Changes of the Pharyngeal Space by Various Oral Appliances for Snoring

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The purpose of this study was to investigate the changes of the pharyngeal space when the following appliances were inserted: the mandibular advancement appliance (MAA), tongue retaining appliance (TRA), and mandibular advancement-tongue retaining appliance (MATRA).

Nine male dental students exhibiting Class I occlusion, normal body mass index (BMI), and no signs and symptoms of snoring were selected for this study. The three kinds of snoring appliances (MAA, TRA and MATRA) were fabricated for each subject. The mandibular advancement of the MAA and MATRA was set at a distance of 5 mm, and the TRA and MATRA were made to hold the tongue in front of the maxillary incisors by 10 to 20 mm. Lateral cephalometric radiographs of the following four states - with no appliance, MAA, TRA, and MATRA - were taken to examine any anatomical changes resulting from the application of the appliances. All four radiographs were traced and analyzed for twenty selected variables related to the pharyngeal space, cranio-cervical posture, and position of the soft palate and hyoid bone.

According to the results of this study, there were significant increases in both the upper and lower oropharyngeal spaces when the mandible and tongue were protruded simultaneously, although there was a significant increase only in upper oropharyngeal space when the mandible or tongue was advanced separately.

In conclusion, it is suggested that the MATRA may result in more positive effect on the control of snoring and OSA compared to a single use of the MAA or TRA, especially for the patients whose upper airway obstruction occurs in the lower oropharynx.

Key words: Snoring, Appliance, Tongue retaining, Oropharynx

I. INTRODUCTION

Snoring is a noise produced by vibration of the soft palate and adjacent structures and represents partial obstruction due to narrowing of the upper airway at that site.[1] In some snoring patients, breathing is normal or minimally impaired, and there are no other symptoms. But, in others, snoring is associated with obstructive sleep apnea syndrome (OSAS), which is characterized by repetitive cessation of airflow because of upper airway obstruction despite simultaneous respiratory effort during sleep. In addition to daytime sleepiness and cognitive and mood impairment, OSAS also increases the risk of hypertension, coronary heart disease, and cerebro-

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vascular diseases,[2] thereby requiring an aggressive management to improve the quality of life and prevent the serious complications.

The treatment modality for OSAS encompasses weight loss, oral appliances, continuous positive airway pressure (CPAP), and upper airway surgery. Of them, CPAP is widely accepted as the most efficacious therapy but still has disadvantages including poor compliance.

An oral appliance was first considered as a treatment for mandibular deficiency and upper airway obstruction in 1934.[3] With the recent interest in snoring and sleep apnea, various oral appliances have been proposed and studied, and emerged as an increasingly popular alternative to the more established therapies. There are two main appliance groups: mandibular advancement appliance (MAA) and tongue retaining appliance (TRA).[4] Although clinical evidences exist that these appliances are effective in the treatment of snoring and OSA patients,[5,6] the exact mechanism of action - how each appliance has influences on the upper airway structure - has still remained unclear and few studies have been attempted to define the combination effect of mandubular and tongue protrusion on the upper airway dimension.

The purpose of this study was to compare the changes in the dimension of the pharyngeal space through a cephalometric analysis when the following appliances were inserted: mandibular advancement appliance (MAA), tongue retaining appliance (TRA) and mandibular advancement-tongue retaining appliance (MATRA).

Ⅱ. MATERIALS AND METHODS

Nine male dental students exhibiting Class I occlusion, normal body mass index (BMI) - the BMI of 2 subjects were near the normal range - and no signs and symptoms of snoring were selected for this study. Their mean age was 25.1 years (range : 23 to 27) and their mean BMI was 22.5 kg/m^2 (range : 19.5 to 25.6). Informed consent was given by all subjects who participated in this study.

Three kinds of snoring appliances (MAA, TRA and MATRA) were fabricated for each subject. The mandibular advancement of the MAA and MATRA was set at a distance of 5 mm (the minimum amount of mandibular protrusion to increase the pharyngeal space,[7] about 50-60% of the maximum protrusive range of the subjects) and the TRA and MATRA were made to hold the tongue in front of the maxillary incisors by 10mm (7subjects) to 20mm (2 subjects who had much larger tongue than other subjects). The incisal separation of all the appliances was 12 mm. No information was given to the subjects about the appliances.

