Evaluation of the Bite Forces in Patients with Unilateral Temporomandibular Disorders


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Most patients suffering from TMD appear to have unsatisfactory masticatory function and compromised values of bite force. The purposes of this study were to investigate and compare bite force between affected and unaffected sides of patients with unilateral TMD and to evaluate its relation with duration of TMD.

42 patients with unilateral TMD, from Department of Oral Medicine, Dankook University Dental Hospital, were selected for this study. The ratio of men to women was 9:33 and their mean age of 27.2±10.4 years. The bite forces were measured over both canines (for anterior bite force) and 1st molars (for posterior bite force) using a bite force recorder while all the subjects were asked to clench successively for 3 seconds not until pain was felt. They were compared with those measured from bilateral TMD patients (N=6, M:F=1:5, mean age: 23.0±27.3 years). The unilateral TMD patients were divided into time groups according to duration of TMD on the basis of 1 and 6 months, respectively. Paired and unpaired t-tests were used for statistical analysis.

Unilateral TMD patients in this study showed that the affected sides had significantly lower bite force than the unaffected sides (force difference of about 7-8 kgf, p<0.05) while there was no significant sides difference in the bilateral patients. Nor did bite force on the affected sides reveal significant difference between unilateral and bilateral TMD patients. With regards to TMD duration, there was significant difference between the patients with TMD < 6 months and ≥ 6 months (p<0.05) while no significant difference existed between < 1 month and ≥ 1 month.

The results of this study indicated that unilateral TMD patients can exhibit more reduced bite force on the affected sides compared with that on the unaffected sides and that bite force on the unaffected sides might be deteriorated more as longer did TMD last.

Key words : Bite force, Bite force recorder, Canine, 1st molar, Unilateral, Temporomandibular disorders

I. INTRODUCTION

Dental treatment is primarily aimed to restore oral function, especially mastication, which is closely related to quality of life. A common way to evaluate a patient’s masticatory function is clinical measurement of masticatory efficiency and occlusal force (or bite force). Factors reported to affect masticatory performance include age, dental status, salivary flow, temporomandibular disorder (TMD) and/or orofacial pain.

Bite force is exerted by the jaw elevator muscles and regulated by the nervous, muscular, skeletal and dental systems and measurement of the maximum bite force is an attempt to quantify the total force of the jaw elevator muscles. A close correlation between bite force and masticatory efficiency has...
been found in several studies\(^2\) and most of the patients suffering from TMD appear to have unsatisfactory masticatory function and compromised values of masticatory efficiency and bite force.\(^{11}\)

Patients with disturbances of the cranio-mandibular system such as pain from masticatory muscles and/or temporomandibular joint (TMJ) are reported to have lower maximal bite force values than healthy subjects.\(^{12,13}\) In the patients group studied by Helkimo et al\(^{12}\) bite force increased with palliation of the symptoms during treatment. However, no significant difference was reported between TMD patients and normal subjects by other authors.\(^{14-16}\) Most of these studies differ with regard to the diagnostic procedures and methodologies, which recommends special caution when comparing the different bite force measurements.\(^{16}\)

In assessing bite force, it is general that the maximum bite forces when left and right sides are totaled are higher than those found in the literature for unilateral biting.\(^{17}\) Bakke et al\(^{18}\) concluded that unilateral bite force is a simple clinical indicator of mandibular elevator strength as a whole, but inadequate to disclose asymmetric conditions. Nevertheless, unilateral bite force measurement might be helpful to demonstrate effect of unilateral TMD. Even though existence of some studies on side-to-side difference in bite force, it seems that there were not many concerning patients having TMD unilaterally and its effect on unilateral bite force value. The purposes of this study were to investigate and compare bite force between affected and unaffected sides of patients with unilateral TMD and to evaluate its relation with duration of TMD.

II. MATERIALS AND METHODS

A bite force recorder (SG 2001-1 Seokwang, Korea) used in this study consisted of two steel bars (SNCMB) that were supplied with strain gauge connected in Wheatstone bridge and a liquid crystal display (LCD) (Fig 1). It has a 4 mm–thick biting site, the actual loaded area by teeth tested. Load on the biting site produces proportional alterations of the resistance and results in electric changes in the circuit when applying DC voltage. The changes in the electric potential are transformed to force variable (kg) in the LCD panel. The biting site of the recorder has the width of 20 mm. It was designed to be used for a single pair of antagonizing teeth and, for clinical uses, silicone plates having thickness of 3.55 mm were attached to both sides of the biting site of the recorder in order to lessen metallic impact on teeth to be tested.

