An Electromyographic Study on Changes of Mandibular Position

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I. INTRODUCTION

Temporomandibular disorders(TMD) is a collective term embracing a number of clinical problems that involve the masticatory musculature, the temporomandibular joint(TMJ) and associated structures, or both. TMD has been identified as a major cause of nondental pain in the orofacial region and is considered to be a subclassification of musculoskeletal disorders[1]. The most frequent presenting symptom is pain, usually localized in the muscles of mastication, the preauricular area, and/or the TMJ. In addition to complaints of pain, patients with these disorders frequently have limited or asymmetric mandibular movement and TMJ sounds[2].

The identification of an unambiguous universal cause of TMD is, as yet, lacking. Many factors can affect the dynamic balance or equilibrium between the components of the masticatory system[3]. Direct extrinsic trauma to any component of the masticatory system can spontaneously initiate loss of structural integrity and concomitant altered function. In addition, there are other contributing anatomic, systemic, pathophysiologic, and psychosocial factors that may sufficiently reduce the adaptive capacity of the masticatory system and cause TMD[4]. Parafunctional habits such as tooth clenching, tooth grinding, lip biting, and abnormal posturing of the jaw have been suggested as initiating or perpetuating factors in certain subgroups of TMD patients[5-10]. Occlusal discrepancies between the retruded contact position and intercuspal position[11-13], extensive overjet[12),14-16], minimal overbite and anterior skeletal open bite[16-18], unilateral posterior crossbite[11] was found to be more common in TMD patients. Therefore, these variable mandibular positions have been suggested as an etiologic factor in TMD.

Surface electromyography(EMG), mandibular electrokinesiography (EKG) and, more recently,

TMJ sound analysis provide the inclusion of quantitative data on the qualitative aspects of a diagnosis[17-19]. EMG represents a sensitive research tool for measuring muscle function and has been widely used since it was first introduced in dental research by R. E. Moyers in 1949[20]. EMG picks up and amplifies the action currents of contracting voluntary muscles and may mirror the neuromuscular system that controls the posture and movements of the mandible[21].

In a previous study of Jarabak[22], it was shown that the protrusive movement of the mandible from the rest position with a 3㎜ interocclusal distance lead to increase some in the masseter muscle contraction and slightly more in the temporal muscle. The retrusive mandibular movement from the rest position with a 3㎜ interocclusal distance lead to increase in the temporal muscle contraction and more in the masseter muscle.

Several investigators have demonstrated a decrease in EMG activities of the masseter and temporal muscles when the mandible is depressed beyond the postural position[23-30].

Since there have been few studies about the effect of various mandibular positions on the masticatory muscle activities, in this study, the integrated EMG activities of the masseter and anterior temporal muscles during maximum clenching in the various mandibular positions were evaluated, in order to determine quantitatively the effect of changes in jaw positioning on the masticatory muscles.

II. MATERIALS AND METHODS

1. Subjects

This study was performed on twenty-eight subjects, eighteen women and ten men, in the age range of 19 to 29 years with a mean of 22 years, dental students of School of Dentistry, Chonbuk National University.

The following criteria were used for the selection of subjects.

(1) absence of history, signs and symptoms of TMD : no TMJ sounds, no tenderness to palpation of the TMJ or of the masticatory muscles, no painful limitations of mandibular movements
(2) natural dentition, no missing tooth, absence of occlusal trauma and no parafunctional oral habits (especially, bruxism etc.)
(3) absence of extensive restorations
(4) no current orthodontic treatment
(5) absence of pathologic periodontal condition

2. Mandibular positioning (of subjects)

To establish the accurate mandibular position for each subject, an interocclusal appliance was made of 2.0 ㎜ thickness transparent acrylic materials(Biocryl C®) by vacuum adapter(Biostar ®), with aluwax occlusal surface for registration of each mandibular position. The increase in the vertical dimension produced by the interocclusal appliances ranged from 1.3 to 1.9 ㎜ in the first molar region.

The following four mandibular positions were selected for this study.