Lateral cephalometric radiographs of the following

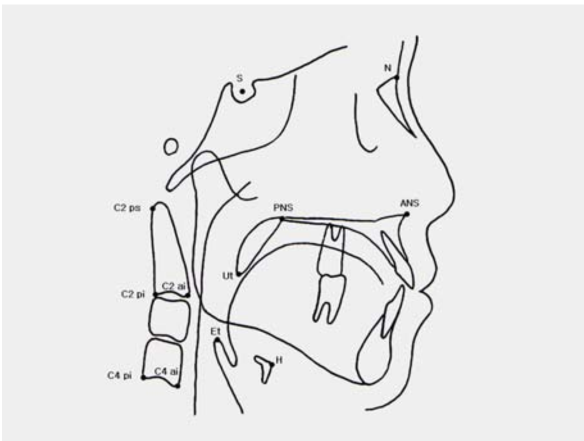

Fig. 1. Cephalometric landmarks. S: center of sella turcica, the center of the pituitary fossa of the sphenoid bone; N: nasion, the most anterior point on the frontonasal suture; ANS: anterior nasal spine; PNS: posterior nasal spine; Ut: uvula tip, the most inferior point of the uvula; Et: epiglottis tip, the most superior point of the epiglottis; H: the most anterosuperior point on the body of the hyoid bone; C2ai, C4ai: the most anteroinferior point on the corpus of the second and fourth cervical vertebrae; C2ps: the most posterosuperior point on the corpus of the second cervical vertebra; C2pi, C4pi: the most posteroinferior point on the corpus of the second and fourth cervical vertebrae bodies

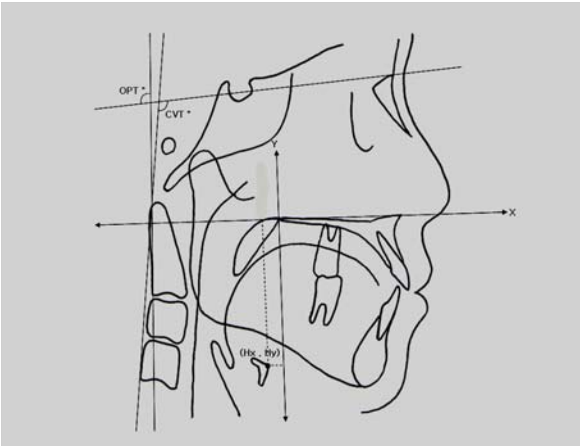

Fig. 2. Cervical posture and position of the hyoid bone

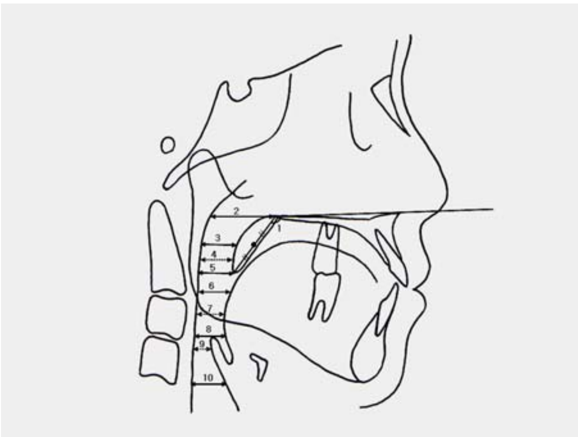

Fig. 3. Linear and angular measurements.

1. ANS-PNS/U,
2. UOAS1(Upper Oropharyngeal Airway Space 1),
3. UOAS2(Upper Oropharyngeal Airway Space 2),
4. SUOAS(Smallest Upper Oropharyngeal Airway Space),
5. UOAS3(Upper Oropharyngeal Airway Space 3),
6. LOAS1(Lower Oropharyngeal Airway Space 1),
7. SLOAS(Smallest Lower Oropharyngeal Airway Space),
8. LOAS2(Lower Oropharyngeal Airway Space 2),
9. SHAS(Smallest Hypopharyngeal Airway Space),
10. HAS(Hypopharyngeal Airway Space)

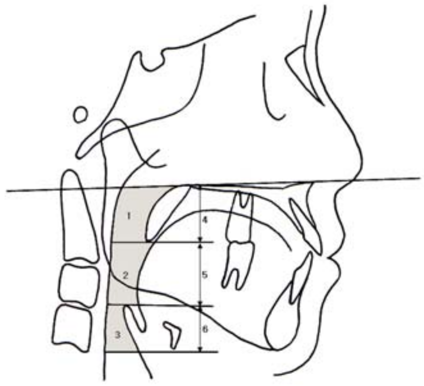

Fig. 4. Measurements of pharyngeal area and height.

