The aim of this study was to clarify the relationship between partially edentulous pattern and the masticatory function in removable partial denture wearers.

Eighty eight removable partial denture wearers and 7 subjects with intact dentition volunteered for this study.

Using the Eichner’s index, all subjects were divided into 6 groups. Electromyographic (EMG) activities of the masticatory muscle were recorded during chewing a piece of raw carrot. The masticatory function was analyzed by using the variation coefficient (VC) of the time parameter of EMG interval recorded during mastication.

The association of the VC with group classification based on Eichner’s index was analyzed using analysis of covariance with gender and age as the covariates.

The result of the analysis revealed that the VC was significantly associated with group classification and the patients in groups without posterior occlusal supports exhibited significantly higher VC values than those in groups with posterior occlusal supports.

These findings suggested that the reduced function in patients without the posterior occlusal contacts was difficult to attain improved and satisfactory outcome with removable partial dentures and that there is a significant need for posterior occlusal support for the preservation of masticatory function.

Key words: Electromyography, removable partial denture, masticatory function, Eichner’s index, occlusal support

Introduction

One of the main reasons for prosthodontic treatment is to restore masticatory function for functional impairment due to the loss of teeth. Since evaluations for functional impairments are subjective in the clinical settings, indication and selection of a treatment modality may be dependent on the experience or preference of the clinician. Furthermore, even if prosthodontic treatments are indicated, clinicians are not able to provide the patients with objective information on how far the impaired function can be restored with prosthodontic treatment.

In literature, the subjectively evaluated masticatory function has been reported to be closely related with the number of remaining natural teeth. Direct measurement of the capacity to reduce the test food to small particles also verified that chewing efficiency decreases as natural occlusion deteriorates, and worsens in subjects with complete dentures. These study results suggested that the status of the dentition appears to be an important factor which has direct effect on chewing efficiency. Especially, some of the studies suggested that the existence of the occlusal support is the key to the preservation of the masticatory function, which is consistent with the widely
accepted concepts of mastication by clinicians. Unfortunately, in these tests, the pattern of tooth loss has never been investigated in detail and the information on reduced masticatory function in denture wearers in relation to the occlusal support is limited. This information, however, is important for the diagnosis of the patient’s present condition and the estimation of oral function after prosthodontic treatment with removable partial dentures. In other words, objective evaluation data of masticatory function in relation to the state of dentition will be of great help for making clinical decisions or prediction of the treatment outcomes when clinicians provide prosthodontic treatments for these patients.

The aim of this study was therefore to clarify the relationship between partially edentulous pattern and the masticatory function in removable partial denture wearers. In this study, the evaluation of the masticatory function was performed using the variation coefficient (VC) of the time parameter of electromyographic (EMG) activity of the jaw closing muscle, which evaluates the smoothness of mastication. The null hypothesis of this study was “Masticatory function as measured by the VC is not related to the dental status”.

Materials and methods

Subjects:
Eighty eight removable partial denture wearers (60 females and 28 males, aged from 31 to 77, mean age of 61.2±9.1) and 7 subjects (4 females and 3 males, aged from 25 to 73, mean age of 50±20.6) with intact dentition volunteered for this study after obtainment of informed consent. They were recruited from patients registered at the Tokyo Medical and Dental University Dental Hospital between the period of years 2000 to 2003. This project was approved by the Institutional Review Board for Human Subjects Protection at the Tokyo Medical and Dental University. Inclusion criteria for the denture wearing subjects were (1) good general health, and (2) presently wearing partial denture with clasp for more than 1 month after completion of final adjustment. Exclusion criteria were (1) any sign or symptom of temporomandibular joint disorders and/or masticatory muscle dysfunction, (2) presence of established or confirmed acute dental disease, and (3) presence of removable partial denture with attachment. As for the controls, the inclusion and exclusion criteria were the same as for the denture wearing subjects with one exception. The inclusion criterion (2) was replaced by “intact bilateral molar occlusal contacts with no missing tooth (excluding 3rd molars)”.

Evaluation of the state of dentition:
The number of teeth, which had the antagonist was counted and called occluding pair, where a fixed bridge was regarded as a valid antagonist. The maximum number of occluding pair in a 28 tooth dentition was thus 14.