(1) Physiologic rest position of mandible
(2) Centric relation position(CR position)
(3) Habitual centric occlusion position(CO position)
(4) Incisal edge-to-edge position(Anterior position)

3. Recording of EMG activities

An eight-channel instrument, EM2 Bioelectric Processor® (Myotronics. U.S.A.) was used to

record EMG activities. Prior to recording of EMG activities, all subjects were introduced to the EMG apparatus, and were carefully instructed about the test. The subjects were positioned with their head unsupported and were asked to maintain a upright position. The bipolar surface electrodes(Ag/AgCl) were positioned on the muscular bellies parallel to muscular fibers of the masseter(MM), anterior temporal(TA) muscles as follows :

- MM ; the operator, standing behind the seated subject, palpated the muscular belly while the subject clenched his/her teeth. The electrode was fixed, parallel to the muscular fibers, about 3cm above and anterior to the mandibular angle.
- TA ; the muscular belly was palpated during tooth clenching ; and the electrode was fixed vertically along the anterior margin of the muscle(corresponding to the fronto-parietal suture)[31].

In order to reduce electrode impedance, the skin was carefully cleansed prior to electrode placement, and recordings were performed 5-6 minutes later, allowing the conductive paste to adequately moisten the skin surface. And in order to minimize methodological error the recordings of EMG muscle activities were made during all experimental procedures by the same examiner. Testing was performed in a silent and comfortable environment, with only one operator in this room.

Reproducibility of EMG recordings during rest, occlusion in CO and maximum clenching has already been tested with the same instrument and measurement protocol[31-32].

All subjects were instructed to clench as hard and rapidly as possible and to maintain for 5 seconds. EMG recordings were made three times for each mandibular position. The subjects rested for 20 minutes between four mandibular positions to avoid muscular fatigue. The highest EMG level was selected as the maximum EMG activity for the test. The recordings were made in the following sequence :

(1) Maximum bite in the intercuspal position without any interocclusal appliance
(2) Maximum bite in the centric relation position with interocclusal appliance
(3) Maximum bite in the habitual centric occlusion position with interocclusal appliance
(4) Maximum bite in the incisal edge-to-edge position with interocclusal appliance

4. Asymmetry Index

The asymmetry index(A.I.) introduced by Naeije et al.[33] was used to quantitatively describe the asymmetry in masticatory muscle activity during maximum clenching.

$$A.I. = \frac{(EMG\ right - EMG\ left)}{(EMG\ right + EMG\ left)} \times 100$$

The asymmetry index has a range from -100% to +100%, where a positive number indicates a right-side muscle dominance and a negative number indicates a left-side muscle dominance. In this study only the absolute value of the asymmetry index was used because it was investigated if there was any difference of muscle activity between right and left side.

5. Statistical Analysis of Data

Statistical tests used were two tailed Student's t-test, the paired t-test and the analysis of variance(ANOVA) by the SPSSWIN(version 7.5). Probability levels of $p<0.05$ were considered statistically significant.

Ⅲ. RESULTS

1. General characteristics of the variables of subjects

The mean age of subjects was 22 years, and the range of vertical dimension change produced by placement of interocclusal appliance was 1.3~1.9 ㎜ in the first molar region. The mean values and standard deviations of electric potentials recorded over the examined muscles during the physiologic rest position was 0.94±0.57 ㎶ in masseter muscle and 0.96±0.41 ㎶ in anterior temporal muscle (Table 1).

2. EMG activities(㎶) of the masseter muscle and anterior temporal muscle during maximum clenching without and with interocclusal appliance in CR position, CO position and anterior position

The EMG activities of the masseter muscles was decreased with interocclusal appliance in CR position, CO position and anterior position compared to without interocclusal appliance, but there was no statistically significant difference within four mandibular positions.

In the anterior temporal muscle, there was a significant difference within four mandibular positions($p<0.05$), and then Scheffe test as the post-hoc test was carried out. The EMG activities of the anterior temporal muscles was significantly decreased with interocclusal appliance in CO position compared to without or with interocclusal appliance in CR position($p<0.05$). And the EMG activities of the anterior temporal muscles was significantly decreased with interocclusal appliance in anterior position compared to without and with interocclusal appliance in CR position($p<0.001$). The EMG activities of the anterior temporal muscles was decreased with interocclusal appliance in CR position compared to without interocclusal appliance, and in anterior position with appliance compared to in CO position with appliance, but there was no statistically significant difference(Table 2).

3. Asymmetry index(A.I.) from the EMG activities of the masseter muscles and the anterior temporal muscles during maximum clenching without and with interocclusal appliance in CR position, CO position and anterior position

No statistically significant difference was found among the four mandibular positions in the masseter and anterior temporal muscles(Table 3).

