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Original Article

Effects of Muscle Thickness of Masseter and Sternocleidomastoid, Forward Head Posture and Breathing in Subjects With and Without Dentures

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Background: For the elderly, masticatory function is one of the most important oral functions and the masticatory ability is related to the wearing of dentures. Many older people wear dentures for their masticatory function, but a significant number of older people who use dentures have found that they feel uncomfortable when performing their daily activities, such as performing masticating functions or talking.

Objects: The purpose of this study is to investigate how the forward head posture (FHP), respiratory function and thickness of masseter (MS), and sternocleidomastoid (SCM) are affected by the presence or absence of dentures in the elderly, and what kind of correlation there is between these variables.

Methods: The study was conducted on 11 patients in the normal group and 13 in the denture group. The participant's cognitive ability was evaluated using Mini-Mental State Examination Korean (MMSE-K), and the FHP was evaluated by measuring the craniovertebral angle (CVA). The thickness of the MS and SCM muscles were measured using ultrasound, and respiration was measured with a spirometry. As for the statistical method, the correlation of each variable was investigated using Spearman's correlation coefficient.

Results: In the normal group, there was a significant correlation between forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) ($p < 0.001$), and in the denture group, FVC and FEV1 ($p < 0.001$), maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) ($p < 0.001$), CVA and Lt. MS ($p = 0.012$).

Conclusion: CVA and Lt. MS of the denture group have a high negative correlation, it is related that the thickness of MS may be thick when the elderly wearing dentures are FHP.

INTRODUCTION

For the elderly, masticatory function is one of the most important oral functions. Maintaining this mastication function is essential for maintaining a healthy quality of life and life itself [1-3]. The muscles involved in this mastication process can be called masticatory muscles. The masticatory process requires mandibular movement as a process of opening and chewing the mouth, and it has been shown that the coordination of not only the masticatory muscles but also the anterior and posterior cervical muscles when the mandibular movement [4].

The forward head posture (FHP) can change the muscle length of the anterior and posterior cervical muscles, can be defined as hyperextension of the upper cervical vertebrae (C1–C3) and forward translation of the lower cervical vertebrae (C4) [5]. These postures were found to change the resting position of the mandibular and adversely affect dental occlusal contact and activation of the masticatory muscles [6,7]. Masseter (MS), one of the masticatory muscles, had a significant difference in muscle activity depending on the head posture [8]. In a recent study, it was also found that the muscle activation of MS was greater during masticatory motion than in the correct alignment posture with FHP [9].

In addition, one of the cervical muscles, that is tightened because overused due to these posture changes is the sternocleidomastoid (SCM) [10,11]. The SCM plays a role in controlling the angle of the head when the temporomandibular joint performs the masticatory function [12] and is also used to

assist breathing as an inspiratory adjuvant muscle [13]. This means that SCM is involved in breathing as well as functional movement of the neck. Moreover, when FHP is maintained continuously, it has been shown to decrease diaphragm contraction and thoracoabdominal mobility, and to elevate the ribcage [14,15], suggesting that it may cause breathing-related changes.

In the elderly, the masticatory ability to create these general changes in the body is also related to the wearing of dentures. Many older people wear dentures for their masticatory function, but a significant number of older people who use dentures have found that they feel uncomfortable when performing their daily activities, such as performing masticating functions or talking [16]. However, there was no study on the correlation of these dentures on the contraction of masticatory and cervical muscles, FHP, and respiration in the elderly. Therefore, the purpose of this study is to investigate how the FHP, respiratory function and thickness of MS and SCM are affected by the presence or absence of dentures in the elderly, and what kind of correlation there is between these variables.

MATERIALS AND METHODS

1. Participants

This study was conducted at the Onju Welfare Center located in Asan city for the elderly aged 65 to 24 who voluntarily agreed to participate. The recruitment of participants was conducted through poster recruitment. All participants had a Mini-Mental State Examination (MMSE) score of more than 24, so they had no problem in cognition, and they were composed of those who could move on their own. And denture group selected those who wore dentures for more than one year. The exclusion criteria for study participants are as follows. First, those with oral health problems excluding dentures; second, those with respiratory diseases or damage such as pneumonia and asthma; third, those who received physical therapy for correcting the FHP within 6 months; fourth, and other nervous system damage.

