Effects of Oral Parafunction on the Stiffness and Elasticity in the Muscles of the Mastication and Facial Expression

Seung-Ki Kim, Mee-Eun Kim, Ki-Suk Kim

Department of Oral Medicine, Dankook University School of Dentistry

The purpose of this study was to evaluate the effects of oral habits on the muscles of mastication and facial expression by means of two parameters: muscle stiffness and elasticity.

10 healthy, fully-dentate male subjects in their twenties were selected for this study; all had normal Class I occlusal relationships. Muscle stiffness and elasticity were measured with a tactile sensor (Venustron, Axiom Co., JAPAN) while subjects were asked to relax and perform various parafunctional activities such unilateral clenching (biting the bite force recorder with a force of 50kg on each subject' s preferred side), jaw thrusting and lip bracing. The following muscles were examined: temporalis anterior (Ta), masseter (Mm), frontalis (Fr), inferior orbicularis oculi (OOci), zygomaticus major (Zm), superior and inferior orbularis oris (OOrs and OOri) and mentalis (Mn). Paired t-test, Correlation Coefficients, ANOVA and Multiple Comparison t-tests were used for statistical analysis.

Unilateral clenching was highly correlated with bilateral stiffness and elasticity of all the muscles tested. Mm was affected by all three oral habits; Ta was affected by unilateral clenching ($p<0.05$); Zm was affected by unilateral clenching and OOrs, OOri and Mn were most affected by lip bracing ($p<0.05$). This study indicates that not only the masticatory muscles but also the muscles of facial expression, mainly circumoral muscles, can be significantly influenced by parafunctional activities such as unilateral clenching and lip bracing.

Key words: Parafunction, Masticatory muscle, Facial expression muscle, Tactile sensor

Ⅰ. INTRODUCTION

Various functional activities of stomatognathic system are established by the cooperation of movements of the jaw, tongue and buccal mucosa and a dysfunction in one of the organs involved can deteriorate harmonious and efficient movements.[1)]Development and aggravation of temporomandibular disorders (TMD) is related to a variety of contributing factors which can inflict stability of stomatognathic system; orthopedic instability, trauma, emotional stress, and parafunctional activities, etc. Among them, oral parafunctional activities such as bruxing, clenching, cheek and tongue biting, unusual postural habits such as thrust of mandible are often performed without the individual even being aware of them and it is common during the activity to place their teeth together and apply force,[2)] subsequently leading to periodic contraction of the muscles such as masseter.[1)]

Until now, effects of parafunctional oral habit with masticatory muscles such as masseter and

Corresponding author : Ki-Suk Kim
Department of Oral Medicine, Dankook University, School of Dentistry
Sinbu-dong San 7-1 Cheonan 330-716
Tel. +82-41-550-1914
Fax. +82-41-556-9665
E-mail: kimks@dankook.ac.kr

Received: 2007-11-29
Accepted: 2008-02-17

temporalis has been studied, but there is a need to pay clinicians' attention to the facial muscles that coordinate with the muscle of mastication. The facial musculature performs a variety of complex and important orofacial functions such as speech, mastication, swallowing and the mediation of emotional and affective states.[3]

Takada et al[4,5] studied the relation between electromyography (EMG) activity of the inferior orbicularis oris muscles and jaw movement and showed the timing of activities of jaw and lip muscles when chewing. Schieppati et al[6] demonstrated that duration and amplitude of facial muscle activity were influenced by the duration of the masticatory cycle and whether lip-to-lip contact was made. Won et al[7] studied the muscle stiffness and elasticity of masticatory muscles on gum chewing. However, the studies on the muscles of facial expression were rare and have been mainly performed in regards with function and esthetics in the field of orthodontics and cosmetic surgery by means of measurement of EMG activity,[8-10] muscle strength[11] and muscle thickness with an ultrasonography,[12-14] MRI[14] and etc.

In addition to conventional methods including EMG and determination of bite force and chewing ability, a tactile sensor system has been recently used to evaluate muscles. Katayama et al[16] reported in evaluation of muscle fatigue in the masseter after gum chewing that the muscle stiffness and elasticity measured with the tactile sensor reflected more accurately muscle fatigue than conventional parameter of EMG and that increases in stiffness and decreases in elasticity of the masseter muscle was proportional to the number of masticatory cycles. Nishikawa et al[17] compared the stiffness of shoulder muscle related to bathing type using the tactile sensor. After examining the facial muscles and soft tissue of the oral cavity by means of tactile sensor, Inada et al[18] reported that the stiffness of the muscles of mastication and facial expression increased with increase in the strength of their contraction, but it was a pilot study with one subject.

The purpose of this study was to evaluate the effects of oral habits on the muscles of mastication and facial expression by means of two parameters: muscle stiffness and elasticity.