1. UOROXA (upper oropharyngeal cross-sectional area in sagittal plane),
2. LOROXA (lower oropharyngeal cross-sectional area in sagittal plane),
3. HYPOXA (hypopharyngeal cross-sectional area in sagittal plane),
4. UOROH (upper oropharyngeal height),
5. LOROH (lower oropharyngeal height),
6. HYPOH (hypopharyngeal height).

four states - with no appliance (baseline), MAA, TRA and MATRA - were taken in the natural head position and at the end of expiration to examine any anatomical changes resulting from the application of the three appliances. Cephalometric radiographs were taken using Orthophos CD®(SIEMENS). All four radiographs were traced and analyzed for twenty selected variables indicating the pharyngeal space, cranio-cervical posture and position of the soft palate and hyoid bone (Fig. 1 to 4). The tracing and analysis of the images was performed by one investigator who was blinded to the information about the appliances and radiographs. Digital planimeter (KP-90®,PLACOM) was employed to measure the pharyngea larea.

Friedman and Wilcoxon signed rank tests were used to compare the changes of the twenty selected variables in this study.

Table 1. Summary of the variables used for cephalometric analysis

Variables	Interpretation
	Anteroposterior dimension of the upper oropharynx (mm)
UOAS1	Upper Oropharyngeal Airway Space 1 (width of upper oropharyngeal airway along ANS- PNS line)
UOAS2	Upper Oropharyngeal Airway Space 2 (width of upper oropharyngeal airway along line parallel to ANS- PNS line through midpoint of PNS-Ut line)
SUOAS	Smallest Upper Oropharyngeal Airway Space (smallest width of upper oropharyngeal airway along line parallel to ANS- PNS line)
UOAS3	Upper Oropharyngeal Airway Space 3 (width of upper oropharyngeal airway along line parallel to ANS- PNS line through Ut)
	Anteroposterior dimension of the lower oropharynx (mm)
LOAS1	Lower Oropharyngeal Airway Space 1 (width of lower oropharyngeal airway along line parallel to ANS- PNS line through C2)
SLOAS	Smallest Lower Oropharyngeal Airway Space (smallest width of lower oropharyngeal airway along line parallel to ANS- PNS line)
LOAS2	Lower Oropharyngeal Airway Space 2 (width of lower oropharyngeal airway along line parallel to ANS- PNS line through Et)
	Anteroposterior dimension of the hypopharynx (mm)
SHAS	Smallest Hypopharyngeal Airway Space (the smallest width of hypopharyngeal airway along line parallel to ANS- PNS line)
HAS	Hypopharyngeal Airway Space (width of lower oropharyngeal airway along line parallel to ANS- PNS line through C4)
	Pharyngeal area (cm^2)
UOROXA	Upper Oropharyngeal Cross-Sectional Area in sagittal plane (area outlined by posterior pharyngeal wall, UOAS1 line, posterior wall of the soft palate and UOAS3 line)
LOROXA	Lower Oropharyngeal Cross-Sectional Area in sagittal plane (area outlined by posterior pharyngeal wall, UOAS3 line, dorsal surface of the base of the tongue and LOAS2 line)
HYPOXA	Hypopharyngeal Cross-Sectional Area in sagittal plane (area outlined by posterior pharyngeal wall, LOAS2 line, anterior pharyngeal wall and HAS line)
	Pharyngeal height (mm)
UOROH	Upper Oropharyngeal Height (distance between UOAS1 line and UOAS3 line)
LOROH	Lower Oropharyngeal Height (distance between UOAS3 line and LOAS2 line)
HYPOH	Hypopharyngeal Height (distance between LOAS2 line and HAS line)
	Cranio-cervical posture (°)
OPT°	OPT/SN, second cervical vertebral tangent on the odontoid process C2ps through C2pi
CVT°	CVT/SN, cervical vertebral tangent, posterior tangent on the odontoid process C2ps through C4pi
	Position of the hyoid bone
Hx	the x co-ordinate of H, when ANS-PNS line is called the X-axis
Hy	the y co-ordinate of H, when a line which passes through PNS at a right angle is called the Y-axis
	Position of the soft palate (°)
ANS-PNS/U	angle between ANS- PNS line and PNS-Ut line

