ASSOCIATION BETWEEN CHEWING ABILITY AND COGNITIVE FUNCTION AMONG OLDER PATIENTS

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Abstract

Tooth loss is commonly linked to reduced chewing ability and cognitive function among the older population. This study aimed to assess the association between masticatory ability and cognitive function among older patients in one of the public university dental clinic in Kuala Lumpur. A cross-sectional study was performed on 76 dental patients aged over 60 years who received treatment at Universiti Kebangsaan Malaysia, Kuala Lumpur. Dental examination was performed to assess the respondents' dental status, namely the number of teeth present and their denture status. Masticatory ability of the respondents was assessed with Masticatory Performance Evaluating Chewing Gum (XYLITOL®; Lotte Co., Ltd., Saitama, Japan). The color-changeable chewing gum was categorized into five levels. Darker pink color showed higher chewing ability while yellow implied poorer score. Based on the colour, a score of 1 to 5 points was given. Cognitive status was measured with the 13-items Mini Mental State Examination (MMSE) questionnaire. The scores ranged between 0 to 30. A score of 23 or below was accepted cutoff point indicating the presence of cognitive impairment. The mean number of remaining teeth was 11.6 ± 10.24, with 30.3% having total tooth loss. The mean chewing score was 3.37 ± 1.41. About 46.1% of respondents were classified as poor chewers, and 53.9% were good chewers. Older people who had fewer teeth and decreased chewing performance had significantly reduced MMSE scores. The MMSE score was significantly correlated with the number of teeth present ($r=0.331$; $p<0.05$) and masticatory ability ($r=0.594$; $p<0.05$). It is suggested that having an optimal number of teeth in the oral cavity for good masticatory function is important to good cognitive functioning. In addition, long-term studies are required to investigate the relationship between the role of masticatory ability on cognition especially among older population.

Keywords: Cognitive Function, Elderly, Mini Mental State Examination, Chewing Ability

Introduction

In recent years, the number of older people worldwide has increased rapidly. Malaysia, like other developing countries, is experiencing population ageing and the condition has become a crucial issue to the nation. Reports have shown that in 2000, the population over 60 years old in Malaysia was 6.3 percent and increased to 7.9 in 2010 and 10.4 percent in 2022 (1). Similarly, the mean of Malaysian life expectancy at birth has escalated from 63.6 years in 1970 to 74.3 in 2010, and 75.0 years in 2018 (1). Thus, growing number of people can be seen surviving into old age due to the demographic changes. In addition, the older population are also at greater risk to physical and psycho-social limitations due to chronic diseases and ageing.

As for oral health, it can be observed that the trend of oral health status worsens as age increased (2). Loss of teeth resulting from dental caries and periodontal disease are widespread in this group. In Malaysia, older people over 60 years old were recorded with an average of 9.8 remaining teeth in the oral cavity while edentulism were recorded in 36.8 percent of the population (3). Tooth loss, complete or partial, may restrict chewing, swallowing, speech and also appearance of the aged group (4). Furthermore, loss of teeth plays an important role to changes of dietary habit among older individuals. Decreased in number of teeth that can function may cause problems in chewing hard food like fruits and vegetables (5), unsatisfactory diet composition (6), lesser uptake of important nutrients (7) and insufficient calorie consumption (8).

With an increase in elderly people worldwide, growing interest in the studies of factors associated with cognitive impairment is recorded. Cognitive impairment can be defined as problems one has with cognitive performance such as thinking, reasoning, memory or attention (9). As for many older people, tooth loss had given rise to reduced masticatory function. The possible relationship between masticatory ability with cognitive decline has been studied widely for the past years (10, 11). It was reported that increased chewing ability causes the concentration of blood oxygen in the hippocampus as well as the frontal cortex to shoot up. These areas are important for learning and memory (12). Likewise, the right hippocampus and thalamus are affected by chewing thus stimulating the memory to enhance cognitive ability. Moreover, deficient chewing function may serve as a relevant risk factor for reduced cognitive ability. This is due to the stimulation of activities in the cerebral cortex from mastication which can be useful in preventing brain function decline (11). In addition, oral conditions like periodontal disease causes inflammation and may increases the likelihood of cardiac disease (13), as well as metabolic disease and stroke. These risk factors are common for reduced cognitive function and dementia (14). Periodontal disease is thought to cause infection systemically, hence raises the chance of getting Alzheimer's disease (15). Nonetheless, long-term population studies yield varied results on the relationship between dental status and impaired cognition, thus a large-scale research on the association need to be further explored (16, 17).