Ⅱ. MATERIALS AND METHODS

1. Tactile sensor system

A tactile sensor system[18] employed for this study was Venustron®(Axiom Co. Ltd., Japan) as seen in Fig 1. The sensor consists of a piezoelastic transducer made of ceramics such as lead zirconate titanate (PZT) and a vibration pickup (made of PZT or polyvinylidene fluoride (PVF2) film) and it is connected to a computer equipped with the appropriate software.

When there is an electric input, the PZT element vibrates at its own inherent resonance frequency. If the sensor probe vibrating in this frequency is pressed against an object, this frequency shifts and the amount of shift in frequency is determined by the object's acoustical impedance, which directly correlated with the hardness/softness of the material. The change in frequency, or $\triangle f$ is defined as the difference between the new frequency, f_x and the initial frequency, f_0, shown as $\triangle f = f_x - f_0$. The initial frequency, f_0 was 57Hz and the tip diameter of sensor probe was 5 mm in this tactile sensor system.

Fig. 1. The tactile sensor system (Venustron®, Axiom Co. Ltd., Japan).

When the sensor probe is placed over the surface to be measured, measurement begins via the Windows' compatible software. A small motor located in the upper end of the probe shaft is activated by the computer, which controls the depression. The sensor tip pushes down on the material once and retracts to provide a continuous stream of simultaneous stiffness, pressure and depression in real time. 200 tactile, pressure and depression data per second are swiftly and sequentially processed and recorded by the computer.

2. Subjects

10 healthy, fully-dentate men in their twenties (mean age of 23.4±2.0 years) were voluntarily selected for this study. All of them had normal occlusion with Class I molar occlusion. To minimize the influence on muscle condition to be evaluated, the exclusion criteria included followings; those with malocclusion including bimaxillary protrusion, anterior open bite and anterior deep bite, TMD, missing teeth (except wisdom teeth) or extensive bridge-work (≥ 3-unit bridge-work), and serious dental caries and periodontal diseases. Systemic musculoskeletal disorders and dermatologic disease were also excluded.

Informed consents for participation in this study were obtained from all the subjects prior to commencing the experiments.

3. Methods

Muscle examinations with a tactile sensor were performed on the muscles of mastication and facial expression in relaxed and oral-habit conditions. Masticatory muscles to be measured in this study included the anterior temporalis (Ta) and masseter (Mm) and the facial expression muscles for the experiment comprised the frontalis (Fr), inferior orbicularis oculi (OOci), zygomaticus major (Zm), superior and inferior orbularis oris (OOrs and OOri) and mentalis (Mn). To avoid unnecessary injury to eyeball, tactile measurement of superior orbicularis oculi (OOcs) was excluded.

Oral habits experimentally performed were clenching, jaw thrust and lip bracing habits. In order to maintain a constant clenching force exerted during measuring the muscles, all the subjects were asked to clench with a force of 50 kg while clenching a bite force recorder placed on between the first molars on their preferred sides, which was defined as unilateral clenching in this study. The bite force recorder used had biting portion with a width of 20 mm and a thickness of 4 mm. For clinical uses, silicone plates were attached to both sides of each biting site of the recorders in order to reduce metallic impact on teeth to be tested. During the recording the tactile of each muscle, careful caution was given not to inflict unnecessary tension on the lips.

When influence of jaw thrust habit on the muscles was evaluated, each of the subjects was instructed to protrude his mandible until the incisal edges of upper and lower incisors were met. Lip bracing was carried out by asking the subjects to close their lips tightly without any tooth contact.

For measurement of the muscle stiffness and elasticity with a tactile sensor, each subject was instructed to sit on a dental unit in an upright position and the skin over the muscles to be measured was marked with a pen. Ta and Mm were identified by manual palpation while each subject was asked to relax and clench alternatively and their thickest area was selected to be measured. Measuring sites for different facial expression muscles were chosen on the basis of anatomical textbooks and other studies.[8,20,21)]

Prior to evaluation of the influence of oral habits, muscle examination with the tactile sensor was carried out in a relaxed condition. While the subjects were in light contact in their teeth, the probe of the tactile sensor was placed perpendicularly over the marked point over the skin, followed by computer-controlled movement; gently pressing straight down on the muscle for a second and retracting. The distance moved by the sensor probe for each muscle was determined separately in regards with the thickness of muscle and relation with adjacent structures; 8 mm for Mm and Zm, 5 mm for OOrs and OOri, and 3 mm for the rest. The examinations were performed bilaterally for each muscle. Fig 2-1 and 2-2 shows hysteresis curves from the muscle measurement with the tactile sensor.

Each measurement per muscle was performed two times and their average values were collected for data analyses. An interval of 3 min was given for each examination and rest period of 30 min was also given before performing each oral habit in order to minimize muscle tiredness.