Ⅲ. RESULTS

Table 2 shows how each appliance changed the cephalometric variables indicating the pharyngeal space, position of the soft palate and hyoid bone, and cranio-cervical posture. From the result of Friedman test, significant differences had been found in the eleven of twenty variables among baseline, MAA, TRA and MATRA groups, and these eleven variables were compared using Wilcoxon signed

Table 2. The results of Friedman test for cephalometric variables indicating the pharyngeal space, position of the soft palate and hyoid bone and cranio-cervical posture.

Variables	Baseline	MAA	TRA	MATRA	p-value
Anteroposterior dimension of the upper oropharynx (mm)					
UOAS1	30.000±4.583	30.556±4.127	30.000±4.093	30.000±4.093	NS
UOAS2	15.333±4.637	17.667±3.937	16.222±3.866	18.222±4.381	*
SUOAS	14.333±4.301	16.111±4.343	16.333±4.899	17.778±4.685	**
UOAS3	16.944±4.990	19.333±5.339	20.222±4.944	21.667±5.074	**
Anteroposterior dimension of the lower oropharynx (mm)					
LOAS1	15.556±4.187	12.944±4.202	18.167±4.287	21.333±5.220	**
SLOAS	13.500±2.291	11.444±2.931	14.278±2.360	17.556±4.773	**
LOAS2	13.944±2.603	13.167±2.475	14.722±2.796	18.556±5.102	**
Anteroposterior dimension of the hypopharynx (mm)					
SHAS	6.389±2.571	7.056±2.351	6.833±2.475	10.111±5.667	NS
HAS	17.667±2.828	16.111±3.258	17.111±3.983	18.556±5.457	NS
Pharyngeal area (cm^2)					
UOROXA	3.878±1.230	4.522±1.267	4.483±1.228	4.756±1.292	**
LOROXA	5.250±1.758	5.217±1.316	6.272±1.923	7.306±1.588	**
HYPOXA	3.394±1.206	2.594±1.195	3.206±1.460	3.800±2.303	NS
Pharyngeal height (mm)					
UOROH	24.222±2.949	36.375±4.406	25.111±2.261	23.889±2.472	NS
LOROH	30.375±6.479	36.375±4.406	31.125±5.617	31.375±4.104	**
HYPOH	26.944±8.981	22.444±8.110	25.889±9.048	25.944±8.308	**
Cranio-cervical posture (°), position of the soft palate (°) and hyoid bone					
OPT°	105.444±6.386	106.222±6.924	105.778±6.418	105.333±5.657	NS
CVT°	113.324±5.286	112.568±6.481	113.789±6.352	113.565±6.387	NS
ANS-PNS/U	127.444±8.263	124.667±9.028	121.778±9.351	120.444±10.525	NS
Hx	-6.111±5.841	-6.444±4.503	-7.222±9.641	-4.556±5.525	NS
Hy	-71.333±4.924	-79.222±5.196	-78.222±4.790	-76.333±5.196	**

*: $p < .05$, **: $p < .01$

rank test.(Table 3)

After insertion of the MAA, the anteroposterior (AP) dimension (UOAS2, SUOAS, UOAS3) and the area (UOROXA) of the upper oropharynx increased significantly, while the AP dimension of the lower oropharynx (LOAS1, SLOAS) decreased significantly. When the TRA was inserted, the AP dimension of the upper oropharynx (UOAS3) and both upper and lower oropharyngeal areas (UOROXA, LOROXA) increased significantly. All cephalometric variables indicating the AP dimension (UOAS2, SUOAS, UOAS3, LOAS1, SLOAS, LOAS2) and the area (UOROXA, LOROXA) of the oropharynx increased significantly with insertion of the MATRA.