The recorder was calibrated with the loads of 50 and 100 kg at room temperature. The arithmetic mean value and standard deviation were calculated by five recordings at the loads given and the correlation coefficients were evaluated for each recorder: \(r=1.00, p=.000\).

42 patients presenting unilateral TMD, who sought the treatment at the Department of Oral Medicine, Dankook University Dental Hospital, were selected for this study. Ratio of male to female was 9:33 and their mean age was 27.2±10.4 years with a range of 12 to 56 years. Exclusion criteria included any dental condition which could deteriorate bite force (i.e., severe tooth and periodontal disease and large prosthesis of more and three-unit bridges). 6 patients with bilateral TMD (M: F=1:5, mean age:
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23.0±27.3 years) were also selected for comparison with the unilateral subjects.

The bite force of each subject was measured at anterior and posterior teeth, separately. For measurement of the posterior bite force, the bite force recorder was positioned between upper and lower first molars on each of both sides. After being asked to bite lightly for several times in order to be familiar with the recorder, the subject was instructed to clench and increase the force successively to the maximum strength for three seconds not until pain was felt.

Rest period of three-minute was given to avoid muscle fatigue and then anterior bite force measurements were done in the same way. The bite force recorder was placed between canines, followed by a short accommodation-period and forceful biting for three seconds.

All the measurement was performed twice on each measuring site and their mean value was determined. The measurement of the bite force for each subject was incorporated into clinical examination and all the measurement were done after receiving informed consent.

Statistical analysis was performed by means of SPSS Window Program ver.12.0. Paired t-test was used to evaluate any difference of the maximum bite force between the affected and unaffected sides of TMD patients. Unpaired t-test was used to determine difference between unilateral and bilateral TMD patients and between TMD duration groups. The level of statistical significance was given when p=0.05.

### Table 1. Comparison of the bite forces between affected and unaffected sides.

<table>
<thead>
<tr>
<th></th>
<th>Unilateral</th>
<th></th>
<th>Bilateral</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anterior</td>
<td>Posterior</td>
<td>Anterior</td>
<td>Posterior</td>
</tr>
<tr>
<td>N</td>
<td>42</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Affected</td>
<td>57.36±21.25</td>
<td>78.46±17.14</td>
<td>57.55±23.89</td>
<td>81.60±9.93</td>
</tr>
<tr>
<td>Unaffected</td>
<td>64.47±20.01</td>
<td>86.49±12.89</td>
<td>61.23±18.55</td>
<td>83.03±10.86</td>
</tr>
<tr>
<td>Paired t-test</td>
<td>p=0.001</td>
<td>p=0.000</td>
<td>p=0.416</td>
<td>p=0.740</td>
</tr>
</tbody>
</table>

(Unit: kg force)

### III. RESULTS

Table 1 shows the maximum bite forces from affected and unaffected sides of the all subjects in this study. The affected side of bilateral patients was defined here as the side where the subject was suffering more. The maximum bite forces between 1\textsuperscript{st} molars were higher than those between canines either in unilateral TMD patients or in bilateral patients. In unilateral TMD patients, the anterior maximum bite forces between canines was 57.36±21.25 kg force on the affected sides and 64.47±20.01 kg force on the unaffected, symptom-free side and there was significant difference between them. (p=0.001) Posterior maximum bite of those patients was significantly lower on the affected sides (78.46±17.14 kg force) compared with the unaffected sides (86.49±12.89 kg force). (p=0.000) However, bilateral patients didn't exhibit significant difference between both sides regardless of bite force measuring site.

Neither anterior nor posterior region showed significant difference in strength when comparing the bite forces on the affected sides between unilateral and bilateral patients. (p=0.742 and 0.121, Table 2)

Relation of the maximum bite force with TMD duration was indicated in Table 3. Difference between the affected and unaffected sides was compared between the unilateral patients (N=39) categorized based on duration of TMD sign and symptoms. 3 out of 42 unilateral patients were dropped out because of their unidentifiable onset
Table 2. Comparison of the maximum bite forces on affected sides between unilateral and bilateral TMD patients.

<table>
<thead>
<tr>
<th></th>
<th>Anterior</th>
<th>Posterior</th>
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<tbody>
<tr>
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<td>Unilateral</td>
<td>Bilateral</td>
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<td>Affected</td>
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<td>57.55±23.89</td>
</tr>
<tr>
<td>Unpaired t-test</td>
<td>p=0.742</td>
<td>p=0.121</td>
</tr>
</tbody>
</table>

(Unit: kg force)

Table 3. Comparison of difference in maximum bite force between affected and non-affected sides related to duration of TMD.