4. Statistical analysis

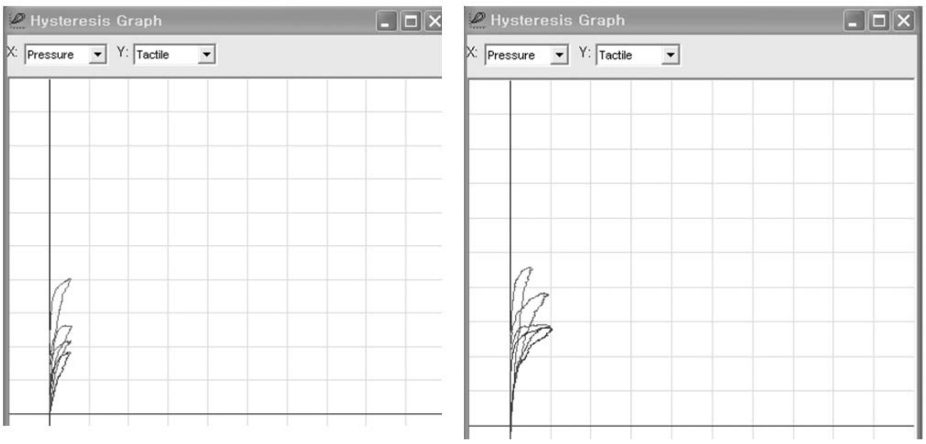
The values indicating stiffness and elasticity of each muscle in varied oral condition was obtained from its hysteresis curve and their mean values from the two examinations were compared. The values obtained from unilateral clenching were compared between the clenching and non-clenching sides of the jaw by paired t-tests and their correlation coefficients were investigated. One-way ANOVA was also used to determine the influence of oral habits on the masticatory and facial muscles. The confidence level was 95%.

Ⅲ. RESULTS

A hysteresis curve composed of two parts, which are formed when the sensor pushes down(bottom) and then retracts(top),[6] was obtained through each examination against the two masticatory and six different facial expression muscles while oral habit was performing (Fig 2-1,2). The slope of the tangent of the hysteresis curve ($\triangle f/\triangle x$) is defined as stiffness of the muscle being measured and the distance between the two parts as its elasticity. The higher value of stiffness indicates decrease of stiffness of target material and the lower value does increase of that.

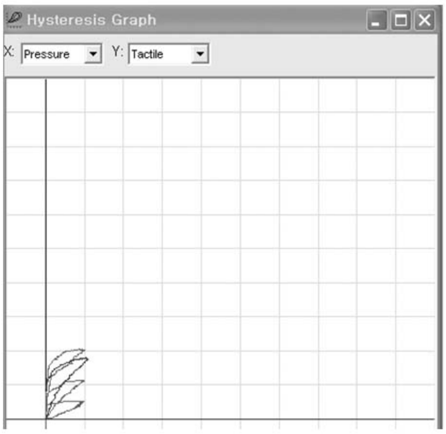
As compared the changes of the muscles on the clenching and non-clenching sides due to unilateral clenching, there was no significant side-to-side difference in the stiffness and elasticity (Table 1). Unilateral clenching was highly correlated with bilateral stiffness and elasticity of all the muscles tested.

Table 2 and 3 represent the stiffness and elasticity in the muscles in 4 different conditions. Unilateral clenching significantly increased the stiffness of Ta and Mm and decreased the elasticity of them. ($p<0.05$) The increase of Mm stiffness and decrease of the elasticity was the most in unilateral clenching, followed by lip bracing and jaw thrust in order($p<0.05$).

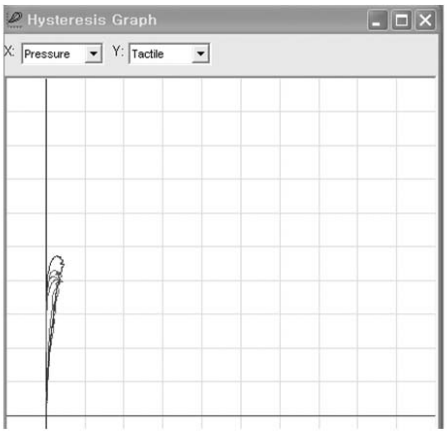


A. The anterior temporalis B. The masseter

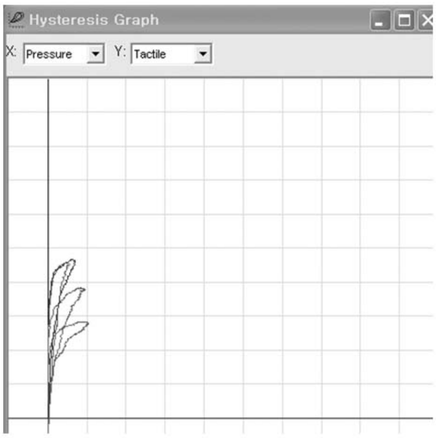
Fig. 2-1. Hysteresis curves of the masticatory muscles obtained from a single subject.



