of masticatory performance in Eichner's group A (n=64), Eichner's group B (n=64), and Eichner's group C (n=64) were 74.21±13.22%, 39.41±16.85%, and 0.89±2.17%, respectively.

We found that the masticatory performance of the normal cognitive status group (n=96) was 41.52±34.11%, significantly higher than the at-risk cognitive impairment group (n=96) which was 34.83±30.56% (*P*<.001).

The masticatory performance of normal cognitive status in Eichner's groups' A, B, and C (n=32) were 80.86±8.83%, 42.58±13.95%, and 1.10±2.69%, while the results for the at-risk of cognitive impairment (n=32) were 67.56±13.64%, 36.24±19.02%, and 0.68±1.51% respectively.

When the results were further divided into modified groups (I-VI), the mean±SD value of masticatory performance for modified group I to group VI (n=32) were 80.00±10.69%, 68.43±13.12%, 51.17± 9.54%, 27.66±14.17%, 1.71±2.83%, and 0.07±0.41% respectively.

The masticatory performance of normal cognitive status and at-risk cognitive impairment for 6 modified groups are shown in table 2. The two-way ANOVA analysis found a significant interaction between cognitive status (normal and at-risk) and 6 modified Eichner's groups (*P*<.001). Modified groups I, II, and IV with normal cognitive status groups showed significantly higher masticatory performance than those with at-risk cognitive impairment groups (*P*<.001). However, no significant difference was detected in modified group III (*P*<.66), V(*P*<.82), and VI(*P*<.96).

A positive correlation was found between cognitive score and masticatory performance (Figure 1).

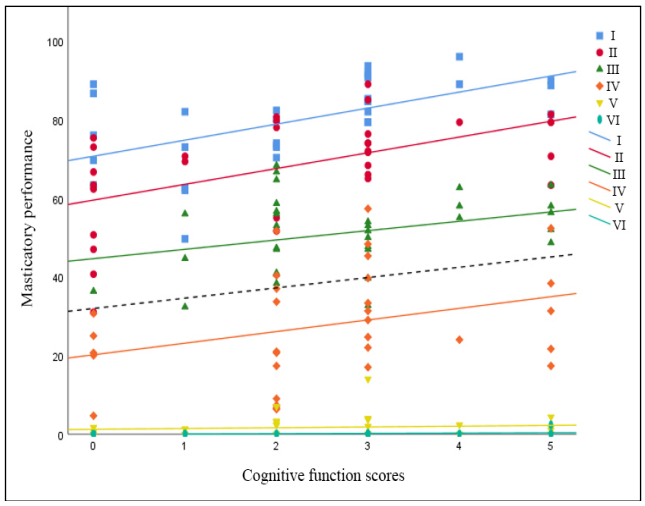


Figure 1. Correlation between cognitive function scores and masticatory performance of modified groups of all 192 participants (each dot represented masticatory performance and cognitive function score of individual participants. Dash line showed a positive correlation indicating that participants having higher masticatory performance tended to have higher cognitive function cores.)

Modified group	Mean±SD		p-value
	Normal (n=16)	At-risk (n=16)	
I	87.06±5.10	72.94±10.18	<.001*
II	74.67±7.28	62.19±14.82	<.001*
III	51.85±7.88	50.48±11.18	.66
IV	33.31±12.51	22.00±13.80	<.001*
V	2.06±3.55	1.35±1.93	.82
VI	0.15±0.58	0.00±0.00	.96

* Statistical significance *P*-value <.05

Table 2. Comparing the mean and standard deviation (SD) of masticatory performance among groups and the cognitive status of each modified group, the p-value less than 0.05 indicated a significant difference between cognitive status in each group.

There was a moderate positive correlation between cognitive function and masticatory performance for modified groups I (r=0.604) and II (r=0.520). A low positive correlation between cognitive function scores and masticatory

performance was noted for modified group IV (r=0.362). However, there was a negligible correlation in modified groups III, V, and VI (correlation coefficients of 0.278, 0.120, and 0.296 respectively).

Discussion

The peanut chewing and sieving method used in this study was first employed for evaluating masticatory performance by Manly and Braley 1950.[16] It is a straightforward technique for measuring the efficiency of chewing. This technique is comparable to the chewing gummy jelly technique[20] but simpler than the chewing color changeable gum technique[21] or glucose extracted from chewing gum[18] that required additional measuring equipment to interpret the result. In this study, 3 grams of dried peanut samples were filled in a plastic bag to prevent accidental swallowing or getting caught between natural teeth which would confound the results.

The significant decline in masticatory performance from Eichner's group A to group B and group C was related to the number of posterior occluding teeth which was a key factor for good mastication performance.[14,22] The difference in masticatory performance was clearer after participants were further divided into 6 modified groups according to the number of occluding teeth. Modified group I which had the greatest number of occluding teeth showed the highest masticatory performance followed by groups II, III, IV, V, and VI, respectively. The results confirmed that masticatory performance is strongly associated with the number of occluding teeth, especially numbers of posterior teeth[23] as found in groups I, II, and III.