The proportion of impaired cognition among elderly Malaysians was reported between 11 to 24% (18). Various factors were reported as potential causes of cognitive impairment among older population. Among them was decreased physical activity, reduced in brain engagement activity, nutritional problems along with reduced physical function (19). Nevertheless, research focus has not been given locally to the study on relationship between chewing function and cognitive ability. As for Malaysia, the prevalence of tooth loss that lead to chewing problems is still high especially among older people (with 78% have less than 20 teeth). Therefore, study on the potential link between the two variables need to be looked into (3). Moreover, there is considerable diversity in the cultures and dietary patterns in Malaysia hence findings from earlier studies may not necessarily applied. Thus, this study aimed to investigate the association between masticatory ability and cognitive function among a group of older patients in a public university dental clinic in Kuala Lumpur.

Materials and Methods

Sample collection

A cross-sectional study was conducted on patients over 60 years old who received dental treatment in the Faculty of Dentistry Universiti Kebangsaan Malaysia, Kuala Lumpur (UKMKL) between October 2022 to March 2023. Through a convenient sampling method, all patients aged 60 years and above attending the dental clinics were invited to participate in the study. Patients who are unable to understand and respond in English or Malay language, with conditions that may affect chewing abilities, like poor existing dentures, post-stroke patients and patients who have undergone oral cancer surgery such as hemi-glossectomy, mandibulectomy or maxillectomy, were excluded.

Instruments

Socio-demographic

Respondents were interviewed on information relating to socio-demographic characteristics like gender, age, race, educational level (no formal education, primary and secondary school, and college or university graduate) household income (B40 - households with income of below RM4,850), M40 - households with income between RM4,850 to RM10,959, and T20 - households with income higher than RM10,959), smoking status and self-reported medical status. Perception on general health were also assessed using a 5-point Likert scale ranging from very good to very bad health status.

Cognitive function assessment

Cognitive status was measured using the Mini Mental State Examination (MMSE) questionnaire (20). MMSE is a commonly used test for measuring cognitive function among the elderly. It includes the tests of orientation, attention, memory, language, and visual-spatial skills. The test consisted of 19 items with scores ranging from 0 to 30. It comprises of orientation (10 points, verbal memory (6 points), concentration and calculation (5 points), language (5 points), praxis (3 points), visuospatial construction (1 point), and judgment and common sense (2 points). The reliability and construct validity of MMSE was satisfactory based on previous research (21, 22). The Malay-MMSE has also been validated in a group of Malay-speaking elderly population in Malaysia (22). MMSE score of ≤23 indicated impaired cognition, whereas a score of >23 was rated as normal or without cognitive impairment (23). The severity of cognitive impairment was further classified into 3 categories: mild cognitive impairment 19–23; moderate cognitive impairment 10–18; and severe cognitive impairment ≤9 (24).

Chewing ability assessment

Chewing ability was assessed with the Masticatory Performance Evaluating Chewing Gum (XYLITOL®; Lotte Co., Ltd., Saitama, Japan) (Figure 1). The compound of this color-changeable chewing gum includes mixed glycerin-fat ester, micro-forming wax, and everyday gum base (25). The ingredients include xylitol, citric acid, and red, yellow, and blue coloring. The consistency and validity of its performance had been confirmed in earlier studies (25, 26). The gum is light green in color before it is chewed. The citric acid in the gum and saliva is released and mixed when

being chewed. When its pH increases, the gum changes its color to red.

Before the chewing ability assessment, respondents were asked to remove their dentures. Then they were required to chew the gum 60 times at a pace of once per second, and the chewing performance was measured by referring to the color legend given. There were five scores for measuring color changes. A gum with darker pink in color showed better chewing performance. The score ranges from 1 to 5 points. Light green records 1 point, yellow 2 points, light pink 3 points, pink 4 points, and dark pink 5 points. The chewing ability of the respondents was divided into two levels, which were 1 to 3 points for poor and 4 to 5 points for good chewing function.

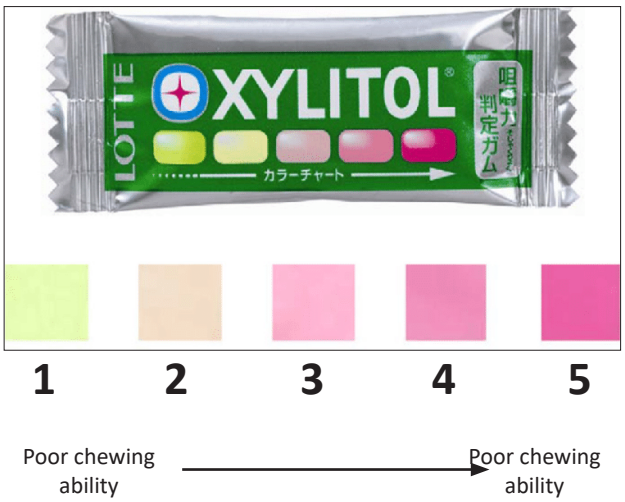

Figure 1: The masticatory performance evaluating gum XYLITOL®

Oral health status examination

Dental assessment was conducted to investigate the respondents' oral condition. This included the number of teeth present, caries experience and denture status. Examination of dental caries will include the assessment of respondent's dentition status, whereby both the crown and root of every tooth will be examined for any decay or restorations. This is conducted visually using disposable mouth mirrors. These assessments were established from the WHO Oral Health Survey Basic Methods 5th Edition 2013 for oral health examination (27). For clinical oral examination, only one examiner was involved. A Kappa value of 0.96 was demonstrated indicating a high intra-examiner consistency.

