The Influence of the Number of Functional Tooth Units (FTUs) on Masticatory Performance

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Abstract

Individual masticatory performance describes the ability of teeth to break down food. The number of functional tooth units (FTUs) can affect masticatory performance. However, there is no research on the minimum number of FTUs needed for good masticatory performance. Furthermore, age and gender also affect masticatory performance, but previous studies disagree on their effects.

The objective of this study is to analyze the effect of number of FTUs, age and gender on masticatory performance. The masticatory performance of 50 subjects was compared. Each subject's number of FTUs was obtained from the contact record of the posterior teeth, and masticatory performance was evaluated by comparing the boluses of mixed colors of chewing gum.

The number of FTUs positively affect masticatory performance (p=0.667); age and gender had no effect (p=0.245 and p=0.169). A higher number of FTUs improves masticatory performance.

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Introduction

Tooth loss is a pathologic condition in the oral cavity. It can be caused by caries, periodontal disease or trauma.[1] Tooth loss is one of the most significant problems of the oral cavity.[2] According to a study conducted in 26 countries by the Global Burden of Disease, from 1990 to 2010, an average of 205 teeth were lost for every 100,000 people; this number is expected to increase. According to the National Health Research, based on three indicators from the DMF-T index, Indonesia had the highest rate of tooth loss in the world in 2013.[3] Its index score for tooth loss was 2.9, meaning that each person is missing three teeth. Tooth loss also increases with age. The tooth loss index for Indonesians aged 35–44 years is 3 (three missing teeth). Indonesians 45–54 years old are missing an average of six teeth, those 55–64 are missing an average of ten teeth, and Indonesians over 65 are missing an average of seventeen teeth.

People with missing teeth often lack functional masticatory abilities.[4] Mastication is the ability to break down food in order to swallow it. Mastication plays an important role in providing nutrition for the body. It also influences overall health.[5] Therefore, the maintenance and rehabilitation of masticatory function are one of the main goals of dental treatment. To achieve these goals, dentists must be able to evaluate a patient's masticatory performance based on the condition of their teeth. Masticatory performance is evaluated by measuring a patient's ability to break down food. This evaluation can be subjective and objective. A subjective examination involves asking patients questions about their perception of their own masticatory performance. An objective examination includes a clinical examination of the patient's teeth. Masticatory performance may be evaluated by examining the patient's bolus, by using jelly gum, or by comparing the boluses of gums of different colors that have been chewed for a set number of masticatory cycles. The colored gum mixing method is also simpler, more effective and more accurate than other methods. The degree to which the different colors of gum are mixed defines different degrees of masticatory performance, which can be evaluated on a visual color scale.[6]

Masticatory performance is affected by the number of teeth that connect with their antagonist. Teeth that do not connect with an antagonist do not improve masticatory

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performance.[7] A Functional Tooth Unit (FTUs) is a pair of antagonistic teeth that come in contact with each other. FTUs can be used to assess the arrangement of functional teeth and to differentiate the number and type of teeth (tooth with tooth, tooth with denture and denture with denture) in order to accurately evaluate masticatory potential. FTUs are calculated by giving one point for each pair of contacting premolar teeth and two points for each pair of contacting molar teeth; the maximum number of FTUs in a patient is 12. Other factors that affect masticatory performance are age and gender. Older people have poorer masticatory performance due to physiological alterations. These alterations may affect motor skills, sensory abilities, masticatory muscle strength and salivary flow rate. Older people also have a higher risk of tooth loss due to systemic disease.[1] Gender differences include bite force, chewing behavior and the anatomic structure of the masticatory muscle.[8]

Previous studies disagree on the minimum number of FTUs for adequate masticatory performance. Some studies determined that patients with eight or more FTUs had no difficulty chewing food, while patients with four FTUs had difficulties.[9] Other studies found that patients with four FTUs can chew food properly.[4] Another study identified five FTUs as the borderline for normal masticatory performance. [7] FTUs have been examined in several studies, but the minimum number of FTUs for normal mastication has not been confirmed. No research has been done on FTUs in Indonesia. Age can also affect masticatory performance, as bite force decreases with age.[10]

