구개열에서 비인두강의 생리해부학적 구조와 과비음과의 연관성 연구

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국문초록

비인강폐쇄란 연구개, 인두측벽 그리고 인두후벽간의 움직임이 서로 조화되어 구강과 비강을 나누어주는 괄약근 기전으로서 연하, 호흡, 발음 등의 생리적기능에 중요한 역할을 한다. 이 기능에 문제가 생긴 경우를 비인강폐쇄부전이라하며 그 원인으로는 (1) 연구개의 길이 및 움직임이상 (2) 비인두강의 해부학적 공간문제 (3) 인두 후벽과 측벽의 기능이상 등이 있다.

본 연구는 구개열 환자의 측면두부방사선계측사진을 통해 비인두강을 생리해부학적으로 분석하였으며, 산출된 말소리의 과비음정도를 Nasometer로 평가하였다. 이로부터 얻은 정상군과 구개열환자군의 결과를 각각 비교하였으며, 비인강폐쇄부전과의 연관성을 알아보기 위하여 Anatomic VPI와 Nasalance score의 값을 비교분석하였다.

얻어진 결과는 다음과 같았다.

1. 측면두부방사선계측사진 결과, 연구개 길이, 연구개 두께, 비인강 깊이, 비인강 면적, Adequate ratio에서 두 그룹간 유의한 차이를 나타내었다.
2. Nasometer 결과, 모음/오/와 구강공명음문장, 구강장해음문장에서 두 그룹 간 유의한 차이를 나타내었다.
3. 구개열환자군에서 비인두강의 폐쇄부전 정도를 표현해주는 Anatomic VPI와 Nasalance score는 전반적으로 연관성이 없었다. 다만, 모음/이/와 일부 구강자음으로 이루어진 문장에서 다소의 상관성을 나타내었다.

결론적으로, 측면두부방사선계측사진과 Nasometer 각각의 검사결과에서 두 그룹간 유의한 차이를 찾아볼 수 있었으나, 구개열환자군내에서 비인강폐쇄부전을 표현하는 Anatomic VPI와 Nasalance score는 모음/이/와 구강자음을 포함한 문장을 제외하고는 전반적으로 연관성이 없었다.

주요어 : 비인강폐쇄부전, 측면두부방사선계측사진, Nasometer, 과비음, 구개열

Ⅰ. Introduction

When speech-language pathologists should give intervention to cleft palate patients, they should evaluate the degree of the patients' phonological and phonetic deficits, and that of velopharyngeal incompetence(or insufficiency, henceforth VPI), usually depending on their perceptual judgements. Severe VPI need medical treatment before speech intervention; if not, we can hardly expect the improvement of their speech. But, if the degree of VPI is mild or moderate, we should carefully consider whether medical treatment should precede speech intervention, or not. In such cases, instrumental measurement can be used for more objective evaluation and for more appropri-

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ate decision-making.

Instruments for VPI measurements involve cephalometry, multiview videofluoroscopy, flexible fiberoptic nasoendoscopy, or nasometry[1,2]. The present study focused on cephalometry for the physioanatomical measurement of nasopharyngeal cavity, and nasometry for the acoustical measurement of hypernasality.

Cephalometry is one of the most traditional, accurate and widely-used method for the observation of nasopharyngeal cavity, but it also has some demerits such as the difficulty of static recording of dynamically moving velopharynx and low resolution on the soft tissues[3]. However, nowadays, the improvement of resolution was achieved by the digitization, and, the most appealing aspect of cephalometry is the fact that most of cleft palate patients should record the cephalogram for orthodontic treatment as usual, which means that the patients do not have to additional recording.

In measuring the degree of hypernasality, nasometry is widely used for its objectively presented results, and convenience[4,5]. Nasometer shows the ratio of acoustic energy output from the nasal and oral cavities of the speakers' utterances, through the microphone mounted in either side of a separated plate[6-10].