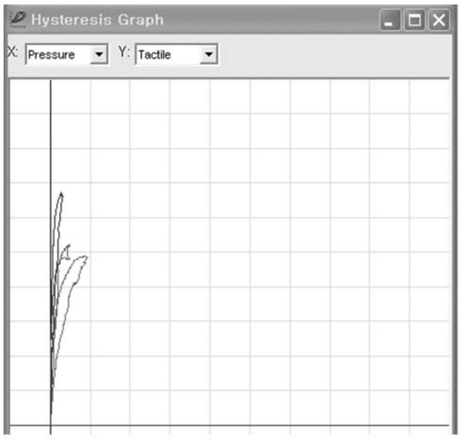
A. The frontalis



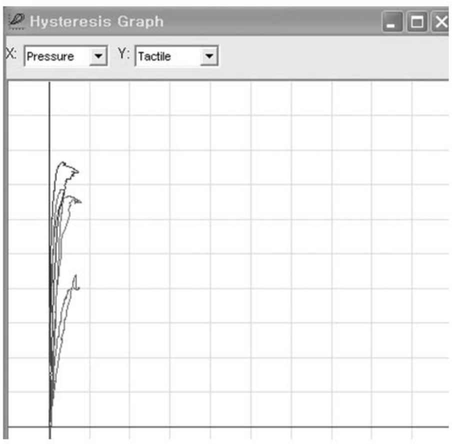
B. The orbicularis oculi inf.



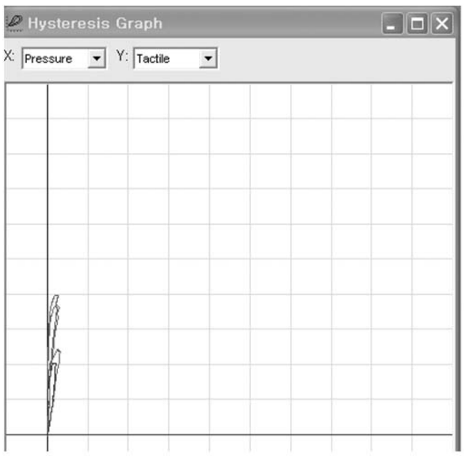
C. The zygomaticus major



D. The orbicularis oris superior.



E. The orbicularis oris inferior.



F. The mentalis

Fig. 2-2. Hysteresis curves of the muscles of facial expression obtained from a single subject.

As concerned the facial expression muscles, unilateral clenching increased the stiffness of Fr (p=0.036) but OOci was little affected by the three activities. The circumoral muscles including Zm, OOri, Mn were affected by the oral habits. Unilateral clenching significantly increased the stiffness of Zm and decreased the elasticity ($p<0.05$, Table 2,3).

Both OOrs and OOri demonstrate significant increase of their stiffness during unilateral clenching and lip bracing, particularly in lip bracing($p<0.05$, Table 2). Their elasticity significantly decreased in lip bracing ($p<0.05$, Table 3). The stiffness of Mn due to lip bracing significantly increased compared with the other conditions ($p<0.05$, Table 2) and its elasticity was also affected in the same manner ($p<0.05$, Table 3).

Ⅳ. DISCUSSION

To the best of our knowledge, as there existed very few studies concerning a relation of oral habit with facial expression muscles, this study aimed to investigate effects of oral habits on the facial expression muscles as well as the masticatory muscles using two parameters of muscle stiffness and elasticity with a tactile sensor.

The results from this study exhibited that unilateral clenching increased the stiffness of some facial muscles including Fr, Zm, OOrs and OOri as well as that of Ta and Mm, the masticatory muscles. It is noticeable that unilateral clenching increased stiffness of Fr ($p<0.05$, Table 2). In the study concerning composition of occipitofrontalis,

Table 1. Comparison of stiffness and elasticity of the muscles in unilateral clenching.