Table 1. General characteristics of the variables of subjects

Number(male:female)	28(10:18)
Mean age(range)	22 years(19 - 29 years)
Vertical dimension change produced by placement of interocclusal appliance(range)	1.3 - 1.9 ㎜ in the first molar region
Electric potential of MM† during physiologic rest position	0.94 ± 0.57(㎶)
Electric potential of TA† during physiologic rest position	0.96 ± 0.41(㎶)

† MM : masseter muscle † TA : anterior temporal muscle

Table 2. EMG activities(μV) of the masseter muscle and anterior temporal muscle during maximum clenching without and with interocclusal appliance in CR position, CO position and anterior position (Mean ± SD)

		Masseter m'	Ant. temporal m'
without appliance[a)]		154.48±72.23	122.55±37.26
with appliance	CR position[b)]	127.66±62.21	105.91±27.58
	CO position[c)]	152.32±57.13	94.39±35.75
	Anterior position[d)]	123.50±61.18	66.09±37.04
F-value		1.63	13.18
p-value		p = 0.19	p < 0.05
Scheffe test as the post-hoc test	a) vs b)	NS	NS
	a) vs c)	NS	p < 0.05
	a) vs d)	NS	p < 0.001
	b) vs c)	NS	p < 0.05
	b) vs d)	NS	p < 0.001
	c) vs d)	NS	NS

a) without appliance : maximal intercuspal position without interocclusal appliance
b) CR position : centric relation position
c) CO position : habitual centric occlusion position
d) Anterior position : incisal edge-to-edge position

Table 3. Asymmetry index(A.I., %) from the EMG activities of the masseter muscles and the anterior temporal muscles during maximum clenching without and with interocclusal appliance in CR position, CO position and anterior position (Mean±SD)

		Masseter m'	Ant. temporal m'
without appliance[a)]		9.09±28.80	9.21±28.42
with appliance	CR position[b)]	5.03±27.89	14.92±26.78
	CO position[c)]	7.07±26.36	14.12±25.36
	Anterior position[d)]	8.59±26.73	16.05±28.23
F-value		0.12	0.34
p-value		p > 0.8	p = 0.79

a), b), c), d) : See table 2.
A.I. : Details are given in the text.

IV. DISCUSSION

This study presents that the effects of changes in mandibular positioning on the myoelectrical activities of the masseter and anterior temporal muscles.

In this study, there was no difference in the EMG activities between in CR position with appliance and in intercuspal position without appliance of the masseter and anterior temporal muscles during maximum clenching. The myoelectrical activity of the masseter muscle with the appliance in healthy subjects agrees with the observations of Kawazoe et al.[34], who demonstrated no difference between EMG potentials with and without an splint in normal subjects but a significant decrease of EMG potentials about 20% with the splint in patients with myofascial pain-dysfunction syndrome during maximum voluntary clenching. The similar behavior of the EMG activity of the anterior temporal muscle in healthy subjects with and without interocclusal appliance in this study is in accordance with the findings of Freesmeyer and Manns[35], Miralles et al.[36], and Manns et al.[37] in the aspects of no difference with the appliance, but it is in disagreement with those of Wood and Tobias[38] who observed an 17% increase of the EMG activity with the splint in place.

Centric occlusion position with interocclusal appliance shows a different behavior in the EMG activity of the masseter and anterior temporal muscles in comparison to the behavior obtained without the appliance. Although the activity of the anterior temporal muscle significantly decrease with the interocclusal appliance in centric occlusion position, the activity of the masseter muscle is similar under both condition.

Anterior edge-to-edge position with interocclusal appliance shows a statistically significant decrease in EMG activity of the anterior temporal muscle compared to either the intercuspal position without interocclusal appliance or centric relation position with interocclusal appliance, and this finding agrees with the result of Williamson et al.[39] in TMD patients. In a study on Class II patients, Pancherz and Anehus-Pancherz[40] found that anterior repositioning of the mandible, using the fixed Herbst appliance without posterior teeth in contact and at the incisal edge-to edge position, resulted in the markedly reduced EMG activities of the temporal and masseter muscles compared to maximum intercuspation.

In this study, the asymmetry index tended to be higher in the anterior temporal muscles than in the masseter muscles, but there are no significant difference. A comparison was made between the changes in the mean asymmetry index resulting from placement of interocclusal appliance in centric relation, centric occlusion and anterior edge-to edge position. During maximum clenching the masseter muscle demonstrated a slight decreased asymmetry index and the anterior temporal muscle showed a increased asymmetry index with interocclusal appliance. However these changes which were all statistically insignificant. This result agrees with the finding of McCaroll et al.[41], who evaluated the symmetry of muscle activity at 10% and 50% of maximum clenching in healthy subjects. Inserting a stabilization splint did not change the asymmetry of activities of the masseter and anterior temporal muscles.