Ⅱ. Materials and methods

The present study analyzed the anatomy of nasopharynx using cephalometry during vowels and sentential nasalance scores using nasometry for 9 Korean cleft-palate patients(four males and five females) and 14 Korean normal subjects(seven males and seven females). Cleft palate subjects were those who have been to Dental Hospital of Yonsei University, whose development of nasopharynx had been finished, and who had no history of orthognathic surgery, pharyngoplasty, or adenoidectomy[6].

1. Physio-anatomical evaluation using cephalometry

For recording the cephalogram, CRANEX 3+ (Soredex Co, Finland) was used. From each subject, we obtained two pictures; one shows the relaxed velopharyngeal sphincter muscles during the comfortable inspiration, and the other shows physiological movement of the muscles during vowel /i/ production. After the recording, we used FCR system (Fuji Computerized Radiography, Model No. AC-3, Fuji Co., Japan) for digitization (Fig. 1, 2).

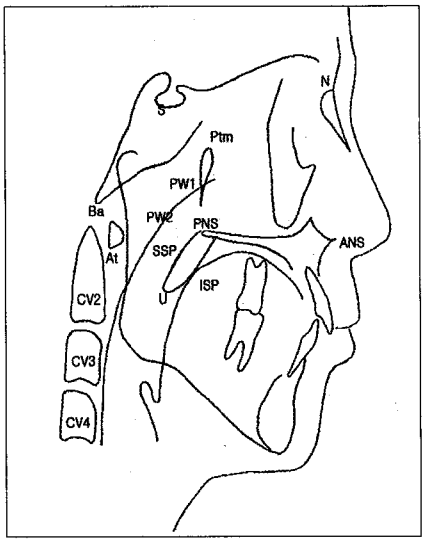

Fig. 1. Cephalometric landmarks at rest.

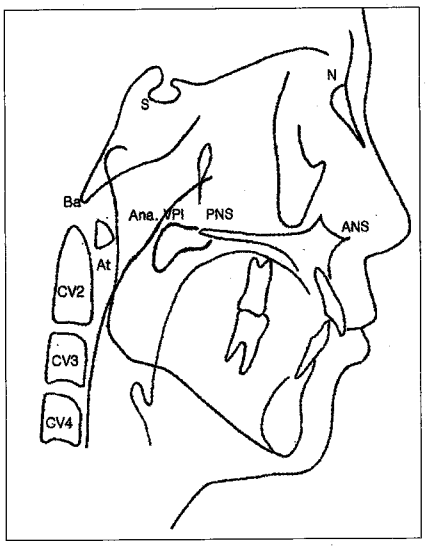

Fig. 2. Cephalometric landmarks articulating vowel /i/.

(1) Reference Points in Cephalometry

S	Sella (the center of sella turcica)
N	Nasion (the most anterior point of the junction between the frontal and nasal bones)
ANS	anterior nasal plane
PNS	posterior nasal plane
Ptm	pterygomaxillary fissure
PW1	point where intersects the posterior pharyngeal wall with the PNS -S line
PW2	point where palatal plane(a line connecting ANS with PNS) extension intersects the posterior pharyngeal wall
U	the tip of the uvula
SSP	superior surface of soft palate at its greatest thickness
ISP	inferior surface of soft palate at its greatest thickness
At	most anterior point of the anterior tubercle of the atlas
Ba	Basion
CV2	most antero-inferior point of the second cervical vertebrae
CV3	most antero-inferior point of the third cervical vertebrae
CV4	most antero-inferior point of the fourth cervical vertebrae

(2) Reference data in Cephalometry

Hard palate length	ANS-PNS
Soft palate length	PNS-U
Soft palate depth	SSP-ISP
Nasopharyngeal depth	PNS-PW2
Area of the nasopharynx	PW1-PW2-PNS

Adequate Ratio (soft palate length/nasopharyngeal depth) PNS-U / PNS-PW2
Anatomic VPI Direct distance between posterior pharyngeal wall and soft palate during articulation
Location of VPI Location of contact point over the palatal plane
upper is inscribed as (+) and lower is inscribed as (-)
FMPW forward movement of pharyngeal wall on the palatal plane