Normal cognitive status in groups I, II, and IV showed significantly higher masticatory performance than at-risk cognitive impairment status indicating that not only masticatory performance was associated with higher cognitive function[24,25] but also the number of occluding teeth. A poor oral condition such as chronic periodontitis,[26] chewing difficulties,[27,28] that affect chewing ability was also correlated with the risk of cognitive impairment. During chewing, oral organs generate neural signals transmitted to the higher brain center, promoting neurogenesis and neuronal activity which is essential for memory development.[29]

Low masticatory stimuli such as powder diet feeding decrease neural activity, resulting in low production of a brain-derived neurotrophic factor that then causes long-term memory loss, spatial memory loss, and neuronal dysfunction.[30] Moreover, prolonged reduction of masticatory stimulation from a poor dental condition caused induced mitochondrial damage, accumulation of lipofuscin, thinner myelin sheath, and decreased postsynaptic density length in the hippocampus, contributing to the incidence of cognitive impairment.[31]

Modified groups V and VI that have very few or no occluding teeth showed the lowest cognitive score. No significant difference was observed between normal cognitive status and at-risk cognitive impairment status. People living with chewing difficulty from multiple tooth losses were found to be strongly correlated with cognitive impairment[27,32] and the risk of developing dementia.[12,28] Similar to a systematic review by Tada A. and Miura H. in 2017,[33] poor mastication was shown to be a risk factor for the rapid decline in cognitive status and increased incidence of dementia. This raised the possibility that posterior occlusal contact not only determined the masticatory performance but also the individual's adaptive ability on chewing, and the strength of the masticatory muscle was also involved.

In edentulous individuals, as in modified groups V and VI, without wearing dentures had a significant risk of physical disability and physical health disorders which could lead to an increased mortality rate due to deterioration in systemic health.[24] Regardless of the nature of tooth contact and its location in the oral cavity, a large number of functional masticatory units (FMUs), including dental prosthesis, was significantly associated with a lower probability of cognitive impairment.[34] People who chew with natural teeth or prostheses may not develop cognitive impairment as long as they have no chewing difficulty.[27] This was confirmed in a cross-sectional study on Korea Longitudinal Study on aging data which found that the decreasing chewing ability was associated with mild cognitive impairment and the older who did not wear dentures had a reduction in chewing performance was strongly correlated with mild cognitive impairment.[35]

Good oral health, especially in older adults, is closely related to higher brain function[36]

and cognitive health[37,38] while multiple tooth losses could induce stress which consequently impacts the individual's learning ability. In addition, long-term edentulism affects cognitive function, decreases physical gait speed, and memory function, and increases the risk of developing cognitive decline and mobility disability in community-dwelling older adults.[39]

Many animal studies had provided evidence that restoring masticatory function resulted in the improvement of brain centers responsible for cognitions.[40,41] Similarly, human studies also showed that oral rehabilitation enhanced brain functions.[42-44] Recent literature evidence suggested that restored masticatory performance in completely edentulism patients by implant-retained removable dental prostheses resulted in improvement in neurocognitive function as determined by using functional magnetic resonance imaging technique and maintaining the overall health of the older adults, leading to a longer life expectancy.[45]

Even though this study could not identify the exact cause-effect of the relationship between mastication and cognitive impairment, the results provided additional evidence to support the idea of maintaining masticatory performance could help maintain cognitive function and avoid cognitive impairment, dementia, and Alzheimer's disease which has a serious oral problem[46] in older adults. Furthermore, an edentulous person with no teeth substitution had the lowest cognitive score in this study and also had a significant risk of physical disability and mental health disorders which might lead to an increased mortality rate.[24] Regardless of the large number of natural teeth in the oral cavity, a large number of FMUs including dental prostheses was significantly associated with a lower probability of cognitive impairment.[34]

Moreover, maintain mastication can increase TGF-β levels which decreasing Streptococcus sanguinis and Streptococcus mutans in gingivitis patients.[47] So, maintaining healthy oral health (by minimizing tooth loss) or dental prosthesis substitution may be an important measure to maintain brain function, nutritional status,[48] and overall health and lead to a longer life expectancy.

Based on the causal relationship identified in this study, we encourage dental health practitioners and policymakers to improve access to oral rehabilitation for people who had multiple tooth losses to improve their brain function, general health, and ultimately the quality of life.[49] Future research is still required for comparing the cognitive function of people who live with natural teeth, wearing fixed dental prostheses and removable dental prostheses to further improve our understanding of the relationship between mastication and cognitive function, including dementia.

Conclusions

The results of this study suggested that the number of occluding teeth is a key determinant of masticatory performance and had a positive correlation with cognitive function scores. For older adults with a comparable number of occluding teeth, the normal cognitive status group showed better masticatory performance than the at-risk cognitive impairment status group. This indicated that protection from multiple tooth loss might be a key factor to prevent cognitive impairment in older adults.

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Declaration of Interest

The authors report no conflict of interest.

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