Furthermore using Eichner’s index, all subjects were divided into 6 groups, depending on the distribution of occluding pairs (Table 1). The Eichner’s index is based on the existence of occlusal contacts of the premolars and the molars, which is called supporting zones. A maximum of 4 supporting zones can exist where at least one tooth must be in contact with an antagonist in both the molar and premolar areas. In this study, there was no patient in groups A2 and A3. Group C1 and C2 were combined because of the low number of subjects in each group.

A1; full occlusal support
B1; 3 supporting zones

<table>
<thead>
<tr>
<th>Group</th>
<th>gender</th>
<th>N</th>
<th>Age</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Male</td>
<td>4</td>
<td>46.3</td>
<td>22.0</td>
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<tr>
<td></td>
<td>Fe</td>
<td>3</td>
<td>55.3</td>
<td>21.8</td>
</tr>
<tr>
<td></td>
<td>(Total)</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>Male</td>
<td>13</td>
<td>59.7</td>
<td>11.7</td>
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<tr>
<td></td>
<td>Fe</td>
<td>17</td>
<td>57.1</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td>(Total)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>Male</td>
<td>6</td>
<td>61.2</td>
<td>11.3</td>
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<tr>
<td></td>
<td>Fe</td>
<td>18</td>
<td>60.6</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td>(Total)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>Male</td>
<td>3</td>
<td>66.7</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>Fe</td>
<td>4</td>
<td>64.5</td>
<td>7.5</td>
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<tr>
<td></td>
<td>(Total)</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>Male</td>
<td>3</td>
<td>63.3</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>Fe</td>
<td>14</td>
<td>66.1</td>
<td>6.6</td>
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<td>C</td>
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<td>3</td>
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<tr>
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<td>Fe</td>
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<td>62.9</td>
<td>8.9</td>
</tr>
<tr>
<td></td>
<td>(Total)</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Age and gender distribution of subjects
B2; 2 supporting zones  
B3; 1 supporting zone  
B4; anterior tooth contacts with no supporting zone  
C; no occlusal contact with a few remaining teeth

**EMG Recordings:**

EMG activities of the masseter and the anterior temporal muscles were recorded bilaterally using disposable bipolar surface electrodes with a fixed inter-electrode distance of 15 mm. Electrode placements were selected by palpation of the muscles prior to measurement. Skin impedance was reduced by alcohol scrub. A ground electrode was attached to the forehead. The 4 channel raw EMG signals were amplified 100 times with a portable EMG preamplifier (ARC2EMG1, Teac), sampled at the rate of 1 kHz and digitized with a 16-bit resolution, and stored in a PC card recorder (DR-C2, Teac). Simultaneously, these data were transferred to a laptop personal computer for monitoring of signals using a custom-made software.

After commencement of the EMG recording, subjects with removable partial denture were asked to clench their teeth at their maximum voluntary contraction level. They were then asked to chew a fresh raw carrot equally cut with dimensions of $13 \times 13 \times 13$ mm in a habitual manner until swallowing, which was conducted in triplicate.

**EMG Data Reduction:**

The stored 4 channel EMG data were analyzed using a semi-automated custom software program. First, the software performed rectification and smoothing of the data signal. Using the EMG signals from the right anterior temporalis muscle, all EMG periods above a minimum threshold level were identified as potential EMG burst periods. The threshold level was set at 20% of each subject’s individually established maximum voluntary contraction level. Then data adjustment was performed to adjust any possible misidentifications of EMG burst due to EMG signal artifact. This involved displaying of conditioned EMG data signals on the computer screen and 2 scorers, who were trained for their ability to precisely discriminate artifact signals from the EMG burst and to evaluate the data. Every EMG burst onset and offset that was judged and identified to be an artifact onset or offset was adjusted in a blind-to-subject-status fashion. The scorers were allowed to refer to other 3 channel signals during this procedure. Every period between the offset of each EMG burst to the onset of the next EMG burst was counted and named as EMG interval.

Finally using the means and standard deviations of EMG intervals for 10 strokes after the third stroke of chewing, the variation coefficient value (VC) was calculated as described with the following formula, 

$$VC = \frac{\text{standard deviation}}{\text{mean}}.$$  

**Statistical analysis:**

A two-sample t-test was used to evaluate differences between males and females.