G-power 3.1.9.7 software (Franz Faul, Kiel University, Kiel, Germany) was used for participant selection. It was based on the effect size of 0.80, significance level of 0.05 and power of 80%, and the sample size required accordingly was 46. A total of 45 participants were recruited in consideration of previous studies [9,17], and among them, 10 participants with low cognitive scores, two participants with neurological problems, and four participants with smoking were excluded. During the experiment, two people from the normal group and three people from the denture group were eliminated due to intermediate abandonment, and finally 11 people from the normal group and 13 people from the denture group completed the experiment (Figure 1). The study was approved by the Institutional Ethics Committee of Hoseo University (IRB no. 1041231-210510-HR-125-06), and the experiment was conducted with the signed consent of all participants.

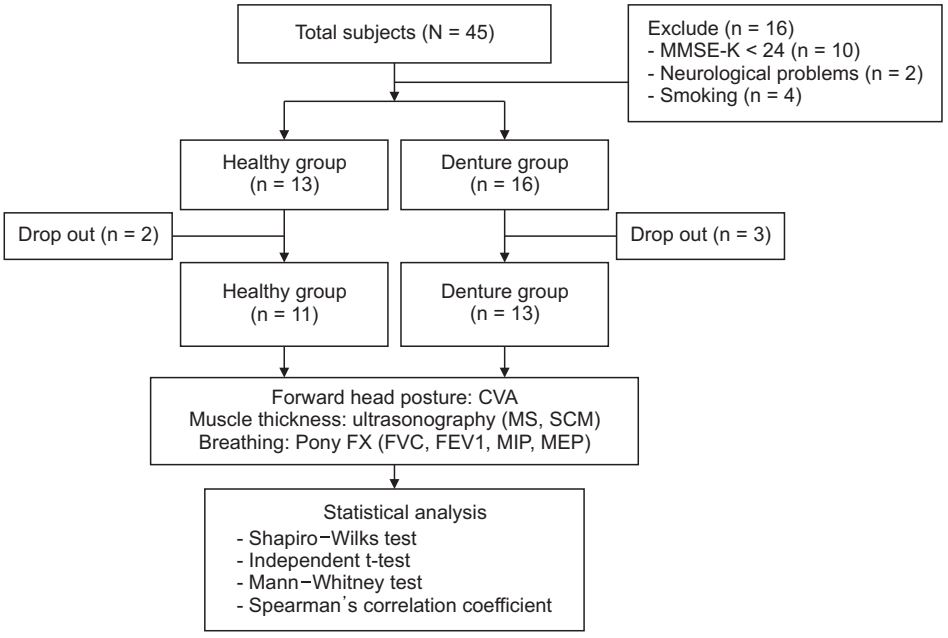

Figure 1. Flow chart of the study. MMSE-K, Mini-Mental State Examination Korean; CVA, craniovertebral angle; MS, masseter; SCM, sternocleidomastoid; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second; MIP, maximal inspiratory pressure; MEP, maximal expiratory pressure.

2. Instrumentation

1) Korean version of Mini-Mental State Examination

Korean version of Mini-Mental State Examination (MMSE-K) was used to evaluate the participant's cognitive status. MMSE-K is a cognitive function measure supplemented by taking into account the situation of the elderly in Korea with low educational attainment on average [18]. In a paper investigating the validity of MMSE-K using a smartphone, it was reported that MMSE-K is an effective cognitive function evaluation method for clinical use [19]. Accordingly, this study included participants with a score of more than 24 according to the MMSE-K.

2) Craniovertebral angle

FHP was measured by craniovertebral angle (CVA). The measurement was based on the angle at which the line parallel to the floor and the line made when the spinous process and tragus of 7th cervical vertebra (C7) were drawn in a straight line meet based on the spinous process of the C7. After instructing the participant to bend and straighten their neck by themselves, C7 was palpated and marked with a sticker. For accuracy, a tripod was installed 1 m away from the right side of the participant during each measurement and measured with a smartphone camera. Participants were set to a natural head position (NHP) through self-balance posture (SBP) measurements [20]. The SBP is a method that allows the participant to flexion and extension the neck from a large range to a small range, so that the most comfortable and NHP is obtained when measuring [21]. In a cross-sectional study that evaluated the reliability of CVA in people with or without neck pain, it was reported that the reliability of CVA was higher during test-retest [22], and the smaller the angle of CVA, the larger the FHP.