There existed no major difference in the increase of the AP dimension of the upper oropharynx and area of oropharynx between the MAA and TRA groups. However, the increase of the AP dimension of the lower oropharynx (LOAS1, SLOAS) was significantly greater in the TRA group than in the MAA group. Although both the MAA and MATRA increased the AP dimension of the upper oropharynx similarly, the increase in the AP dimension and the area of the lower oropharynx was significantly greater in the MATRA group than in the MAA group.

The increase in the AP dimension of the oropharynx (UOAS2, UOAS3, SLOAS, LOAS2) and the lower pharyngeal area (LOROXA) was significantly greater in the MATRA group compared with the TRA group. Only MAA increased

Table 3. The results of Wilcoxon signed rank test on the changes among the measurements using the MAA, TRA and MATRA in variables with significances confirmed by Friedman test

Variables	baseline/MAA	baseline/TRA	baseline/MATRA	MAA/TRA	MAA/MATRA	TRA/MATRA
Anteroposterior dimension of the upper oropharynx (mm)						
UOAS2	* (+)	NS	* (+)	NS	NS	* (+)
SUOAS	* (+)	NS	** (+)	NS	NS	NS
UOAS3	* (+)	* (+)	** (+)	NS	NS	* (+)
Anteroposterior dimension of the lower oropharynx (mm)						
LOAS1	* (−)	NS	** (+)	* (+)	** (+)	NS
SLOAS	* (−)	NS	** (+)	* (+)	** (+)	* (+)
LOAS2	NS	NS	** (+)	NS	** (+)	* (+)
Pharyngeal area (cm^2)						
UOROXA	* (+)	* (+)	** (+)	NS	NS	NS
LOROXA	NS	* (+)	* (+)	NS	* (+)	* (+)
Pharyngeal height (mm)						
LOROXH	* (+)	NS	NS	* (−)	* (−)	NS
HYPOXH	* (−)	NS	NS	** (+)	* (+)	NS
Position of the hyoid bone						
Hy	** (−)	** (−)	** (−)	NS	NS	NS

* : $p < .05$, ** : $p < .01$

+ : A/B, when B is larger than A

− : A/B, when A is larger than B

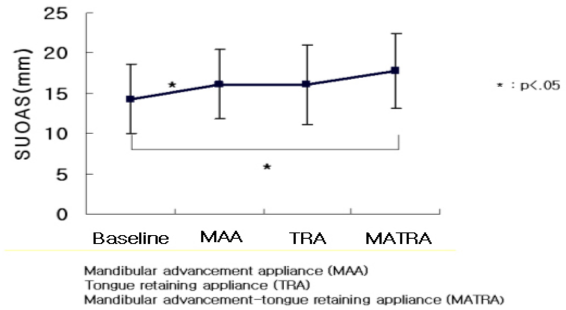

Fig. 5. The changes of the smallest upper oropharyngeal airway space (SUOAS) by using the MAA (mandibular advancement appliance), TRA (tongue retaining appliance) and MATRA (mandibular advancement-tongue retaining appliance).

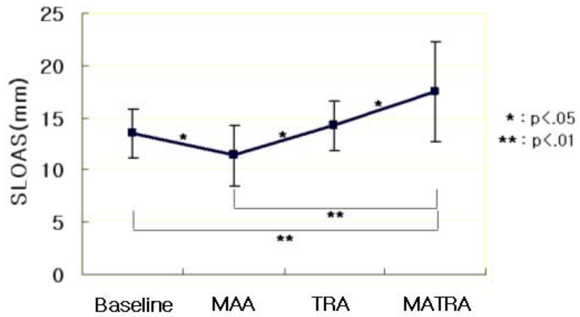

Fig. 6. The changes of the smallest lower oropharyngeal airway space (SLOAS) by using the MAA (mandibular advancement appliance), TRA (tongue retaining appliance) and MATRA (mandibular advancement-tongue retaining appliance).

significantly the lower oropharyngeal height (LOROH), and decreased the hypopharyngeal height (HYPOH).

Vertical position of the hyoid bone (Hy) decreased significantly with placement of each appliance in and there were no significant differences among three appliances.