And, the relationship between the VC and the number of occluding pair was demonstrated in the correlation model. Since each subject’s gender and age were considered confounders of the relationship, partial correlation coefficient between the VC and the number of occluding pair after adjustment of gender and age was calculated.

Furthermore association of the VC with group classification based on Eichner’s index was analyzed using analysis of covariance (ANCOVA) with gender and age as the covariates. Multiple comparisons among the groups were made using Bonferroni adjustment.

All statistical analyses were performed using a statistical software package with the probability of type I error set at the 0.05 level. (SPSS Japanese, version 11.0).

**Results**

Table 2 shows the VC of males was significantly lower than those of females.

Partial correlation between the VC and the number of occluding pairs after adjustment of gender and age was significant \(r = -0.691, p < 0.001\).

ANCOVA with gender and age as the covariates demonstrated that VC significantly associated with group classification \(F = 13.34, P < 0.001\). Bonferroni adjusted multiple comparisons among the 6 groups revealed that the VCs of Groups B4 and C were significantly higher compared to those of Groups A1, B1, and B2 (Fig. 1).

<table>
<thead>
<tr>
<th>Table 2. Means of s.d. of the VC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Male</strong></td>
</tr>
<tr>
<td>(\text{mean} \pm \text{s.d.})</td>
</tr>
<tr>
<td>0.131 ± 0.0505</td>
</tr>
</tbody>
</table>

Two-sample t-test
Discussion

These data allowed us to reject the null hypothesis that “Masticatory function as measured by the VC is not related to the dental status”. Specifically, the number and distribution of occlusal supports had significant effects on the VC.

The strength of this study was the number of subjects enrolled and investigated, whom functional evaluations were performed using a method, which proved itself to be highly precise and accurate. These study aspects are important since even the best study in literature, which studied the chewing efficiency in 139 subjects, only examined 19 subjects with complete or partial dentures. Prior to this study, a much larger sample was investigated by using questionnaires. Unfortunately the correlation between the self-assessed chewing ability and chewing efficiency defined as capacity to triturate a test food is not very close, at any rate not in denture wearers. Many individuals with reduced dentition and dentures judged their masticatory function as good while a communication test will result in values much lower than those with complete natural dentition. It is probable that self-assessment of chewing ability is in general, too optimistic when compared with the results of objective functional tests.

In regard with the method of functional evaluation, the VC directly captures the smoothness of the chewing process and focuses on the process of comminuting foods, making bolus and deglutition, while traditional chewing tests focused exclusively on the chewed foods. Our previous study suggested that the VC has high reliability and validity for evaluation of masticatory function, which reflects the ease of chewing foods during mastication.

The result of this study demonstrated significantly lower VC value in male subjects, which reflects more rhythmical and smooth mastication in male subjects compared to the females. This is in consistent with the previous findings, which revealed a significant gender difference in masticatory performance and this might be due to gender difference in muscle strength.

As illustrated in the introduction section, masticatory function was reported to decrease as natural occlusion deteriorates. Although our study evaluated a different aspect of the masticatory function, the findings that the number of occluding pairs significantly associated with the decrease in VC value are in general agreement with these reports. Furthermore, the VC value in patients without posterior occlusal support resulted in consistently higher in comparison with those of patients with natural dentition or posterior occlusal supports, while presence of the anterior tooth support did not have any significant influence in patients without posterior occlusal support (group B4 and C). These findings partially support the previous study, which identified a significant relationship between the presence of...
occlusal support as evaluated with Eichner’s index and masticatory performance. Unfortunately, this study did not investigate the roles of anterior and posterior tooth support separately. Over all, our findings suggested that reduced function in patients without the posterior occlusal contacts can be hardly improved by removable partial dentures as in the function of patients with natural dentition and that these is a significant need for posterior occlusal support for the preservation of masticatory function.

In summary, this study suggested that the VC value has high availability for evaluation of masticatory function in removal partial denture wearers, which reflects the ease of chewing foods during mastication. And the results of this study greatly increased the level of comprehension of impaired masticatory function due to tooth loss and prediction of how far prostodontic treatments can improve the impaired function. Accumulation of these data will allow clinicians to objectively make clinical decisions and predict the treatment outcome in the future.

References