3) Ultrasonography

Ultrasonography was used to measure the thickness of MS and SCM. The measured of MS is as follows: 1) The participant was in a supine position. 2) The participant palpated the right MS while powerfully clenching their teeth. 3) The ultrasound conductor was placed in the middle of the MS, and its location was the thickest part of the MS located at the same angle as the occlusal plane [23]. 4) The state in which teeth were relaxed and stable and the maximum clenched were repeated and measured three times each, and a break of 10 seconds was given for each measurement. 5) The measurement proceeded with the minimum pressure possible. 6) The thickness was checked based on the thickest part of the measured ultrasound image, and the opposite side was also performed in the same manner.

The measurement of SCM was carried out in a method proven by Jesus et al. [17], and the order is as follows: 1) The participant is supine with the biofeedback behind the neck. At this time, the pressure of the biofeedback was set to 20 mmHg. 2) The neck was turned to the left to palpation the right SCM. 3) The conductor of ultrasound was placed in a direction parallel to the respiratory tract and about 5 cm to the right from the neck centerline so that the SCM, neck artery, and vertebral arch could be properly visualized. 4) After measuring once in a stable state, the biofeedback pressure value was shown to the participant, and the participant was instructed to flexion the neck at a pressure of 10 mmHg and maintain the pressure of 30 mmHg for 5 seconds. 5) It proceeded with the minimum pressure possible during the measurement, and was repeatedly measured three times each. 6) A break of 10 seconds was given for each measurement, and the opposite side proceeded the same.

4) Spirometry

Spirometer (Pony FX; COSMED Inc., Rome, Italy) was used to measure the respiratory function, and the forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), maximal inspiratory pressure (MIP), and maximal expiratory pressure (MEP) were measured. MIP is widely used for evaluating inspiratory strength, and MEP is the only test to measure expiratory strength [24]. The method of measuring FVC is as follows: 1) The participant sat upright in a chair and practiced 3 times or more with the same breathing as usual. 2) Put the mouthpiece in your mouth and take a deep inspiration, then expiration strongly, quickly, and forcefully for 6 seconds. At this time, they blocked nose with their hand to breathe only with mouth. 3) Measurements were repeated 3 times, and a break of 3 minutes was given for each measurement [25]. The maximum expiration amount during the first second of the FVC shown at this time was indicated as FEV1.

The method of measuring MIP is as follows: 1) The participant sat upright in a chair and practiced 3 times or more with the same breathing as usual. 2) After light expiration, they held a mouthpiece in the mouth and inspiration as much as possible, and at this time, the participant blocked nose with their own hand. 3) It was conducted until the end sound came out

from Pony FX, and the measurement was repeated 3 times. 4) Each measurement was given a 3-minute break. The method of measuring MEP is as follows: 1) The participant sat upright in a chair and practiced 3 times or more with the same breathing as usual. 2) After lightly inspiration, held a mouthpiece in the mouth and expiration to the maximum. At this time, the participant blocked nose with their hand and proceeded. 3) It was conducted until the end sound came out from Pony FX, and the measurement was repeated 3 times. 4) Each measurement was given a 3-minute break.

3. Data Analysis

Statistical analysis used the IBM SPSS statistics software program (ver. 20.0; IBM Co., Armonk, NY, USA). Through Shapiro–Wilk normality test, it was investigated whether the variables were normally distributed. As a result of the test, since both MS and Lt. SCM were not normally distributed, and other variables were normally distributed, the normal group and the denture group were compared using the Independent t-test and the Mann-Whitney U test. Through Spearman's correlation coefficient investigated the correlation between denture groups and normal groups. At this time, the p-value was set less than 0.05 ($p < 0.05$).

Table 1. Characteristics of subjects in people with normal and denture group (N = 24)

Variable	Normal group	Denture group
Sex (male/female)	1/10	3/10
Age (y)	77.45 ± 6.61	79.50 ± 4.11
Height (cm)	154.04 ± 0.07	159.15 ± 0.09
Weight (kg)	58.91 ± 10.98	57.43 ± 8.49
BMI (kg/m^2)	25.02 ± 5.11	23.85 ± 3.37

Values are presented as number only or mean ± standard deviation. BMI, body mass index.

RESULTS

In this study, a total of 24 participants were included with 11 people normal groups and 13 people dentures groups. The general characteristics of the participant are as follows (Table 1). There was no significant difference in the general characteristics of the normal and the denture group.