(1) Single vowels
/a/, /ɛ/, /i/, /o/, /u/
(2) Nasal sonorant-involving sentences
① na-mu-ɛ mæ-mi-ga nɔ-mu ma-na-yo (There are too many leaf hoppers in a tree)
② nu-na-raŋ i-mo-raŋ ma-i-mil na-nu-ɔ-yo.
(My sister and aunt share their hearts each other)
(3) Oral sonorant-involving sentences
① o-wɔ-ɾo-i-ɾi wɔ-ɾyo-i-ɾi-ɛ-yo. (May the 5th is Monday)
② i-ɾyo-i-ɾɛ i-ɾi-ɾo o-ɾæ-yo. (He said to come here on Sunday)
(4) Oral occlusive-involving sentences
① pa-da-k'a-ɛ-sɔ čo-gæ-ɾil ču-wɔ-š'ɔ-yo. (We picked up seashells on the seaside)
② t^{h}o-k'i-wa kɔ-bu-gi-ga s^{h}i-a-bil hæ-yo. (A rabbit and a turtle are running a race)

Fig. 3. Vowels and Sentences for Nasometer Assessment.

2. Evaluation of hypernasality using nasometry

By using Nasometer(Model No. 6200-3, Kay Elemetrics Co, U. S. A.), we measured nasalance scores during the production of single vowels, /a/, /e/, /i/, /o/, and /u/, and sentences including oral and nasal sonorants and oral occlusives of 10~13 syllables(Fig. 3).

We compared the results of the two instrumental measurements between cleft-palate subjects and normal subjects, and to find the relationship between the results and VPI, anatomic VPI(direct distance

between posterior pharyngeal wall and soft palate during articulation) and nasalance scores were compared. For the statistic analysis, we used paired t-test and Pearson r Correlation Coefficient through SAS(version 8.01) program.

Ⅲ. Results

1. In cephalometry, there were significant differences in soft palate length, soft palate thickness, nasopharyngeal depth, nasopharyngeal area, and adequate ratio between two groups($p<.05$)(Table 1).
2. In nasometry, there were significant differences between two groups in vowel /o/ and sentences including oral consonants($p<.05$)(Table 2).
3. In cleft palate patients, though no general correlation was found between Anatomic VPI and nasalance scores, vowel /i/ and sentences including oral consonants were slightly correlated($r=.87, .67$)(Fig. 4-6).

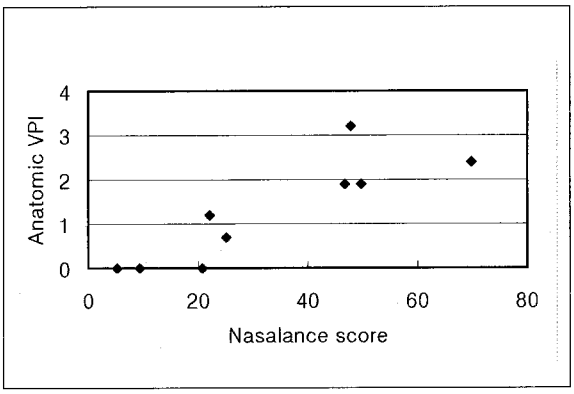

Fig. 4. Correlation between Anatomic VPI and Nasalance score in Vowel /i/ of cleft palate group.

Table 1. Reference data of two groups in cephalometry (mean ± SD)

	Normal	Cleft-palate	p value
Hard palate length*	56.74 ± 3.41	53.24 ± 5.13	0.0618
Soft palate length*	36.83 ± 2.75	25.21 ± 5.36	0.0001
Soft palate thickness*	10.74 ± 0.98	8.92 ± 0.77	0.0001
Nasopharyngeal depth*	27.77 ± 2.68	23.68 ± 4.29	0.0100
Nasopharyngeal area**	302.75 ± 39.95	172.92 ± 82.07	0.0012
Adequate ratio	1.33 ± 0.13	1.07 ± 0.12	0.0001
Anatomic VPI*	0.43 ± 0.63	1.26 ± 1.17	0.0777
Location of VPI*	-3.16 ± 2.84	-5.14 ± 4.25	0.1933
FMPW*	0.26 ± 1.05	1.00 ± 1.07	0.1161