<table>
<thead>
<tr>
<th></th>
<th>&lt; 1 month</th>
<th>= 1 month</th>
<th>Unpaired t-test</th>
<th>&lt; 6 month</th>
<th>= 6 month</th>
<th>Unpaired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>N=19</td>
<td>N=20</td>
<td></td>
<td>N=30</td>
<td>N=9</td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>-6.54±15.81</td>
<td>-7.84±14.86</td>
<td>p=0.793</td>
<td>-6.68±14.23</td>
<td>-8.96±18.74</td>
<td>p=0.698</td>
</tr>
<tr>
<td>Posterior</td>
<td>-10.06±14.45</td>
<td>-4.65±9.80</td>
<td>p=0.178</td>
<td>-9.42±12.26</td>
<td>-0.17±10.71</td>
<td>p=0.049</td>
</tr>
</tbody>
</table>

(Unit: kg force)

time. In the patients with TMD of less than 1 month (N=19), bite force difference in anterior tooth region was not different from those with TMD of more and 1 month (N=20). (p=0.793) However, sides difference of posterior bite force was higher in the group of < 1 month than the group of ≥ 1 month although there was no significant difference between them. (p=0.178) Based on duration of 6 months, the two duration group (< (N=30) and ≥ 6 months (N=9)) didn’t show significant difference in anterior tooth region. (p=0.698) On the while, the difference in posterior tooth region was significantly higher in the group of < 6 months compared with the group of ≥ 6 months. (p=0.049)

IV. DISCUSSION

In this study, all the subjects were asked to clench and increase the force successively to the maximum strength not until pain was felt, which mean the maximum bite force here can be called, in the strict sense, the maximum comfortable bite force. As patients had different tolerance of pain, some exerted the maximum force in spite of pain or discomfort but others did not to try increase the force maximally due to pain. These individual discrepancies might cause some trouble in collecting consistent data, which is why the patients were made maximum bite force not to provoke pain.

Another methodological consideration in this study is measurement site of bite force. The maximum bite force was supposed to assess on anterior and posterior region, respectively. The 1st molar was selected for the posterior bite force with regard to its ability to develop the greatest maximum bite force. Previous studies of ours usually employed central incisors as measuring site of anterior tooth region, but the they are likely too close to compare any side-to-side difference of bite force in the subjects with unilateral TMD. Thus canine was therefore selected.

The results of this study show that bite forces between 1st molars were higher than those between canines either in unilateral TMD patients or in
bilateral patients. (Table 1) Helkimo et al demonstrated that the maximum bite forces were greater when measured between molars than between incisors. The forces at the incisors are approximately a third of those measured at the molars and the reason could be that the molars have a larger supportive area and a favorable position close to the masticatory muscles. It seems, on the basis of our measurement, that bite force between canines is greater than that measured between incisors.

Previous studies have shown that patients with functional disturbances in the masticatory system present decreased bite force, when compared with healthy individuals. It is generally agreed that the bite force level is related to a number of physiological factors such as muscle strength, craniomandibular anatomy, and neuromuscular feedback mechanisms.

The maximum bite force could be reduced by pain in jaw-closing muscles or in the TMJ. Molin had already observed that the manifestation of the mandibular pain dysfunction syndrome in females determined lower forces, as a result of the more intense pain that they experienced on the affected side. A significant negative correlation was found between the signs and symptoms of TMD and bite force.

Unilateral TMD patients in this study exhibited more decreased strength on the affected side than the unaffected side, which was found both between canines (p=0.001) and between molars (p=0.000). There was sides difference of about 7-8 kgf in the unilateral patients while bilateral patients didn’t show significant sides difference. When comparing bite force on the affected sides of unilateral patients with that of bilateral patients, there was no significant difference between them. (Table 2) Although several authors indicated that no significant difference was found between the right and left sides in any of the groups assessed, many of them didn’t confine their subjects to those with unilateral TMD. In addition, TMD embraces a number of clinical problems that involves masticatory musculatures, temporomandibular joint (TMJ) and associated structures and, therefore, classification by affected structures is of important for evaluation and treatment of the disease.

It is widely accepted that pain affects jaw function, including a tendency to avoid movements or to perform them more slowly, and limits the ability to work against heavy loads. Some authors indicated that muscular tenderness in an influencing factor to reduce the maximum bite force. Pain in the masticatory muscles prevented the patients from exerting maximum bite force. Following hypertonic saline injection in the masseter muscles of subjects, Svensson et al found a decrease in maximum occlusal force and weakness of jaw closing muscle EMG activity. Pain conditions affecting the TMJ may be associated with a splinting reaction, which may serve to limit jaw movements, and with peripheral and central sensitization contributing to the pain. Experimental TMJ pain elicited by pressure has been reported to reduce jaw-elevator activity during chewing and patients with TMD have generally longer duration of chewing cycles and lower bite force. In a study concerning the patients with TMJ pain, Handsottir and Bakke observed that the maximum bite force was positively correlated with pressure pain threshold (PPT) of the patient’s TMJ. On the other hand, Bonjardim et al showed that DI (dysfunction index) was not correlated with the bite force, which are corroborated by those of Shiau et al. Nor did Ikebe et al find an association of TMD with bite force. It is thought that these findings might explain controversial results in many studies employing heterogeneous TMD subjects. Further study should be concerned with specific diagnostic groups of TMD and its pain intensity.