In this study, mean ± standard deviation of CVA, MS, SCM, FVC, FEV1, MIP, and MEP of the normal group and denture group are shown in Table 2. No significant differences were found between groups.

The results of CVA, MS, SCM, FVC, FEV1, MIP, and MEP correlation analysis of the normal groups in this study are shown in Table 3. Statistic results show that the normal group had a significant correlation between FVC and FEV1 ($p < 0.05$).

Statistics show that dentures have a significant correlation between FVC and FEV1, MIP and MEP, and that CVA and Lt. MS have a negative correlation with a significance probability of 0.012 (Table 4).

Table 2. Comparison between normal and denture group (N = 24)

	Normal group	Denture group
CVA	53.32 ± 1.70	50.19 ± 2.12
Rt. MS	1.18 ± 0.37	1.22 ± 0.15
Lt. MS	1.46 ± 0.34	0.96 ± 0.21
Rt. SCM	1.22 ± 0.45	1.45 ± 0.36
Lt. SCM	2.48 ± 0.99	2.93 ± 1.39
FVC	1.82 ± 0.14	1.60 ± 0.19
FEV1	1.37 ± 0.09	1.20 ± 0.15
MIP	49.18 ± 5.27	42.92 ± 5.31
MEP	59.0 ± 5.16	51.69 ± 6.72

Values are presented as mean ± standard deviation. CVA, craniovertebral angle; Rt., right; MS, masseter; Lt., left; SCM, sternocleidomastoid; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second; MIP, maximal inspiratory pressure; MEP, maximal expiratory pressure.

Table 3. Correlation coefficient analysis of normal group (N = 11)

	CVA	Rt. MS	Lt. MS	Rt. SCM	Lt. SCM	FVC	FEV1	MIP	MEP
CVA	1								
Rt. MS	–0.597	1							
Lt. MS	–0.491	0.519	1						
Rt. SCM	0.251	–0.091	0.132	1					
Lt. SCM	0.032	–0.137	–0.196	0.543	1				
FVC	0.100	–0.169	–0.300	0.278	0.077	1			
FEV1	–0.023	0.068	–0.077	0.575	0.247	0.884*	1		
MIP	–0.355	–0.084	–0.223	–0.297	–0.429	0.478	0.251	1	
MEP	0.018	0.109	–0.327	–0.437	–0.328	0.191	–0.077	0.342	1

CVA, craniovertebral angle; Rt., right; MS, masseter; Lt., left; SCM, sternocleidomastoid; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second; MIP, maximal inspiratory pressure; MEP, maximal expiratory pressure. *$p < 0.05$.

Table 4. Correlation coefficient analysis of dental group (N = 13)

	CVA	Rt. MS	Lt. MS	Rt. SCM	Lt. SCM	FVC	FEV1	MIP	MEP
CVA	1								
Rt. MS	−0.424	1							
Lt. MS	−0.671*	0.399	1						
Rt. SCM	0.539	−0.314	−0.527	1					
Lt. SCM	−0.157	−0.019	0.016	−0.352	1				
FVC	0.408	−0.037	−0.187	0.385	−0.333	1			
FEV1	0.322	0.088	−0.060	0.418	−0.231	0.916**	1		
MIP	0.121	0.048	−0.118	0.019	−0.226	0.512	0.495	1	
MEP	0.135	0.118	−0.203	0.016	−0.341	0.481	0.379	0.946**	1

CVA, craniovertebral angle; Rt., right; MS, masseter; Lt., left; SCM, sternocleidomastoid; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second; MIP, maximal inspiratory pressure; MEP, maximal expiratory pressure. *p < 0.05, **p < 0.01.

DISCUSSION

Many elderly people wear dentures to solve the problem of tooth loss, one of the representative oral health problems of the elderly, but this has disadvantages that it can cause problems such as discomfort and pain in the oral cavity [16]. FHP affects tooth occlusion and masticatory muscle activity, and this posture refers to an abnormal neck posture characterized by hyperextension of the upper cervical vertebra and flexion of the lower cervical and upper vertebrae [24]. FHP causes upper-crossed syndrome due to shortening of SCM and upper trapezius muscles and weakening of lower trapezius muscles [26,27], which causes chest pain and respiratory system functional degradation [28]. Therefore, this study investigated how wearing dentures affects the thickness of MS and SCM during contraction, FHP and respiratory function, as well as correlation between the variables.

