Original article

Evaluation of occlusal force and masticatory performance in elderly adults with natural dentition unaffected by occlusal support

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Abstract

Purpose: This study aimed to clarify whether occlusal force and masticatory performance reduced in elderly adults and whether these parameters were affected by age.

Methods: Seventy-eight elderly adults (elderly group) and 76 young adults (control group) with natural dentition were asked to maximally clench for 3 s, and occlusal force was calculated. The amount of glucose extraction after chewing a gummy jelly was measured as the parameter for masticatory performance. Occlusal force and masticatory performance were compared between the elderly and control groups. The correlation between age and occlusal force and between age and masticatory performance was also investigated.

Results: Occlusal force was significantly smaller in the elderly group ($P < 0.05$). Masticatory performance was lower in the elderly group, but this difference was not statistically significant. No significant correlation was observed between age and occlusal force in the control group, but a negative correlation was found in the elderly group ($P < 0.05$). No significant correlation was found between age and masticatory performance in either group.

Conclusion: Occlusal force was affected by age and reduced significantly, whereas masticatory performance was not affected by age and was maintained in elderly adults.

Keywords; elderly adults, masticatory function, masticatory performance, occlusal force

Introduction

Since one of the main purposes of dental treatment is recovery of masticatory function, numerous attempts have been made to evaluate it. Objective measurements of masticatory function include assessing occlusal force, masticatory performance, masticatory muscular activity, and masticatory movement. Of these, occlusal force and masticatory performance have been widely used to evaluate masticatory function because they can be measured relatively easily [1-22].

It has been reported that occlusal force is significantly associated with occlusal support and gender rather than age [2,3]. Some studies investigating occlusal force in elderly adults with relatively good occlusal support reported that it was not affected by age [5,11]. Another study comparing occlusal forces between young adults (22.7 ± 1.5 years old) and older adults (54.1 ± 6.4 years old) with complete natural dentition, although not a study of the elderly, reported that there was a significant difference between the two groups with respect to the second premolar region [1]. On the other hand, significant associations have been reported between masticatory performance and both occlusal support and occlusal force [2,3,15]. It has also been reported that masticatory performance significantly reduced even in cases where only the second molar was missing [17]. These findings

indicate that to evaluate occlusal force and masticatory performance in the elderly, occlusal support must be carefully considered. Therefore, occlusal force and masticatory performance need to be investigated in individuals with complete natural dentition presenting no change in occlusal support.

This study aimed to clarify masticatory function in elderly adults by analyzing occlusal force and masticatory performance of young and elderly adults with complete natural dentition. Examining masticatory function in the elderly and young adults is clinically significant because it helps to clarify whether the two should be evaluated separately when analyzing masticatory function. The hypothesis tested was that masticatory function in elderly adults, evaluated by occlusal force and masticatory performance, was lesser than that of young adults.

Materials and Methods

Ethics statement

This study was conducted in accordance with the principles of the Declaration of Helsinki. All experimental procedures were approved by the Ethics Committee of The Nippon Dental University (NDU-T2012-29). Informed consent was obtained from all participants after explaining the study protocol and methods.

Subjects

Seventy-eight elderly adults (elderly group: 35 males and 43 females, average 75.8 years old) aged 65 years or older and 76 young adults (control group: 34 males and 42 females; 21 to 49 years old; average 34.4 years old) participated in this study. The selection criteria were: 1) no clinical abnormalities in the masticatory system, 2) natural dentition, with the possible exception of the third molars, and 3) no complaints regarding occlusion.

Experimental design

Before the experiment, the habitual chewing side was defined by asking the subjects to chew a gummy jelly freely and pick the side on which chewing was easier. Subjects were then asked to clench their jaw maximally for approximately 3 seconds, and occlusal force on their habitual chewing side was calculated as a parameter for occlusal force. Next, the amount of glucose extraction after chewing a gummy jelly on the habitual chewing side for 20 s was measured as a parameter for masticatory performance. The occlusal force and masticatory performance were recorded once.

Occlusal force

A prescale of appropriate size (Dental Prescale II, GC Inc., Tokyo, Japan) was inserted into the oral cavity such that the entire dentition would fit on the film. Subjects were asked to maximally clench in the intercuspal position for about 3 seconds, and were instructed to exert maximum strength that could be sustained according to the method reported by Shiga et al. [22]. Then, the occlusal force on the habitual chewing side after cleaning was calculated using an occlusal force analyzing system (GC Inc.).

Masticatory performance

Subjects were asked to chew a gummy jelly (Glucolumn, GC Inc.) on their habitual chewing side for 20 seconds, and then hold 10 mL of water in their mouth and spit into a cup with a filter. The filtrate in the cup was collected as a test sample, and the glucose concentration was measured using a glucose measuring device (GS-II, GC Inc.). The measured value was used as the amount of glucose extraction.