	Stiffness (△f/△x)			
	Clenching side	Non-clenching side	*Paired t-test*	Correlation coefficients
Ta	0.421 ± 0.226	0.491 ± 0.267	*p=0.070*	0.918 (p=0.000)
Mm	0.396± 0.234	0.335 ± 0.208	*p=0.134*	0.866 (p=0.001)
Fr	0.151 ± 0.092	0.158 ± 0.116	*p=0.621*	0.939 (p=0.000)
OOci	1.111 ± 0.349	1.112 ± 0.380	*p=0.977*	0.959 (p=0.000)
Zm	0.548 ± 0.201	0.509 ± 0.231	*p=0.135*	0.949 (p=0.000)
OOrs	1.147 ± 0.590	1.209 ± 0.594	*p=0.120*	0.981 (p=0.000)
OOri	1.098 ± 0.390	1.140 ± 0.422	*p=0.568*	0.851 (p=0.002)
Mn	1.086 ± 0.311	1.059 ± 0.313	*p=0.646*	0.834 (p=0.000)
	Elasticity (Hz)			
	Clenching side	Non-clenching side	*Paired t-test*	Correlation coefficients
Ta	45.000 ± 14.568	43.060 ± 13.325	*p=0.253*	0.939 (p=0.000)
Mm	49.630 ± 11.339	49.220 ± 9.443	*p=0.892*	0.614 (p=0.059)
Fr	33.440 ± 12.142	37.590 ± 14.995	*p=0.163*	0.818 (p=0.004)
OOci	83.470 ± 31.147	82.520 ± 33.500	*p=0.660*	0.982 (p=0.000)
Zm	53.710 ± 13.502	54.010 ± 15.988	*p=0.909*	0.865 (p=0.001)
OOrs	46.250 ± 28.886	45.070 ± 27.946	*p=0.437*	0.988 (p=0.000)
OOri	63.970 ± 39.223	66.180 ± 35.410	*p=0.474*	0.974 (p=0.000)
Mn	91.320 ± 17.395	92.431 ± 14.446	*p=0.405*	0.976 (p=0.000)

Table 2. Changes of stiffness (△f/△x) in the muscles of mastication and facial expression related to oral habits.

	Relaxation	Clenching (unilateral)	Jaw thrusting	Lip bracing	ANOVA	Multiple comparison t-test
Muscles of mastication						
Ta	1.064 ± 0.703[a]	0.456 ± 0.243[a]	0.927 ± 0.664	0.857 ± 0.736	p=0.018	[a](p=0.028)
Mm	0.882 ± 0.272[b]	0.366±0.218[b,c,d]	0.799 ± 0.303[c]	0.684 ± 0.177[d]	p=0.000	[b](p=0.000), [c](p=0.000), [d](p=0.002)
Muscles of facial expression						
Fr	0.302 ± 0.225	0.155 ± 0.102	0.256 ± 0.157	0.265 ± 0.144	p=0.036	N.S.
OOci	1.180 ± 0.376	1.112 ± 0.355	1.138 ± 0.309	1.170 ± 0.322	p=0.918	N.S.
Zm	1.076 ± 0.370[e]	0.529 ± 0.212[e,f,g]	0.930 ± 0.298[f]	0.944 ± 0.348[g]	p=0.000	[e](p=0.000), [f](p=0.002), [g](p=0.001)
OOrs	1.790 ± 0.496[h,i]	1.178 ± 0.577[h,j]	1.646 ± 0.552[j,k]	0.562 ± 0.264[i,k]	p=0.000	[h](p=0.002), [i](p=0.000), [j](p=0.033), [k](p=0.000)
OOri	1.756 ± 0.501[l,m]	1.119 ± 0.396[l,n,o]	1.612 ± 0.442[n,p]	0.677 ± 0.275[m,o,p]	p=0.000	[l](p=0.000), [m](p=0.000), [n](p=0.004), [o](p=0.013), [p](p=0.000)
Mn	1.099 ± 0.383[q]	1.073 ± 0.304[r]	1.135 ± 0.325[s]	0.735 ± 0.247[q,r,s]	p=0.000	[q](p=0.007), [r](p=0.014), [s](p=0.002)

Significant differences existed between the same alphabets.

Table 3. Changes of elasticity (Hz) in the muscles of mastication and facial expression related to oral habits.

	Relaxation	Clenching (unilateral)	Jaw thrusting	Lip bracing	ANOVA	Multiple comparison t-test
Muscles of mastication						
Ta	61.41 ± 18.28[A]	44.03 ± 13.62[A,B]	66.15 ± 13.66[B]	58.82 ± 22.99	p=0.001	[A](p=0.026),[B](p=0.002)
Mm	74.83 ± 13.43[C,D,E]	49.43 ± 10.16[C,F,G]	63.28 ± 11.14[D,F]	60.37 ± 9.78[E,G]	p=0.000	[C](p=0.000),[D](p=0.019), [E](p=0.002),[F](p=0.003),[G](p=0.029)
Muscles of facial expression						
Fr	43.80 ± 12.82	35.52 ± 13.45	41.25 ± 11.39	41.33 ± 10.80	p=0.181	N.S.
OOci	86.12 ± 30.85	83.00 ± 31.49	87.23 ± 31.82	85.09 ± 30.39	p=0.977	N.S.
Zm	67.95 ± 10.75[H]	53.86 ± 14.40[H,I]	66.15 ± 13.66[I]	61.07 ± 9.82	p=0.002	[H](p=0.007),[I](p=0.024)
OOrs	57.22 ± 27.73[J]	45.66 ± 27.67	53.35 ± 24.33[K]	28.92 ± 11.02[J,K]	p=0.002	[J](p=0.004),[K](p=0.019)
OOri	88.36 ± 33.05[L]	65.08 ± 36.39	69.53 ± 36.31	41.55 ± 26.51[L]	p=0.000	[L](p=0.001)
Mn	92.86 ± 16.72[M]	91.88 ± 17.46[N]	92.19 ± 16.71[O]	62.92 ± 20.31[M,N,O]	p=0.000	[M](p=0.000),[N](p=0.000),O(p=0.000)