As a result of the study, it was found that wearing dentures in comparison between groups did not significantly affect the thickness of MS and SCM, FHP, and respiratory function. As a result of examining the correlation between variables, FVC and FEV1 in the normal group have a high positive correlation ($p < 0.001$) was shown, but other variables showed no significant correlation. Also, in the denture group, FVC and FEV1, MIP and MEP showed a high positive correlation ($p < 0.001$), and CVA and Lt. MS showed a high negative correlation ($p = 0.012$).

FVC is the amount of air blown out after inspiratory air as quickly and strongly as possible, measured for determine the presence or absence of restrictive lung disease, and FEV1 is a test method that can measure the presence or absence of obstructive lung disease, meaning the amount of air expiratory during the first second of FVC measurement [29]. The reason that both the normal and denture groups showed a high correlation in FVC and FEV1, because they were both methods of measuring lung dysfunction, consistent with previous studies showing significant differences of FVC and FEV1 with aging in elderly people [30]. It is judged that the reason for the high correlation between MIP and MEP in the denture group is because they are indicators used to evaluate inspiratory and expiratory muscle strength, respectively [23].

The results of this study reported negative correlation between CVA and Lt. MS in denture group is similar to previous studies showing that MS in groups with and without FHP was observed thicker when the mouth was closed, semi-open, and fully open [31]. In previous studies, when comparing the thickness of left and right MS and presence or absence of FHP in a normal person, a person with a protruding upper jaw, and a person with a protruding lower jaw, the results showed that the thickness of Lt. MS in those with protruding upper jaw was highest and FHP was the largest [6]. In this study, the CVA of the normal group and the denture group were measured as 53.32 ± 1.70 and 50.19 ± 2.12, respectively. In a previous study, it was reported that non-FHP when the CVA value was about 55 degrees and mild FHP when it was less than 48–50 degrees [6]; in this study, although there was no significant difference between the groups, it was confirmed that the denture group had a lower CVA value and the value was close to mild FHP than the normal group. In addition, the protruding shape of the upper jaw has a characteristic of hypodivergent with a shorter lower jaw than normal, and other previous studies have shown that MS of a person with such hypodivergent characteristic is observed thicker than that of normodivergent or hypodivergent with an average lower jaw length [32]. Based on these findings and the results of a study showing a significant

correlation between CVA and Lt. MS in the denture group in this study, it is carefully considered that the wearing of dentures caused changes in neck posture and jaw structure, resulting in a protruding upper jaw.

This study has two limitations. First, it is difficult to generalize the research results to male because the distribution of gender is concentrated on female. Second, the sample size of the study participants was small. Before the experiment, 47 participants were recruited in consideration of the results of population calculation and previous studies [9,17], but 23 participants were dropped out due to cognitive problems, smoking, and giving up halfway, so only 24 participants completed the experiment. It is believed that a more detailed analysis will be possible if the experiment is conducted by increasing the number of participants in subsequent studies. In addition, it is thought that further research through regression analysis is necessary, and it is thought that clinically useful data could be obtained.

CONCLUSIONS

In this study, it was found that wearing dentures when comparing between groups did not significantly affect the thickness of MS and SCM, FHP, and respiratory function. However, as a result of examining the correlation between variables within each group, it was found that CVA and Lt. MS had a high negative correlation in dentures group, which is considered that wearing dentures caused changes in neck posture and jaw structure, showing a significant correlation in CVA and Lt. MS. In future studies, if we follow up and observe whether changes in jaw structure actually occur in the elderly with FHP while wearing dentures, it is thought that it will serve as a basis for research necessary to improve the oral health of the elderly.

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CONFLICTS OF INTEREST

No potential conflicts of interest relevant to this article are reported.

AUTHOR CONTRIBUTION

Conceptualization: YIH. Data curation: SYK, YIH. Formal analysis: SYK, YIH. Funding acquisition: SYK, KSK, YIH. Investigation: SYK, YIH. Methodology: KSK, YIH. Project administration: SYK, YIH. Resources: YIH. Supervision: KSK, YIH. Validation: KSK, YIH. Visualization: SYK, YIH. Writing - original draft: SYK. Writing - review & editing: KSK, YIH.

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