In this study, it was also evaluated whether side-to-side difference of bite force in unilateral TMD patients related with duration of TMD signs and symptoms. As mentioned earlier, no significant difference between time groups was found when dividing into < and ≥ 1 month although sides difference was decreased in the group of ≥ 1 month.
However, there was significant difference between the groups of < 6 months and = 6 months. (p=0.049) Sides difference of −9.42±12.26 kgf in the group of < 6months was greatly decreased by −0.17±10.71 kgf in that of ≥ 6 months, which indicating that chronic TMD deteriorated bite force not only the affected sides but also the unaffected sides. It is thought that intimate functional interaction among the masticatory system components enables disturbance on one side to affect the bite force of the other side, which was likely more noticeable in chronic patients.

V. CONCLUSIONS

Unilateral TMD patients in this study showed force difference of about 7–8 kgf between the affected and unaffected, asymptomatic sides (p<0.05) while there was no significant sides difference in the bilateral patients. Nor did significant strength difference on the affected sides exist between unilateral and bilateral TMD patients. With regards to TMD duration, significant side-to-side difference in posterior bite force was found between the groups of < and ≥ 6 months (p<0.05) while there was no significant difference between the groups of < and ≥ 1 month.

The results of this study indicated that unilateral TMD patients can exhibit more reduced bite force on the affected sides compared with that on the unaffected sides and that bite force on the unaffected sides might be deteriorated more as longer did TMD last.

REFERENCES

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국문요약

편측성 측두하악장애 환자의 교합력 평가

단국대학교 치과대학 구강내과학과

이우정 · 김미은 · 김기석

측두하악장애(Temporomandibular disorders, TMD) 환자들 대다수는 저작기능 장애와 교합력 감소를 보여주는데 본 연구는 편측성 TMD 환자에서 증상이 있는 측과 무증상측 사이의 교합력 차이를 비교하고 좌우측 교합력의 차이와 증상 지속기간과의 관련성 여부를 평가하고자 하였다.

단국대학교 치과대학병원 구강내과에 치료를 위해 내원한 편측성 TMD 환자 42명(남:여=9:33, 평균 27.2±10.4세)을 대상으로 하여 교합력측정기를 이용하여 전치부와 구치부의 최대교합력을 측정하였다. 전치부 교합력은 좌우측 전치에서 측정하였고 구치부 교합력은 제1대구치에서 측정하였는데 환자는 통증을 유발하지 않는 범위에서 3초간 최대로 측정기를 쬐도록 하였다. 양측성 증상을 보이는 환자 6명(남:여=1:5, 평균 23.0±7.3세) 에 대해서도 같은 방법으로 평가하여 교합력을 비교하였다. 또한, 증상의 지속기간에 따라 1개월 미만과 1개월 이상, 6개월 미만과 6개월 이상의 군으로 나누어 증상족과 무증상측의 교합력을 비교하였다. 통계분석을 위하여 paired t-test와 unpaired t-test를 사용하였다.

연구결과, 편측성 TMD 환자들에서는 증상측의 교합력이 무증상측 보다 유의성 있게 낮았으나 (7-8 kgf 차이, p<0.05) 양측성 환자들에서는 좌우 차이가 없었다. 편측성 환자들의 증상량과 양측성 환자들과의 비교에서는 유의한 차이가 관찰되지 않았다. 증상의 지속기간에 따른 증상측과 무증상측 교합력 차이를 비교했을 때, 1개월을 기준으로 나누었을 때는 두 군 사이에 유의한 차이가 없었으나 6개월을 기준으로 나누었을 때는 두 군 사이에 통계적으로 유의한 차이가 관찰되었다(p<0.05).

본 연구의 결과는 편측성 TMD 환자에서는 증상량이 무증상량보다 교합력이 저하되어 있으며, 증상이 오래 지속될수록 증상측과 무증상측의 교합력 차이가 감소한다는 것, 즉 무증상측의 교합력이 더욱 저하될 수 있다는 것을 보여준다.

주제어: 교합력, 교합력측정기, 전치, 제1대구치, 편측(성), 측두하악장애