Gender may also affect masticatory performance. Men typically have more bite force, chew for less time and chew faster than women.[10] However, again, some previous studies have found no differences in masticatory performance between men and women.[1] The minimum number of FTUs for good mastication has not yet been determined. Also, no research has been done on FTUs in Indonesia. Furthermore, the different results of previous studies indicate that further research is needed on the influence of age and gender on masticatory performance and on the average minimum number of FTUs required for normal mastication. The influence of age and gender on masticatory performance has also not been investigated using colored gum mixing. This method was chosen for this study because of its accuracy in evaluating masticatory performance.

Materials and methods

This research is a cross-sectional analytical study. The subjects were chosen through a consecutive sampling method. All subjects are at least 20 years old, have no mobile teeth, and have no missing teeth and have normal occlusion, or have only one missing tooth. The subjects were divided into two groups: a control group (12 FTUs) and a test group (1–11 FTUs). Fifty subjects were included in the study, 25 in each group. The subjects were also divided according to age: young adults (20–39), adults (40–59) and the elderly (over 60). The subjects were further divided according gender. Masticatory performance was evaluated in two steps. First, the contacting pairs of posterior teeth were examined, and then masticatory performance was measured based on a gum bolus of mixed colors of gum. The boluses were examined by a researcher who had been calibrated to use a visual color scale. Each subject chewed the two colors of gum for 50 masticatory cycles.

Patients who met the requirements of the study were given information about the study. They were invited to participate, and they filled in an informed consent form, provided personal data, and agreed to be subjects in the study. Each patient's number of FTUs was determined by recording the number of contacting pairs of posterior teeth. To identify contacting teeth, the bucal mucosa were retracted using a mouth mirror and the patient was asked to occlude. One point was awarded for contacting pairs of premolar teeth and two for contacting pairs of molars. The maximum number of FTUs is 12, and the minimum is 0. The subjects were instructed to chew two colors of gum for 50 cycles. The masticatory rhythm was regulated with a metronome; each masticatory cycle was one second. Then the mixed–color gum bolus was removed from the patient's mouth using tweezers. It was put in a transparent plastic bag and flattened to a thickness of 1 mm by pressing it between two mixing slabs with a 1 mm spacer. The color of the bolus was then compared to the visual color scale. After the information was collected, the data was organized and then

analyzed. Variable frequency and distribution of FTUs, age and gender were obtained using univariate analysis. The average number of FTUs required to perform normal mastication was calculated. Next, Spearman's bivariate analysis correlation test was conducted to determine the influence of FTU on masticatory performance and also to determine the degree to which a higher number of FTUs improves masticatory performance. The Kruskal-Wallis test was then performed to identify any differences in masticatory performance among age groups. The Mann–Whitney test was used to identify gender differences in masticatory performance.

Results

Table 1 shows that 15 of 25 subjects with 1 to 11 FTUs demonstrated good masticatory performance; the mean number of FTUs for good performance was 7.6. Ten of 25 subjects with 1 to 11 FTUs, with a mean FTU of 2.9, demonstrated poor masticatory performance. Next, to determine the influence of number of FTUs on masticatory performance, a Spearman correlation test was performed. In Table 3, the positive value is 0.667 ($p>0.05$), which means that there is a correlation between number of FTUs and masticatory performance. Every increase in number of FTUs improves masticatory performance. A Mann–Whitney test was performed to determine the differences between the average FTUs of the control group and the test group and their effect on masticatory performance. Table 4 shows a p-value of 0.096 ($p<0.05$), which means that there are no significant differences in the masticatory performances of these groups.

Variable 1–11 FTUs	N	Mean (SD)
Good Masticatory Performance	15 (60%)	7.6 (2.09)
Poor Masticatory Performance	10 (40%)	2.9 (2.02)

Table 1. Average number of FTUs for good and poor mastication.