Data analysis

The data was analysed using IBM SPSS statistics version 27.0 software. Mean with standard deviation were calculated for continuous variables. As for categorical variables, frequency along with proportion was determined. The Chi-square test of independence was utilized to establish associations between categorical variables. As for the correlation between the variables (remaining teeth, chewing ability score, and MMSE score), the Spearman correlation coefficient was used. A $p<0.05$ was set as the significant level for data analysis.

Results

Demographic characteristics of respondents

Seventy-six patients receiving dental treatment agreed to participate in the study. Table 1 shows the demographic data and perception on the general and oral health of the patients.

Table 1: Demographic characteristics of the study population

Items	n (%)	Mean (SD)
Gender		
Male	46 (60.5)	
Female	30 (39.5)	
Age		67.3 (5.59)
Race		
Malay	43 (56.6)	
Chinese	20 (26.3)	
Indian	13 (17.1)	
Level of education		
No formal education	3 (3.9)	
Primary education	12 (15.8)	
Secondary education	34 (44.7)	
Tertiary education	27 (35.5)	
Household income		
B40	69 (90.8)	
M40	5 (6.6)	
T20	2 (2.6)	
Systemic diseases		
Yes	65 (85.5)	
No	11 (14.5)	
Perception on own health status		
Very good	3 (3.9)	
Good	35 (46.1)	
Moderate	38 (50)	
Bad	0 (0)	
Very bad	0 (0)	
Smoking status		
Yes	8 (10.5)	
No	68 (89.5)	

Oral health condition, chewing ability, and cognitive status

More than half of the respondents had less than 20 functional teeth (68.4%) with a mean of 11.64 (SD 10.24) remaining teeth. Twenty-three respondents (30.3%) had complete tooth loss or edentulous. For chewing ability assessment, the mean chewing score was 3.37 (SD 1.41). About 46.1% of respondents were poor chewers, and 53.9% were good chewers. Majority of the respondents (76.3%) had normal cognitive function and none with severe cognitive impairment. Around 18.4% older people showed mild cognitive impairment while only 5.3% was moderately impaired. The calculated mean MMSE score was 26.29 (SD 4.50). Table 2 presents the dental status, chewing capacity, and cognitive ability characteristics of respondents.

Table 2: Oral health condition, chewing ability and cognitive function characteristics of study population

Items	n (%)	Mean (SD)
Dental status		
Dentate	53 (69.7)	
Edentate	23 (30.3)	
Number of remaining teeth		11.64 (10.24)
20 teeth or more	24 (31.6)	
Less than 20 teeth	52 (68.4)	
Denture usage		
Yes	39 (51.3)	
No	37 (48.7)	
Chewing ability		3.37 (1.41)
Poor	35 (46.1)	
Good	41 (53.9)	
Cognitive status		26.29 (4.50)
Normal cognition	58 (76.3)	
Mild cognitive impairment	14 (18.4)	
Moderate cognitive impairment	4 (5.3)	
Severe cognitive impairment	0 (0)	

Association between number of teeth, chewing ability, and cognitive status

Table 3 summarizes the association between oral health condition and chewing ability with cognitive function. The Chi-square test analysis showed a significantly higher proportion of cognitively impaired patients had remaining teeth of below 20 (94.4%) ($p<0.01$). Comparably, everyone in the study population (100%) who were cognitively impaired had poor chewing ability ($p<0.05$).

Table 3: Association of number of teeth and chewing ability with cognitive function of study population

	Cognitive impairment n (%)	Normal cognition n (%)	p value
Number of teeth			p<0.01
20 teeth or more	1 (5.6)	23 (39.7)	
Less than 20 teeth	17 (94.4)	35 (60.3)	
Chewing ability			p<0.01
Poor	18 (100)	17 (29.3)	
Good	0 (0)	41 (70.7)	

Table 4 shows the correlation between dental component and chewing ability with the total MMSE score. The number of teeth left in the oral cavity had a significant correlation with the respondents MMSE score ($r=0.331$; $p<0.01$). Similarly, the chewing ability was correlated significantly with the study population MMSE score ($r=0.594$; $p<0.01$).