Significant differences existed between the same alphabets.

Kushima et al[23] reported that the frontal belly (frontalis muscle), the temporoparietal muscle, the temporoparietal facia and the superficial fascia appear to form a superficial musculoaponeurotic system. In addition, the temporoparietal muscle originates from the temporal fascia. Though OOci was little affected in our experiment, it is still wondering whether or not OOcs, close to the frontalis muscle, relates with unilateral clenching. To avoid unnecessary injury to eyeball, tactile measurement of OOcs wasn't performed. Elasticity of all the muscles was changed in the same way (Table 3).

Whereas Ta was affected only with unilateral clenching, Mm was affected with all three oral habits but the decrease of elasticity and increase of stiffness was the most in unilateral clenching. Zm was also greatly affected by unilateral clenching. Unilateral clenching caused increased muscle stiffness and decreased elasticity in many of the muscles tested here and was highly correlated bilaterally (Table 1).

Jaw thrust habit did not influence all the muscles tested with an only exception of elasticity of Mm, which can be partly explained by the distance of jaw thrust. In order to place each of the subjects in the same situation, they were instructed to protrude their mandible to edge-to-edge relation of central incisors, which might be too small to cause muscle tension.

It is interesting that lip bracing increased the stiffness of Mn and decreased its elasticity along with the change of OOrs and OOri (Table 2,3). One of special neural features of the facial muscles is that physiological orofacial functions usually do not require the isolated contraction of individual muscles, but most of these complex functions simultaneously involve many muscles.[8] According to Nairn[24] and Salmons,[25] those functions mainly involving the OOrs and OOri most often simultaneously recruit the muscles fixating the corners of the mouth. It is thought that these findings, referred as selectivity,[8] can be explained as co-contraction of the OOrs, OOri and Mn muscles during lip bracing habit in this study. It is worthy to note that Mm was also affected in performing lip contraction without any tooth contact. Mm was affected by and large by all three oral habits tested here.

There were several methodological aspects to be concerned in this study. The first problem was to identify the facial expression muscles to be measured. Previous studies on facial musculature with EMG[8,25] demonstrated the high inter- and intra-individual variability in location and morphology of the individual muscles, as well as in the overlying soft tissue. The small caliber and proximity of these muscles to one another make it difficult to identify selective muscle bellies.[22] Bentsianov and Blizer[21] suggested that having the patient perform an exaggerated muscle function task based on the known primary action of each muscle will help make its belly more easily palpable, which recommends the electromyographic localization of each muscle during rest and function. However, investigation of EMG activities for facial area needs to use of invasive needle EMG technique or especially-designated surface EMG electrodes with small size and firm and secure skin attachment.[8,26] In this regard, it is thought that the tactile sensor will be a simple and easy way to evaluate the specific facial muscle in clinical setting. Specific measuring sites for facial expression muscles tested in this study were determined based on the anatomical knowledge from textbook and previous EMG studies. To lessen individual's variability, all the subjects in this study were selected from healthy young male in their twenties.

Secondly, it should be kept in mind the relatively superficial depth of the muscles of facial expression.[22] These muscles lie immediately below the skin and dermis within the subcutaneous fat, which can vary in thickness from site to site on the face and from person to person. Based on that human skin ranges from 1 to 4 mm in its thickness, Motooka et al[27] determined 3 mm as the distance moved by sensor to calibrate hardness of facial skin, and Katayama et al[16] and Inada et al18) determined the distance of 7 mm for measurement of masseter muscle. In an ultrasonographic evaluation on perioral muscles, Ferreira et al[28] indicated that orbicularis oris had the average length of 24.66 mm and average thickness of 3.57 mm. From all these findings, relative anatomical relation and our pilot study, a depth of 8mm was selected for Mm and Zm, 5mm for OOrs and OOri, and 3mm for Ta, OOci and Mn.