Variable	N Poor Masticatory Performance (1–2)	N Good Masticatory Performance (3–5)	p-value
Number of FTUs			
1–11	10 (40%)	15 (60%)	0.667
12	0 (0%)	25 (100%)	

Table 2. Influence of number of FTUs on masticatory performance.

Variable	N (%)	Mean (SD)	p-value
Number of FTUs			
8–11	10 (40%)	3.12 (0.05)	0.096
12	25 (100%)	4.54 (0.83)	

Table 3. Average masticatory performance of the control group (FTUs 12) and test group (FTUs 8–11).

Variable	Mean (SD)	p-value
Masticatory Performance		
Men	2.67 (1.07)	0.169*
Women	3.31 (0.50)	
Masticatory Performance		
Young Adults (20–39)	3.56 (0.65)	0.245**
Adults (40–59)	2.78 (0.92)	
a. Elderly (over 65)	2.96 (1.13)	

Table 4. Influence of gender and age on masticatory performances. * Mann-Whitney U Test ** Kruskal-Wallis.

A Mann—Whitney test was performed to determine the influence of gender on masticatory performance. Table 4 shows a p-value of 0.169 ($p>0.005$), indicating that there is no significant difference in the masticatory performance of men and women. This means that gender does not influence masticatory performance. A Kruskal–Walls test was used to identify differences in the masticatory performance of each age group. The p-value for this test was 0.245, indicating that age has no significant effect on masticatory performance. The color variations of the boluses of mixed colors of gum chewed by each subject were also examined. Mastication performance grade 5 means that the gum colors mixed perfectly and evenly to purple in the bolus. In the visual color scale, every masticatory performance grade results in a different color bolus, ranging from dark purple to light bluish purple. The following color variations were used in this study:

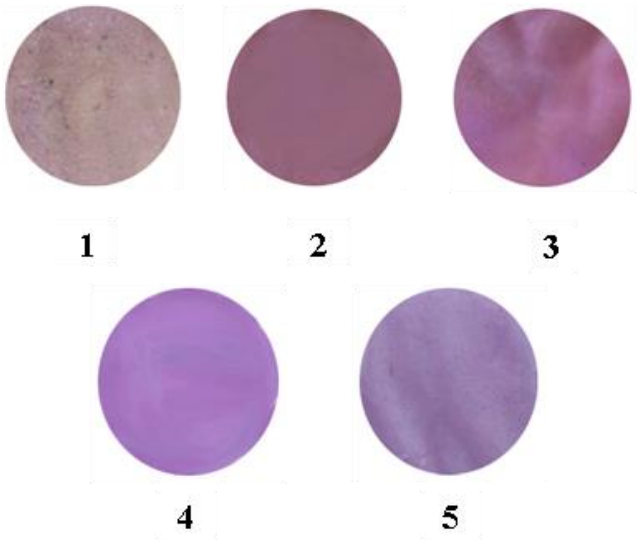

Figure 1. Color variations indicating masticatory performance grades 1–5

Discussion

According to the univariate analysis, the mean number of FTUs required for good masticatory performance is 7.6, including at least one contacting pair of molars and all pairs of premolars on the right and left sides, two contacting molar pairs (one on each side), and one contacting molar pair on one side and one contacting premolar pair on both sides. This result is similar to those of Ueno et al., who found that Japanese subjects with an average of eight FTUs have no difficulty chewing food, but subjects with four FTUs have some difficulty.[9] In contrast, Hsu et al. found that Taiwanese subjects with four FTUs were able to perform good mastication.[4] Several factors can affect the average number of FTUs needed for good masticatory performance. One of these factors is the subject's characteristics, as determined by diet selection. Subjects who often eat hard foods have strong masticatory muscles. Diet can also affect the temporomandibular joints.