Ⅳ. DISCUSSION

When selecting subjects, skeletal subtype, gender and body mass index (BMI) should be considered because the effects of appliances may differ according to those personal variations. Previous studies showed that there were series of characteristics of upper airway structure that differ between patients with OSA and normal subjects matched for skeletal subtype and gender.[8] It was also reported that there were significant differences in the effects of protrusion of the mandible and tongue when the subjects were divided according to BMI, particularly in the lower oropharygeal (retroglossal) airway space.[9] To lessen the effect due to these personal variables, therefore, only male subjects having Class I occlusion and normal BMI (the BMI of 2 subjects were near the normal range) were selected for this study.

In addition to the personal characteristics described previously, cranio-cervical posture and state of respiration can also influence the upper airway dimension. If the head posture is changed by tilting the head backward from the lower cervical region, the pharynx will be narrowed. On the other hand, if the head is tilted backward from the upper cervical vertebrae, the pharynx will be widened.[10] In this study, the effects of the cranio-cervical posture on the upper airway dimension could be ruled out from the results that there was no significant change in the cranio-cervical posture (OPT°, CVT°) when the subjects were wearing the MAA, TRA and MATRA. Considering the state of respiration, upper airway caliber remains relatively constant during inspiration, enlarges in early expiration, and then narrows significantly toward the end of expiration[11]. In this study, lateral cephalometric radiographs were taken at the end of expiration to ensure consistency of the upper airway caliber.

Reference line used for cephalometric analysis can be another important factor affecting the result of analysis. Previous studies used Go-B[7,12,13]or Go-Me [14] as a reference line to measure the anteroposterior (AP) dimension of the pharynx on the cephalometric radiograph. But it is thought that because the inclination of these reference lines are changed by opening movement of the mandible, possibly leading to false positive increase or decrease of the pharyngeal dimension. Therefore, we employed ANS-PNS, which remains constant irrespective of the mandibular movement, as a reference line to measure the AP dimension of the pharynx.

Upper airway closure in patients with snoring and OSA is mainly due to recurrent opposition of the soft palate and posterior movement of the base of the tongue during sleep.[15,16] Therefore, the goal of therapy with an oral appliance is to enlarge the oropharyngeal airway or to reduce its collapsibility. According to the previous studies, the changes in the upper or opharyngeal space (velopharynx) caused by MAA that produced advancement and downward rotation of the mandible was increase in the AP diameter,[14,17] lateral diameter,[18] cross-sectional area in the sagittal plane,[7] cross-sectional area in the horizontal plane[12,18,19] and volume[19] of the space. In this study, the AP dimension (UOAS2, SUOAS, UOAS3) of the upper oropharynx increased significantly after insertion of the MAA and MATRA. It is, therefore, suggested that these appliances contributed to forward movement of the middle (UOAS2) and inferior (UOAS3) portion of the soft palate through the mechanical connection between the palatopharyngeus muscle and the superior pharyngeal constrictor muscle.

According to the previous studies, the lower oropharyngeal (postlingual) space increased significantly in some studies.[10,14,20,21] but did not in other studies[7,12,17] following insertion of the MAA. It is assumed that there have existed considerable personal variations in the effects of the MAA among the subjects participated in each study. In this study, the AP dimension of the lower oropharyngeal space (LOAS1, SLOAS) decreased significantly with insertion of the MAA. Tsuiki et al[22] reported that the activity of the genioglossus muscle increased following mandibular advancement during respiration, in both upright and supine position, possibly leading to prevent the tongue from occluding the pharynx. However, it is assumed that the increased activity of the genioglossus muscle does not always insure the pharyngeal patency. According to a study by Pae et al,[23] oropharyngeal space decreased in spite of the increase in the genioglossus muscle EMG activity. Further investigation is needed to explain why individuals differ so much in their response to MAA.

There are two studies[9,22] that attempted to define the effect of tongue protrusion on upper airway dimension. In one study[9] using videoendoscopy, the cross-sectional area of the lower oropharynx was significantly increased by half-maximal protrusion and the cross-sectional area just proximal to the free margin of the soft palate was significantly increased by maximal protrusion of tongue. Another study[22] using lateral cephalometric radiography showed that TRA increased significantly the cross-sectional area of the oropharynx and hypopharynx in the sagittal plane as well as the AP dimension of the upper and lower oropharynx. However, it is likely that their results were affected by the use of Go-B as a reference line.