Thirdly, although some parafunctional activities were given during the experiments to investigate their influence on the muscles of mastication and facial expression, they were quite different from actual oral habits mostly under unconscious level. It is widely accepted that conscious and controlled, voluntary, mandibular movements and subconscious and uncontrolled, involuntary, muscle activity (i.e., nocturnal bruxism) are quite different.[29] Whereas the first is generated for functional use at a peripheral level, outside the CNS, the second is initiated and regulated at the CNS level. Muscle activity generated at the peripheral level has the benefit of the nociceptive reflex, indicating that influence from the peripheral structures such as the teeth has an inhibitory effect on it. On the contrary, nocturnal bruxism seems to be generated at the CNS level and stimulation of the CNS has an excitatory effect on this activity. These differences suggest the possibility that the muscles of mastication and facial expression might be more greatly influenced under unconscious level than under the experimental oral conditions of this study. Moreover, the force of 50 kg was instructed for the subjects to exert as the clenching force, which was determined as about a half of the mean value of the maximum bite forces obtained from the subjects. When it was regarded the fact that an average bruxing event involved 60% of the maximum clenching power before the individual went to sleep,[30] the resultant muscle fatigue due to nocturnal bruxism or clenching would be more considerable.

From the results of this study, it is suggested that not only the masticatory muscles but also the muscles of facial expression, mainly circumoral muscles, can be significantly influenced by parafunctional activities such as unilateral clenching and lip bracing. Further studies concerning the muscles of mastication and facial expression need to be performed in the subjects suffering from TMD with/without oral habits. Sex- and age-difference should also be studied.

REFERENCES

1. Sakaguchi K, Kawasaki T, Araki O. Time-series analyses of mandibular and perioral soft tissue movements during mastication. J Oral Rehabil 2003;30:270-277.
2. Rugh JD, Robbins JW. Oral habit disorders. In Ingersoll B(Ed). Behavioral aspects in dentistry. New York, 1982, Appleton-Century-Crofts, pp.179-202
3. Wohlert AB, Goffman L. Human perioral muscle activation patterns. J Speech Hear Res 1994;37: 1032-1040.
4. Takada K, Miyawaki S, Tatsuta M. The effects of food consistency on jaw movement and posterior temporalis and inferior orbicularis oris muscle activities during chewing in children. Arch Oral Biol 1994;739-805.
5. Takada K, Yashiro K, Sorihashi Y, Morimoto T, Sakuda M. Tongue, jaw and lip muscle activity and jaw movement during experimental chewing efforts in man. J Dent Res 1996;75:1598-1606.
6. Schieppati M, Di Francesco G, Nardone A. Patterns of activity of perioral facial muscles during mastication in man. Exp Brain Res 1989;77:103-112
7. Won TH, Kim ME, Kim KS. Muscle stiffness and elasticity of masticatory muscles on gum chewing. Korean J Oral Med 2007;32(4):421-430.
8. Lapatki BG, Stegeman DF, Jonas IE. A surface EMG electrode for the simulataneous observation of multiple facial muscles. J Neuroscience Methods 2003;123:117-128.
9. Nozomi T, Toshimichi I, Kazunori Y. Electromyographic activity of lower lip muscles when chewing with the lips in contact and apart. Angle Orthod 2004;74:31-36.
10. Jacinto-Goncalves SR, Gaviao MB, Berzin F, de Oliveira AS, Semeguini TA. Electro-myographic activity of perioral muscle in breastfed and non-breastfed children. J Clin Pediatr Dent 2004;29:57-62.
11. Neely JG, Pomerantz RG. Measurement of facial