* : ㎜, ** : ㎟

Table 2. Nasalance score of two groups in nasometry (mean ± SD)

	Normal	Cleft-palate	p value
/a/	17.32 ± 9.12	12.60 ±12.44	0.6172
/ɛ/	18.1 ± 9.83	19.25 ± 14.47	0.8217
/i/	24.99 ± 15.84	32.96 ± 21.51	0.3173
/o/	4.95 ± 5.78	19.02 ± 15.51	0.0273
/u/	5.92 ± 7.17	17.98 ± 20.47	0.1220
Nasal Sonorants①	36.70 ± 5.61	40.57 ± 9.39	0.2273
Nasal Sonorants②	37.83 ± 5.69	41.88 ± 7.98	0.1692
Nasal Sono-Mean	37.27 ± 5.43	41.23 ± 8.40	0.1823
Oral Sonorants①	10.13 ± 5.39	23.15 ±14.46	0.0282
Oral Sonorants②	10.86 ± 5.55	22.79 ±15.27	0.0496
Oral Sono-Mean	10.50 ± 5.11	22.97 ±14.75	0.0364
Oral Occlusives①	6.99 ± 2.98	14.77 ±12.24	0.0958
Oral Occlusives②	7.89 ± 3.70	17.45 ±12.13	0.0474
Oral Occl-Mean	7.44 ± 3.24	16.11 ±11.90	0.0625

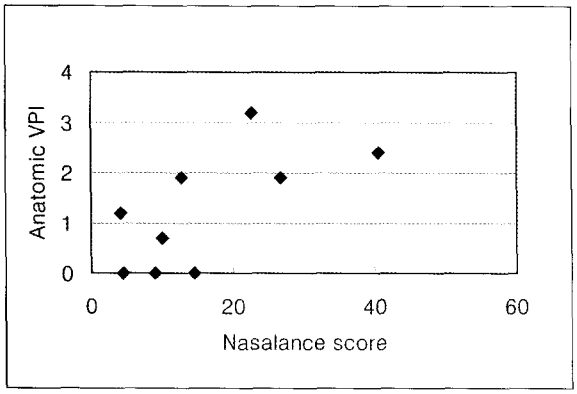

Fig. 5. Correlation between Anatomic VPI and Nasalance score in Oral Occlusives of cleft palate group.

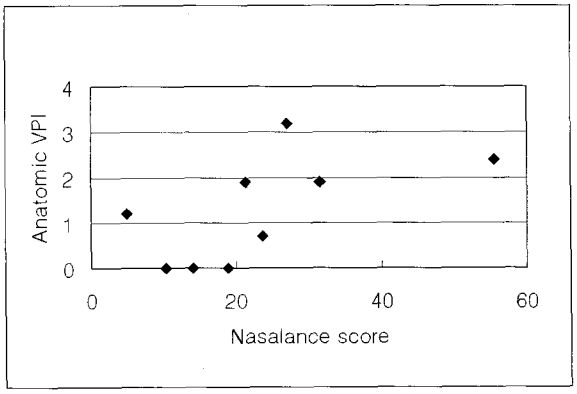

Fig. 6. Correlation between Anatomic VPI and Nasalance score in Oral Sonorants of cleft palate group.

Ⅳ. Dicussion

By the cephalometric analysis, we found statistically significant difference between the two groups, cleft-palate patients and normal subjects in soft palate length and depth, nasopharyngeal depth and size, and adequate ratio(soft palate length/nasopharyngeal depth)($p<.05$)[11-13].

The difference of the soft palate depth and length may be due to contracted and scarred tissues after the surgery, and that of nasopharyngeal depth means that cleft-palate patients' characteristic skeletal Class Ⅲ malocclusion hindered the anterior development of maxillary bone, which caused the posterior settlement of the bone[14,15]. Adequate ratio is the important ratio to evaluate the possibility of velopharyngeal competence, and its normative ratio is known to be 1.3 or 1.4[11,16,17]. However, cleft-palate subjects on the whole, showed lower rate than normal subjects. The reason is known to be the short soft palate length, rather than shallow nasopharyngeal depth, therefore we can consider that one of the primary cause of cleft palate patients' VPI is shortened soft palate length.