Therefore, in healthy subjects with complete dentitions and relatively stable bilateral occlusion, changes in magnitude and distribution of occlusal contacts and elimination of occlusal interferences through insertion of a stabilization splint do not result in immediate changes in the activity patterns of the masticatory muscles. Contrary to this finding, Humsi et al.[42] observed the stabilization splint in TMD patients caused an immediate improvement in masseter muscle

symmetry at the time of delivery.

Our experimental results agree with those of Visser and Mccarrol et al.[43] who found that raising the vertical dimension and protrusive positioning of the mandible decreased the activity of the temporal muscle. So we expect that the insertion of a occlusal splint with raising the vertical dimension or anterior positioning of the mandible in TMD patients lead to decrease the EMG activity of the anterior temporal muscle during maximum clenching.

Many studies about the clinical effectiveness of occlusal splints have decided that they cause muscular relaxation, which reduces muscular spasm and brings a decrease in EMG activity[34),39),44-45]. One possible explanation for the reduction of EMG activity is that the elimination of occlusal interferences by treatment with a stabilization splint could reduce the degree of sensory information from the periodontal receptors, and finally the muscle relaxation effect occurs[46]. There is general agreement that an occlusal splint eliminates occlusal interferences with a minimal increase of the vertical dimension of occlusion, and that this cause a change in the degree of tactile afferent impulses from the periodontal mechanoreceptors and thus muscular relaxation[34], and establish a more symmetric muscular rest activity[47].

However this explanation is based on a concept established through general experiences of many clinicians, and yet the exact physiologic mechanism of reduction in EMG activity and asymmetry is not clearly understood and there are several different theories regarding the precise effect that appliances may have on stomatognathic system[48-49]. On the basis of the results of this study, further evaluation for the effect of occlusal splint-induced changes in jaw position on the masticatory muscle activities would be necessary.

V. CONCLUSIONS

The purpose of this study was to evaluate the effect of the changes of mandibular position on the masticatory muscle activities. Twenty eight healthy dental students without any signs and symptoms of temporomandibular disorders participated in this study. To record electromyographic activity, EM2® was used and an interocclusal appliance with vertical dimension range from 1.3 to 1.9 ㎜ was used to establish the accurate mandibular position for each subject. Selected mandibular positions were centric relation position, habitual centric occlusion position and incisal edge-to-edge position.

The obtained results were as follows:

1. There was a statistically significant difference among four mandibular positions in anterior temporal muscles, but no difference in masseter muscles.
2. The EMG activities of the anterior temporal muscles was significantly decreased with interocclusal appliance in CO position compared to without or with interocclusal appliance in CR position($p<0.05$).
3. The EMG activities of the anterior temporal muscles was significantly decreased with interocclusal appliance in anterior position compared to without or with interocclusal appliance in CR position($p<0.001$).
4. No statistically significant difference was found in the asymmetry index of the masseter and anterior temporal muscles among four mandibular positions.

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국문초록

하악위 변화에 따른 저작근의 근전도학적 연구

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저자는 하악의 위치변화가 저작근에 미치는 영향을 근전도학적으로 평가하고자, 측두하악장애의 징후와 증상이 없는 정상 성인 28명을 대상으로 중심위 교합장치(centric relation splint), 중심교합위 교합장치(centric occlusion splint), 전방 재위치 교합장치(anterior repositioning splint)를 장착시킨 상태에서 하악의 중심위, 중심교합위, 전방위를 유도한 후 최대 이악물기 상태의 좌우측 교근 및 전측두근의 근전도를 채득, 분석, 평가한 결과 다음과 같은 결론을 얻었다.

1. 전측두근에서 하악의 위치변화에 따른 최대 근활성도의 차이가 나타났으나($p<0.05$), 교근에서는 나타나지 않았다.
2. 전측두근의 경우 중심교합위에서 최대 이악물기 상태의 최대 근활성도는 교합 장치물을 장착하지 않은 경우 및 중심위에서와 비교하여 감소하였다($p<0.05$).
3. 전측두근의 경우 전방위에서 최대 이악물기 상태의 최대 근활성도는 교합 장치물을 장착하지 않은 경우 및 중심위에서와 비교하여 감소하였다($p<0.001$).
4. 교근과 전측두근의 좌우 비대칭지수(asymmetry index)는 하악의 위치변화에 따른 차이가 나타나지 않았다.