Table 4: Association between number of teeth and chewing ability score with MMSE score

	MMSE score
Number of teeth	r=0.331; p<0.01*
Chewing ability score	r=0.594; p<0.01*

*Pearson correlation coefficient; significant at $p<0.05$

Discussion

This cross-sectional study assessed the association between chewing ability and cognition of older patients aged 60 years and above. To date, this was the first study conducted in the local setting which measured chewing function clinically, in order to determine its potential association to cognitive disorders. In this study, loss of teeth and chewing problems experienced among older adults were significantly associated with cognitive function. Respondents with higher chewing ability score were shown to have higher MMSE score. Several worldwide studies that assessed the relationship between poor chewing ability and multiple tooth loss with cognitive ability among elderly had shown similar results (10, 28). It was noted that the periodontal mechano-receptors were abnormally altered due to missing posterior teeth. This condition caused a decreased in sensory signals from the periodontal ligaments, and eventually affects the neural activity (29). Moreover, many research had pointed out that mastication activity that originate from posterior teeth that occlude may cause an increment of blood flow at the cerebral region, cortical area initiation and increased in blood oxygen status (12). Consequently, decreased in chewing

ability due to reduced number of posterior teeth could be a possible factor for cognitive decline (12).

Masticatory dysfunction has a systemic effect that increases the risk of dementia. Mastication raises the levels of blood oxygen levels in both the frontal cortex and hippocampus. These regions were required for learning as well as memory (30). The trigeminal afferent nerves transmitted the sensory information to the trigeminal sensory core, cerebellum, hypoglossal motor nucleus, along with reticular formation at the brainstem. The formation of the reticular is essential for brain activities. These include attention, perception, and learning consciousness (31). Meanwhile, neurons originating from the trigeminal sensory nucleus travel to several regions namely the thalamic posterior ventral nucleus, reticular formations, and hypothalamus. As a result, sensory information from the masticatory organs can affect the hippocampus via the thalamus and cerebral cortex. In one of the current study that compare the variability of cerebral blood flow between subjects who were edentulous and with dental implant, findings concluded that cerebral blood flow increased significantly with subjects using implanted prostheses (32).

Although the association between chewing ability and cognition has been studied widely in recent years, the findings yielded mixed results and were debatable. Some studies argued the possibility of cognitive impairment that actually increased the likelihood of having chewing difficulties. This is because people with cognitive impairment, especially older adults, may be less able to keep up with good oral hygiene practices. This may increase the risk of getting oral diseases which may cause tooth loss and affect the chewing performance especially hard foods. Although some studies showed that older adults who were cognitively impaired were expected to have dental caries, the link between dental diseases and cognitive impairment is not significantly established (33).

Our findings showed that the remaining teeth in the oral cavity had low positive correlation with cognitive function scores among the study population. However, the number of teeth present does not determine chewing ability entirely. It is rather a multifactorial action that involves several components including physical, social, and psychological aspects (34). Even with a low number of remaining teeth, chewing ability can be improved if the patient is provided with a prosthesis to replace the missing teeth, such as denture or dental bridge. The number of occlusal units of the posterior teeth should also be considered when determining chewing ability. Furthermore, chewing activity is established individually and also needs adjustment. In addition, the functional chewing ability is also linked to various non-dentally related functional impairments in the elderly population, for example reduction in salivary flow and biting force, together with general health and psycho-social well-being.

Although the findings presented a significant association between variables, the study showed some limitations. This was a cross-sectional study design thus making it unfeasible to establish a causal relationship between chewing ability and cognitive function. Larger scale studies and longitudinal in nature may be required to investigate the relationships further. In addition, it is also useful to assess the nutritional conditions of the patients as chewing efficiency is significantly related to food intake patterns and nutritional conditions especially in the older community. Conditions like frail and weakness, systemic diseases, together with information on polypharmacy were deficient. All these elements could have acted as confounding factors in the study (35). In addition, other clinical information like plaque score and tooth mobility could also be included in the oral examination in future research to ensure comprehensive assessment of oral health condition that leads to chewing function. Nonetheless, research areas on cognition and oral health among older population are not extensively explored in Malaysia, so findings from the present study may assist researchers to establish further associations in the future.

Conclusion

This was the first study that measured chewing proficiency objectively and discovered its potential association to cognitive disorders within a local setting. This study concluded a significant association between poor chewing ability and cognitive decline among older patients receiving treatment in Universiti Kebangsaan Malaysia dental clinics. Findings suggested that having 20 and more natural and functional teeth through old age is important for healthy aging.

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Competing interests

We declare no competing of interests.

Ethical Clearance

Approval obtained from the Research Ethics Committee, Universiti Kebangsaan Malaysia (UKM PPI/111/8/JEP-2022-495). All respondents provided written consent.

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