Different studies might also have different results due to subject selection. Another possibility is the differences among data frequency on each group that has good and has masticatory performance. Averages were calculated to analyze the data, but it is possible that many subjects in some studies have a high number of FTUs, resulting in a higher average. It may be assumed that every study included subjects with various numbers of FTU, but each is still only valid for certain populations. The results of some studies on the effect of FTUs on mastication cannot be generally applied because the subject pools were too small or too homogenous. Nevertheless, studies on the effect of the number of FTUs on mastication can still be considered in masticatory rehabilitation. An analysis of descriptive statistics suggests that subjects with 2.9 FTUs have poor masticatory performance. According to Naka et al., dentures are recommended to increase the number of FTUs in patients with fewer than three FTUs.[7] Oral practitioners can certainly use such studies to suggest treatment plans and patient prognoses.[7]

This study examines the correlation between the number of FTUs and masticatory performance. A high number of FTUs improves masticatory performance. This study also found that the masticatory performance of the test group (8–11 FTUs) was as good as that of the control group (12 FTUs). This is because masticatory performance was not a criterion for dividing the subjects. The average masticatory performance grade in control group was higher than that of the test group, but both groups still demonstrated good masticatory performance. There were, however, differences in the masticatory performance of the groups according to the gum color mixing test. The mixing gum boluses of the control group were dark purple, while the test group had bluish purple boluses. The limitations of the visual color scale caused all the boluses to be categorized in the same grade, but the color differences indicate some differences in masticatory performance. However, this could also be due to a research bias in this study due to small number of subjects and differences in color perception.

This study found that gender had no influence on masticatory performance. In contrast, Park et al. found that women have less bite force and masticatory strength than men. [11] Hormones affect masticatory muscle fiber activity in men. During puberty, bite force increases in men and remains constant in women. Men's teeth are also bigger, increasing their bite force still more. Tooth strength correlates positively with masticatory performance. [12] Generally, men have more bite force than women and chew faster for a shorter time. The use of an electromyographic (EMG) to measure masticatory performance based on masticatory

muscle activity indicates that men have more EMG activity per cycle which has greater vertical amplitude than that of women. There are also no significant differences in the pattern of mandibular movement during mastication in men and women.[13] Different studies have different results due to different tooth conditions in the subjects. In some studies with results contradicting those of this study, the subjects were homogenous and had no tooth loss. Studies with similar results to this one including subjects with various conditions and amounts of tooth loss. Bite force can be used to predict masticatory performance, but in subjects with various tooth conditions, its correlation with masticatory performance is insignificant compared to the number of FTUs. This is also supported by a study that found that different conditions of occlusion cause no significant differences in masticatory performance in men or women.[12]

Another factor examined in this study is age. In this study, age has no significant relationship to masticatory performance. The risk of decreased masticatory performance as a result of aging is caused by physiological changes, such as decreased bite force, decreased salivary flow rates, and increased risk of tooth loss due to systemic conditions.[1] In women, bite force decreases after the age of 25; in men, it decreases after the age of 45. Masticatory performance can be significantly affected by bite force as a person ages.[11] However, ageing itself does not impair mastication abilities.[14] Elderly patients can perform good mastication if they have as many occlusion contacts as younger patients. Therefore, healthy elderly patients with no systemic disease experience no significant reduction in masticatory performance.[1] It is also possible that this study found no difference among the three age groups because the elderly group included a small number of subjects. This means that the elderly group was less representative of the population, and the results could be biased. However, this study found that masticatory performance in elderly patients with no systemic disease is as good as that of adults with the same number of FTUs.

Conclusion

From this study, it can be concluded that good mastication can be performed with a minimum mean of 7.5 FTUs. There was no significant difference in the number of FTUs between the control group and the test group, and age does not directly affect masticatory performance. Further studies on the effect of the number of FTUs on masticatory performance should include a large number of subjects to obtain more accurate results. Additional confounding factors such as bite force, salivary flow rate, and individual characteristics should be considered as well so that the variables that define masticatory performance can be determined. In future studies, software such as Adobe Photoshop or View Gum could be used to evaluate color mixing in gum boluses; this would enable more accurate assessment of color mixing. Further studies could also use more defined color scale variations to classify masticatory performance as excellent, good, fair, bad or very bad.

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Declaration of Interest

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