When we measured the nasalance scores of vowels and sentences by Nasometer, significant difference between the cleft palate subjects and normal ones was found in oral sonorants and oral occlusives ($p<.05$). Comparing the mean of scores, a high vowel /i/, and back vowels /o/ and /u/ showed high scores, which means that nasalance score during the vowel production is related with the location of velopharyngeal closure and the degree of elevation of soft palate[18]. Nasal sonorants are made by nasal resonance with relaxed soft palate which can be found in both cleft palate patients and normal persons, therefore we can expect that the nasalance scores of nasal sonorants will be similar between the two groups, which proved to be true. In normal subjects, oral sonorants and oral occlusives are expected to show low scores, for their proper velopharyngeal closure, on the while, in cleft palate subjects, their improper closure may be the cause of high scores in those consonants[19,20]. As results, we could confirm the expectations, and now, we will consider the relationship between the abovementioned results and physioanatomical structures of nasopharynx, analyzed by cephalometer.

Anatomic VPI shows the degree of VPI, and nasalance scores shows the degree of hypernasality. In cleft palate subjects, we found no significant correlation between them with the exception of a vowel /i/($r=.87$). It is usually known that increased nasalance could result from decreased oral intensity, increased nasal intensity, or both; we can also find the same pattern when the speech sounds are produced with nasopharyngeal gap, regardless of normal or cleft palate subjects[21-24]. Therefore, we can consider that physioanatomical structures and nasalance score have the significant correlation each other.

Ⅴ. Conclusions

Velopharyngeal closure is a sphincter mechanism between the activities of the soft palate, lateral pharyngeal wall and the posterior pharyngeal wall, which divides the oral and nasal cavity. It participates in physiological activities such as swallowing, breathing and speech. It is called a velopharyngeal dysfunction when this mechanism malfunctions. The causes of this dysfunction are defects in (1) length, function, posture of the soft palate, (2) depth and width of the nasopharynx and (3) activity of the posterior and lateral pharyngeal wall.

The purposes of this study are to analyze the nasopharynx of cleft palate patients using cephalometry and to evaluate the degree of hypernasality using nasometry to find its relationship with velopharyngeal dysfunction.

Conclusively, when we compared the results of cephalometric and nasometric measurements, we could not fin d the significant difference between the cleft palate subjects and normal subjects. In the case of cleft palate subjects, the relationship between the anatomic VPI and nasalance scores was only found in the vowel /i/ and oral consonant-involving sentences.

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Abstract

PHYSIOANATOMY OF NASOPHARYNGEAL SPACE AND HYPERNASALITY IN CLEFT PALATE

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Velopharyngeal closure is a sphincter mechanism between the activities of the soft palate, lateral pharyngeal wall and the posterior pharyngeal wall, which divides the oral and nasal cavity. It participates in physiological activities such as swallowing, breathing and speech. It is called a velopharyngeal dysfunction when this mechanism malfunctions. The causes of this dysfunction are defects in (1) length, function, posture of the soft palate, (2) depth and width of the nasopharynx and (3) activity of the posterior and lateral pharyngeal wall.

The purposes of this study are to analyze the nasopharynx of cleft palate patients using cephalometry and to evaluate the degree of hypernasality using nasometry to find its relationship with velopharyngeal dysfunction.

The following results were obtained :

1. In cephalometry, there were significant differences in soft palate length, soft palate thickness, nasopharyngeal depth, nasopharyngeal area, and adequate ratio between two groups.
2. In nasometry, there were significant differences between two groups in vowel /o/ and sentences including oral consonants.
3. In cleft palate patients, though no general correlation was found between Anatomic VPI and nasalance scores, vowel /i/ and sentences including oral consonants were slightly correlated.

In conclusion, cephalometry and nasometer results were significantly different between the two groups. Though in the cleft palate group, Anatomic VPI and nasalance scores, which are indices for velopharyngeal closure, excluding the vowel /i/ and sentences including oral consonants show generally no significance.

Key words : Velopharyngeal Dysfunction, Cephalometry, Nasometer, Hypernasality, Cleft palate