This study exhibited that the AP dimension of the upper oropharynx (UOAS3) and both the upper and lower oropharyngeal areas (UOROXA, LOROXA) increased significantly with insertion of the TRA. The effects of the TRA can be explained by the following two mechanisms. At first, tongue protrusion may stretch the soft palate through the mechanical connection between the lateral wall of the soft palate and the base of the tongue through the palatoglossus muscle and result in the forward movement of the soft palate. Secondly, the lower oropharyngeal space can be maintained or increased by mechanically preventing the base of tongue from moving posteriorly or keeping the tongue in a protruded position.

In this study, the AP dimension of the lower oropharynx didn't increased noticeably by the TRA ($p=0.055$), though it showed a tendency to increase. On the while, the MATRA increased significantly the AP dimension of the lower oropharynx. Based on these findings, it is assumed that there may exist synergistic effect between the MAA and TRA in their ability to increase the lower oropharyngeal space. Because protruded mandible allows enough space for the forward movement of the tongue, the oropharyngeal space may be able to increase easily when the tongue is protruded together with the mandible. Along with further researches on the change of the upper airway dimension using three-dimensional airway imaging, polysomnographic study should be carried out to investigate whether clinical effectiveness of the MATRA is also superior to the MAA and TRA.

This study showed that the hyoid bone moved downward after insertion of each of the three appliances, which is thought to be associated with downward movement of the mandible. However, in other studies,[7,20] there was no significant change in the position of the hyoid bone with respect to the maxillary plane. It is thought to be that this disagreement may be due to the difference in the vertical dimension of the appliances.

In summary, it was only the mandibular advancement-tongue retaining appliance (MATRA) that significantly increased both the upper and lower oropharyngeal space consistently, though the mandibular advancement appliance (MAA) and tongue retaining appliance (TRA) increased the upper oropharyngeal space. Based on the results of this study, it is suggested that the MATRA may result in a more positive effect on the treatment of snoring and OSA compared to the MAA and TRA, especially for the patients whose upper airway obstruction occur in the lower oropharynx.

REFERENCES

1. Suratt PM, Dee P, Atkinson RL, Armstrong P, WilhoitSC. Fluoroscopic and computed tomographic features of the pharyngeal airway in obstructive sleep apnea. Am Rev Respir Dis 1983;127:487-492.
2. Waller PC, Bhopal RS. Is snoring a cause of vascular disease? An epidemiological review. Lancet 1989;1:143-146.
3. Robin P. Glossoptosis due to atresia and hypotrophy of the mandible. Am J Dis Child 1934;48:541-547.
4. Ferguson KA. Oral appliance therapy for the management of sleep-disordered breathing. Semin Respir Crit Care Med 1998;19:157-164.
5. Schmidt-Nowara W, Lowe A, Wiegand L et al. Oral appliances for the treatment of snoring and sleep apnea: a review. Sleep 1995;18:501-510.
6. Mohsenin N, Mostofi MT, Mohsenin V. The role of oral appliances in treating obstructive sleep apnea. JADA 2003;134:442-449.
7. Yeo IS, Han KS, Kim CH. Change of pharyngeal space and mandibular position by intraoral appliance for snoring. Korean J Oral Med 2002;27:271-283.
8. Lowe AA, Ono T, Ferguson KA et al. Cephalometric comparisons of craniofacial and upper airway structure by skeletal subtype and gender in patients with obstructive sleep apnea. Am J Orthod Dentofa .Orthop 1996;110:653-664.
9. Ferguson KA, Love LL, Ryan CF. Effect of mandibualr and tongue protrusion on upper airway size during wakefulness. Am J Respir Crit Care Med 1997;155: 1748-1754.
10. Linder-Aronson S, Woodside DG. Excessive face height malocclusion: Etiology, diagnosis, and treatment. Chicago, 2000, Quintessence Co., pp.
11. Schwab RJ, Gefter WB, Hoffman EA et al. Dynamic upper airway imaging during awake respiration in normal subjects and patients with sleep disordered breathing. Am Rev Respir Dis 1993;148:1385-1400.
12. Eveloff SE, Rosenberg CL, Carlisle CC, Millman RP. Efficacy of a Herbst mandibular advancement device in obstructive sleep apnea. Am J Respir Crit Care Med 1994;149:905-909.
13. Schmidt-Nowara W, Mead TE, Hays MB. Treatment of snoring and obstructive sleep apnea with dental orthosis. Chest 1991;99:1378-1385.
14. Ahn HK, Chung SC, Kim YK, Lee SW. Treatment of snoring and obstructive sleep apnea with dental orthosis. Korean J Oral Med 1997;22:383-394.
15. Lowe AA. The tongue and airway. Otolaryngol Clin N Am 1990;23:677-695.
16. Choi JK, Kee WC, Lee JM, Ye MK. Variable site of oropharyngeal narrowing and regional variations of oropharyngeal collapsibility among snoring patients during wakefulness and sleep. J Craniomandib Disord 2001;19:252-259.
17. Bonham PE, Currier GF, Orr WC, Othman J, Nanda RS. The effect of a modified functional appliance on obstructive sleep apnea. Am J Orthod Dentofacial Orthop 1988;94:384-392.
18. Ryan CF, Love LL, Peat D, Fleetham JA, Lowe AA. Mandibular advancement oral appliance therapy for obstructive sleep apnoea: effect on awake calibre of velopharynx. Thorax 1999;54:972-977.
19. Smith SD. A three-dimensional airway assessment for

