Original

Relationship between Oral Function and Occlusal Bite Force in the Elderly

Naoko Imagawa1, Nahoko Kato-Kogoe2, Kei Suzuki3, Michi Omori4, Yoshifumi Suwa5, Kazuya Inoue6, Hiroyuki Nakano7, Kayoko Yamamoto8, Kuniyasu Kamiya9, Satoyo Ikehara9, Masaaki Hoshiga10, Junko Tamaki10, Ryo Kawata10 and Takaaki Ueno1

Introduction
In the present treatment of oral cancer, hard tissue reconstruction is required. Recently, bone grafts with vascularized free flaps have been developed, and this technique enables sufficient recovery of oral function.1-4 On the other hand, concern about personal oral function management (oral health literacy) decreases in older adults, and they enter either the pre-frail stage, in which caries and periodontal disease progress and the number of remaining teeth decreases, or the oral frailty stage characterized by worsening eating habits as oral function declines. Therefore, it is important to reconstruct hard tissue and maintain oral function, particularly in older adults. Although there have been many reports on bone reconstruction techniques, reports on oral function standardization for jaw reconstruction are limited.

In this study, we report on the relationship between oral function and occlusal bite force in the elderly.

Materials and Methods
Subjects
Subjects of the present study were 53 men and 55 women aged 60 years or older living in Takatsuki City (108 subjects). They were given the following examination in November 2017.

Examination items
After individual interviews, subjects were given oral examinations by dentists. Their age and sex were recorded as basic attributes. In addition, the level of dental health, masticatory performance and oral function were assessed.

Oral environment
- Number of teeth
- Probing periodontal pocket depth
- Number of teeth with bleeding

Masticatory performance indicators (maximum occlusal force, gummy jelly score, time required for 30 chews)
- Maximum occlusal force: Maximum occlusal force was measured once for each side using a simple occlusal force measuring device (Occlusal Force Meter GM10; Nagano Keiki Co., Ltd., Tokyo, Japan) to find the maximum value for each subject.
- Gummy jelly score: Gummy jelly score was used to assess mastication ability. To obtain gummy jelly scores, each subject chewed one test gummy jelly as the chewing sample (UHA Mikakuto Co., Ltd., Osaka, Japan) 30 times, and then spit the comminuted pieces onto a gauze cloth. The pieces were transferred to a transparent petri dish and used as samples for visual inspection by two evaluators who visually compared the size of the pieces in the same sample on a scale of 1 to 10 in order to obtain a masticatory performance score.5 If the scores of the two evaluators differed, the higher score was used.
- Chewing time: The time required for 30 chews was measured by the time (in seconds) spent chewing 30 times.

Oral function indicators
- Tongue pressure: Tongue pressure was measured using a tongue...
pressure measuring device (JMS tongue pressure measurement device; Morita Corporation, Tokyo, Japan).

Salivary flow rate: The amount of saliva was measured by the Saxon test; rolled cotton was chewed for 2 minutes, and the weight of the rolled cotton was measured.

Lip pressure: Lip pressure was measured using a lip pressure measuring device (LDC-110R Lip De Cum lip force measurement device; Ducklings, Cosmo Instruments Co., Ltd., Tokyo, Japan) (Fig. 1).

Correlations between two variables
Correlations were assessed between the bivariables of age, number of teeth, maximum occlusal force, gummy jelly score, chewing time, lip pressure, tongue pressure and saliva flow rate.

Ethical considerations
The study was approved by the Ethics Committee of Osaka Medical College (approval #2309), and subjects provided informed consent for oral examinations and oral function assessments.

Statistical analysis
We conducted statistical analysis with Spearman’s rank-order correlation coefficient in order to evaluate the associations between indicators of masticatory performance and oral function. Gender differences were examined by Mann-Whitney U test. The level of significance was \( p < 0.05 \).

Results

Oral environment
Number of teeth: The mean number of teeth was \( 19.9 \pm 8.8 \) (range: 0 to 28). The average for male and female subjects was \( 17.9 \pm 9.3 \) and \( 21.8 \pm 8.0 \), respectively.

Probing periodontal pocket depth: Subjects were divided into two groups; the 4 to 6 mm group, and the over 6 mm group. In the 4 to 6 mm group, the average number of teeth was \( 2.0 \pm 2.5 \). The average for male and female subjects was \( 2.2 \pm 2.8 \) and \( 1.8 \pm 2.2 \), respectively. In the over 6 mm group, the average number of teeth was \( 1.1 \pm 2.2 \). The average for male and female subjects was \( 1.2 \pm 2.1 \) and \( 1.1 \pm 2.2 \), respectively.

Number of teeth with bleeding: The average number of teeth with bleeding was \( 4.4 \pm 5.4 \) (range: 0 to 21). The average for male and female subjects was \( 4.2 \pm 5.4 \) and \( 4.7 \pm 5.5 \), respectively.