muscle strength in normal subjects. The Laryngoscope 2002;112:1562-1568
12. Vinkka-Puhakka H, Kean MR, Heap SW. Ultrasonic investigation of the circumoral musculature. J Anat 1989;166:121-133.
13. Satiroglu F, Arun T, Isik F. Comparative data on facial morphology and muscle thickness using ultrasonography. Eur J Orthod 2005;27:562-567.
14. Rasheed SA, Munshi AK. Electromyographic and ultrasonographic evaluation of the circum-oral musculature in children. J Clin Pediatr Dent 1996:20: 305-311.
15. Gosain AK, Klein MH, Sudhakar PV, Prost RW. A volumetric analysis of soft-tissue changes in the aging midface using high-resolution MRI: implications for facial rejuvenation. Plast Reconstr Surg 2005;115:1143-1152.
16. Katayama H, Inada J. Evaluation of muscle fatigue in the masseter muscle using a tactile sensor. J Osaka Odontology Society 2000;63:23-32.
17. Nishikawa K, Murakami K. Effect of bathing on the stiff-ness of shoulder muscle. Ningen Kougaku 2000;36:318-319.
18. Inada J, Katayama H, Yoshida Y. Research pertaining to the hardness/softness of the facial muscles and the soft tissue of the inner oral cavity. Japanese Journal of Oral Biology 1998;40:160.
19. http//www.axiom-j.co.jp/explanation.htm.
20. Rohen JW, Yokochi C. Color atlas of anatomy. 1st. ed., 1983, Lippincott Williams & Wilkins, pp.52-59.
21. Bentsianov B, Blitzer A. Facial anatomy. Clin Dermatol 2004;22:3-13.
22. Fridlund AJ, Cacioppo JT. Guidelines for human electromyographic research. Psychophysiology 1986; 23:567-589.
23. Kushima H, Matsuo K, Yuzuriha S, Kitazawa T, Moriizumi T. The occipitofrontalis muscle is composed of two phys-iologically and anatomically different muscles separately affecting the position of the eyebrow and hairline. Br J Plast Surg 2005;58: 681-687.
24. Narin RI. The circumoral musculature. Structure and function. Br Dental J 1975;138:49-56.
25. Salmons S. Muscle. In: Williams PL (Ed). Gray's anatomy. The anatomical basis of medicine and surgery, 38th ed., New York, Edinburgh, London, 1995, Churchill Livingston. pp.783-789.
26. Cole KJ, Konopacki RA, Abbs JH. A miniature electrode for surface electromyography during speech. J Acoust Soc Am 1983;74:1362-1366.
27. Motooka N, Omata S, Koizumi J *et al.* Development of new instrument to assess viscoelasticity of skin and muscle. Tech digest of the 15th senor symposium, 1997, pp.87-90.
28. Ferreira LM, Minami E, Pereira MD, Chohfi LM, Andrews Jde M. Anatomical study of the levator labii superioris muscle. Rev Assoc Med Bras 1997;43: 185-188.
29. Okeson JP. Management of temporomandibular disorders and occlusion. 5th ed., St. Louis, 2003, Mosby Inc., pp.149-189.
30. Clarke NG, Townsend GC, Carey SE. Bruxing patterns in man during sleep. J Oral Rehabil 1984;11:123-127.

국문요약

구강악습관이 저작근 및 안면표정근의 경직도 및 탄성도에 미치는 영향

단국대학교 치과대학 구강내과학교실

김승기 · 김미은 · 김기석

구강안면통증의 주원인의 하나인 측두하악장애는 다양한 기여요인에 의해 발생하거나 악화되는데, 특히 이갈이, 이악물기 등의 비기능적 구강악습관은 중요한 기여요인으로 고려된다. 구강악습관과 저작근의 관련성에 대해서는 근전도 등을 이용한 연구가 이루어져왔으나, 안면표정근에 미치는 영향에 대해서는 연구된 바가 거의 없다. 그러므로 본 연구는 근육의 탄성도과 경직도를 정량적으로 평가할 수 있는 촉각센서(tactile sensor)를 이용하여 구강악습관이 저작근과 안면표정근에 미치는 영향을 평가하고자 하였다.

건강하고 건전한 치열을 가지고 있으며 Class I 교합관계의 정상골격인 지원자10명(20대 남성)을 연구대상으로 선택하여 촉각센서(Venustron II, Axiom Co, 일본)를 이용하여 이완 상태와 편측 이악물기(피검자가 선호하는 측의 제1대구치 부위에서 교합측정기를 50Kg force의 힘으로 깨문 상태), 턱내밀기(전치 상하절단연이 만나는 위치까지 턱을 내민 상태), 입술힘주기(치아는 닿지 않는 상태에서 입술만 꾹 다문 상태) 상태에서 저작근과 안면표정근의 경직도와 탄성도를 측정하였다. 측정근육은 측두근 전부, 교근(이상 저작근), 전두근, 하안륜근, 대관골근, 상 · 하 구륜근, 이근(이상 안면표정근)이었다. 통계처리를 위해 paired t-test, correlation coefficients, ANOVA 및 multiple comparison t-tests을 사용하였다. .

편측 이악물기를 할 때 측정한 모든 근육에서 경직도와 탄성도는 좌우 차이를 보이지 않고 높은 상관관계를 보였다. 교근은 편측 이악물기 뿐만 아니라 턱내밀기, 입술힘주기의 시행된 모든 구강악습관에 의해 경직도가 증가하고 탄성도는 감소하였다($p<0.05$). 측두근과 대관골근은 편측 이악물기의 영향을 받았으며, 상 · 하구륜근 및 이근의 경직도와 탄성도는 입술힘주기에 의해 크게 변화하였다($p<0.05$). 본 연구의 결과는 편측 이악물기, 턱내밀기, 입술힘주기 같은 구강악습관은 저작근뿐만 아니라 안면표정근, 특히 구강주위근육에도 영향을 준다는 것을 보여준다.

주제어 : 구강악습관, 저작근, 안면표정근, 촉각센서