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Table 1 Comparison of occlusal force between elderly and young group in male and female

	Mean (N)	SD	P-value
Male			
Young group	600.8	192.5	0.024*
Elderly group	506.1	144.5	
Female			
Young group	495.5	144.3	0.009**
Elderly group	422.1	108.0	

* $P < 0.05$; ** $P < 0.01$ **Table 3** Correlation between occlusal force and aging in male and female

	Correlation coefficient	P-value
Male		
Young group	0.005	0.977
Elderly group	-0.404	0.016*
Female		
Young group	-0.007	0.967
Elderly group	-0.459	0.002**

* $P < 0.05$; ** $P < 0.01$

Statistical analysis

All data were analyzed using Statistical Package for the Social Sciences for Windows 15.0 J (SPSS, Chicago, IL, USA). Occlusal force and amount of glucose extraction on the habitual chewing side were compared between the elderly and control groups. The correlation between age and occlusal force and between age and masticatory performance were investigated in both groups. After confirming normality by the Shapiro-Wilk test, an independent *t*-test was used to compare values between the two groups, and Pearson's correlation coefficient was used to evaluate the correlation between age and both occlusal force and masticatory performance. A *P*-value < 0.05 was considered significant in all analyses.

Results

Occlusal force was smaller in the elderly than in the control group, with statistically significant differences between the elderly and control groups (males: $P = 0.024$, females: $P = 0.009$) (Table 1). Masticatory performance was lower in the elderly than in the control group, but no significant differences were observed between them (Table 2). No significant correlation was found between age and occlusal force in the control group, but there was a negative correlation in the elderly group (males: $P = 0.016$, females: $P = 0.002$) (Table 3). No significant correlation was found between age and masticatory performance in the control and elderly groups (Table 4).

Discussion

Similar to a dominant hand, humans have a habitual chewing side on which chewing is easier and show a functional difference compared with the non-habitual side [4,23]. Recently, the habitual chewing side has come to be used when evaluating masticatory performance [9,10,17]. Therefore, in this study, the habitual chewing side was selected as the side for evaluating masticatory function (occlusal force and masticatory performance). Although not analyzed in this study, many parameters, such as grip strength, oral quality of life, masticatory score, and nutritional status were recorded. Therefore, though it is desirable to consider the average of multiple records to evaluate occlusal force and masticatory performance, only one record was used.

A number of researchers investigated factors related to masticatory function (occlusal force and masticatory performance), and reported that masticatory function is more affected by occlusal support and gender than by age [2,3,15]. However, these studies also included subjects with insufficient or missing occlusal support. Therefore, in order to clarify the relationship between masticatory function and age, it is necessary to eliminate the influence of occlusal support and gender. Therefore, in this study, subjects with a complete natural dentition were selected to eliminate the effects of occlusal support. Moreover, to eliminate the influence of gender, the analysis was performed by distinguishing between males and females.

Table 2 Comparison of masticatory performance between elderly and young group in male and female

	Mean (mg/dL)	SD	P-value
Male			
Young group	234.1	39.8	0.083
Elderly group	218.7	32.8	
Female			
Young group	208.1	25.3	0.118
Elderly group	199.7	23.4	

Table 4 Correlation between masticatory performance and aging in male and female

	Correlation coefficient	P-value
Male		
Young group	0.041	0.817
Elderly group	-0.212	0.223
Female		
Young group	-0.004	0.979
Elderly group	-0.199	0.200

Chong et al. [11] investigated occlusal force in young and elderly adults with ≥ 20 teeth and found no significant difference between the two groups. However, according to their results, young adults presented larger occlusal force as compared to elderly adults. They also found that occlusal force in elderly adults varied widely (185 to 1,200 N). Since all subjects had ≥ 20 teeth, some may have had insufficient occlusal support (small occlusal force), which could be the cause of the large variation in force. This presumably affected the results, and there was no significant difference between the two groups. Based on these findings, it is impossible to conclude that there is no relationship between occlusal force and age. Therefore, it is necessary to examine participants with complete natural dentition, as done in this study. This study investigated the occlusal force in elderly and young adults with complete natural dentition and found that it was significantly smaller in the elderly than in young adults. Regarding the relationship between age and occlusal force, no significant correlation was found in young adults, but a negative correlation was found in the elderly group. From the results of this study and the reports that physical strength and muscle strength decrease with age, it can be concluded that the occlusal force in elderly adults, even in those with complete natural dentition, decreases with age.

Kosaka et al. [15] classified elderly adults into three groups (Eichner A to C) and investigated factors related to masticatory performance in each group. They reported that masticatory performance was significantly associated with occlusal force in all groups. Based on this result and the fact that occlusal force in elderly adults is significantly reduced, it is expected that masticatory performance may also reduce significantly. Tanaka et al. [17] classified elderly adults into five groups with occlusal support of the molars and investigated masticatory performance in each group. They reported that masticatory performance was significantly reduced even with the loss of a single second molar. To evaluate masticatory performance in elderly adults thoroughly, those with complete natural dentition need to be studied. Therefore, this study compared masticatory performance of young and elderly adults with complete natural dentition. Elderly adults had a lower masticatory performance than that of young adults, but the difference was not significant. Moreover, no significant relationship between age and masticatory performance was found in either of the groups. As this result differed from that of occlusal force, it is considered that mastication is not performed using maximum muscle force [24]. Even if there is a decrease in muscle force with age [6,14], it can be assumed that since the muscle force required for mastication can be exerted fully, there was no significant decrease in masticatory performance. Therefore, masticatory performance can be maintained with a complete natural dentition.

In this study, only 78 elderly adults (35 males and 43 females) were analyzed because the selection condition of the study was to have a complete natural dentition. Therefore, further investigations with a larger sample are warranted.

Conflict of interest

The authors declare that they have no conflict of interest.

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