Masticatory performance indicators
Maximum occlusal force: The average maximum occlusal force was \( 313.5 \pm 234.9 \) N (range: 11 to 1090 N). The average for male and female subjects was \( 338.3 \pm 266.2 \) N and \( 289.6 \pm 199.6 \) N, respectively.

Gummy jelly score: The average gummy jelly score was \( 4.1 \) (range: 0 to 9). The average for male and female subjects was \( 4.2 \pm 2.4 \) and \( 4.1 \pm 2.2 \), respectively.

Chewing time: The average chewing time was \( 28.5 \pm 10.0 \) s (range: 17 to 67 s). The average for male and female subjects was \( 28.3 \pm 11.0 \) s and \( 28.6 \pm 9.2 \) s, respectively.

Oral function indicators
Tongue pressure: The average tongue pressure was \( 26.3 \pm 9.0 \) kPa (range: 2.4 to 44.8 kPa). The average for male and female subjects was \( 26.6 \pm 8.3 \) kPa and \( 26.0 \pm 8.3 \) kPa, respectively.

Amount of saliva: The average saliva flow rate was \( 1.5 \pm 0.93 \) g (range: 0.2 to 4.7 g). The average for male and female subjects was \( 1.8 \pm 1.0 \) g and \( 1.2 \pm 0.7 \) g, respectively.

Lip pressure: The average lip pressure was \( 12.8 \pm 7.1 \) kPa (range: 0.8 to 28). The average for male and female subjects was \( 17.9 \pm 9.3 \) and \( 21.8 \pm 8.0 \), respectively.

Figure 2. Correlation between maximum occlusal force and gummy jelly score. We conducted statistical analysis with Spearman’s rank-order correlation coefficient. \( r_s \): Spearman’s rank correlation coefficient, \( *: p<0.001 \). There is a positive correlation between maximum occlusal force and gummy jelly score.
Correlations between two variables

A negative correlation was seen between number of teeth and age (p<0.05). Positive correlations were seen between maximum occlusal force and gummy jelly score, maximum occlusal force and tongue pressure, maximum occlusal force and lip pressure, number of teeth and maximum occlusal force, and number of teeth and gummy jelly score (p<0.05) (Figs 2, 3, and 4).

Discussion

It has been reported that the incidence of oral cancer in Japan is greatest in people in their 60s, and that the number of oral cancer diseases is also increasing with the aging of the population. Recently, it has also been reported that good oral function was observed with bone graft with vascularized free flap and dental implant treatment. Nakajima et al. and Nokubi et al. reported good results when evaluating the chewing function of patients using gummy jelly after oral cancer surgery. Although there have been many reports on bone reconstruction techniques, reports regarding oral function standardization for jaw reconstruction are limited.

Hirao et al. studied 104 elderly females without severe decreases in cognitive function and who participated in physical fitness sessions. Occlusal force was found to be 232.7±181.2 N, which is similar to our results. On the other hand, Utanohara et al. reported that the average maximum tongue pressure was 37.6±8.8 kPa in subjects in their 60s and 31.9±8.9 kPa in subjects in their 70s. In addition, male subjects in their 20s, 30s and 40s showed significantly higher tongue pressures than their female counterparts; however, there were no statistically significant sex differences in the 50s, 60s or 70s. Our values were lower than Utanohara’s because the subjects of Utanohara’s research maintained occlusal contact in all premolar and molar regions (Class A in the Eichner index). Ikebe et al. reported that declines in posterior occlusal contact and occlusal force appear to be associated with masticatory performance with aging in older adults. In this study, the amount of saliva decreased, but occlusal force did not decrease. We believe that it is necessary to further assess the relationship between amount of saliva and occlusal force.

Some factors suggested to influence masticatory function are a large number of teeth and sufficient dental occlusion, as well as sufficiently strong occlusal force to enable biting apart and grinding food. In other words, it can easily be conjectured that a strong occlusal force would enable sufficient mastication and, conversely, a weak occlusal force would make mastication more difficult. Statistically, a significant positive correlation has been observed between occlusal force and masticatory performance, and it has been suggested that strong occlusal force is an important condition for achieving sufficient masticatory function. Moreover, a negative correlation was observed between number of teeth and age in the present study. Kono et al. and Miura et al. found that there is a significant association between maximum lip pressure and level of long-term care need, and that maximum lip pressure decreases with increasing severity of long-term care need. This suggests that there is a very close relationship between loss of lip closure force and decrease in activities of daily living. In the field of oral health, the aim of hard tissue reconstruction is restoring good oral function. Further research is necessary in order to confirm the utility of these methods in evaluating hard tissue reconstruction in the future.

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Conflicts of Interest
The authors have declared that no COI exists.

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