the treatment of snoring and/or sleep apnea with jaw repositioning intraoral appliances: A case study. J Craniomandib Practice 1996;14:332-343.
20. Johal A, Battagel JM. An investigation into the changes in airway dimension and the efficacy of mandibular advancement appliances in subjects with obstructive sleep apnoea. Br J Orthod 1999;26:205-210.
21. Choi JK, Kee WC, Kang DS. The effect of mandibular anterior repositioning on the upper airway volume. Korean J Oral Med 1999;24:69-80.
22. Tsuiki S, Ono T, Kuroda T. Mandibular advancement of modulates respiratory- related genioglossus electromyographic activity. Sleep 2000;4:53-58.
23. Pae EK, Lowe AA, Sasaki K et al. A cephalometric and electromyographic study of upper airway structures in the upright and supine positions. Am J Dentofac Orthop 1994;106:52-59.

국문초록

수종의 코골이장치 장착에 따른 인두공간의 변화

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코골이와 수면무호흡증은 대부분 상기도의 인두부위의 폐쇄에 의해 발생되므로, 이 부위의 폐쇄를 방지하기 위해 혀나 하악을 전방으로 이동시키는 다양한 구강내 장치가 코골이 및 수면무호흡증의 치료에 사용되고 있다. 본 연구는 세 종류의 코골이장치 즉, 하악전방이동장치(mandibular advancement appliance, MAA), 혀견인장치(tongue retaining appliance, TRA), 하악-혀전방이동장치(mandibular advancement-tongue retaining appliance, MATRA)가 구인두와 하인두 공간을 어떻게 변화시키는지를 비교하고자 하였다.

Class I 교합을 갖고 코골이 및 수면무호흡증의 증상이 없으며 체질량지수 (BMI)가 정상인 남성 9명을 대상으로 상기 세 종류의 코골이장치를 제작하였으며, 이때 MAA, MATRA의 하악전방이동량은 5mm로 TRA, MATRA의 혀전방이동량은 10-20mm로 설정하였다. 그리고, 코골이장치를 장착하지 않은 CO상태와 MAA, TRA, MATRA를 장착한 상태에서 측모두부규격방사선사진을 촬영한 후, 구인두와 하인두 공간, 두경부 자세, 연구개와 설골의 위치와 관련된 20가지 측정항목에 대해 통계분석을 시행하였다.

분석결과 MAA, TRA, MATRA 모두 상부 구인두 공간을 유의성 있게 증가시켰으나, MATRA 만이 하부 구인두 공간을 유의성 있게 증가시켰다. 이러한 결과는 코골이와 수면무호흡증을 개선시키는데 있어 MATRA가 MAA와 TRA에 비해 효과적일 수 있음을 시사한다.

주제어: 코골이, 구강내 장치, 혀견인, 구인두