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An Electromyographic Study of the Levator Palatini Activity in the Production of Korean Sentences Containing Three Types of Initial Stops Placed at the Postnasal Position

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= 국 문 초 록 =

한국 구개열 환자의 농음(Fortis) 산출곤란 원인규명을 위한 실험음성학적 연구

-정상인에 관한 구개범거근 근전도 소견을 중심으로-

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배경 및 목적 : 한국 구개열환자에게는 된소리 자음(농음)의 구음산출의 난도가 높다는 것은 임상적으로 잘 알려져 있다. 그러므로 본 연구에서는 한국 구개열 환자에게 있어서 난도가 높은 농음의 산출 메커니즘의 기본적 요소를 규명하므로서 언어치료의 새로운 방법모색에 기여하고져 하였다.

연구방법 : 비강자음에 후속된 3종의 어두 파열자음 산출시의 구개범거근의 근활동 양상의 차이를 비교검토하므로서 농음의 산출특성을 검색하고져 하였다. 관찰기록 방법은 근전도는 유구침금전극(hooked wire electrodes)을 구강내로부터 경점박적으로 유도하였다.

연구결과 : 격음과 농음의 파열자음에서 평음보다 높은 구개범거근의 근활동이 관찰되었으나 격음과 농음 사이에선 유의미적인 차이는 보이지 않았다.

결 론 : 금후의 과제로는 피험자를 늘려 재확인을 하는 일, 및 농음과 격음의 변별요소에 관해 더욱 검토할 필요가 있는 것이 시사되었다.

중심 단어 : 구개열 환자, 된소리(농음) 파열자음, 근전도에 의한 연구, 음절두 파열자음, 구개범거근 활동.

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Background and Purpose

It has been clinically noted that Korean cleft palate patients often presented a relative difficulty in the production of words starting with an initial forced stop compared with those words starting with other types of stops. In order to elucidate the underlying possible factors making the production of the forced stop difficult in cleft palate patients, an electromyographic study was made in normal Korean subjects during the production of test sentences including nasal sound immediately followed by syllables with initial stops of three different types, and the levator activity was compared among the three types.

It is known that in Korean there is a three-way distinction in both manner and place of articulation that serves to differentiate nine stop consonant phonemes. For classification, the three types are generally referred to as "forced", "lax" and "aspirated". All stop types may occur in the syllable-initial position to be realized as voiceless, while in the medial position, the lax stops are usually manifested by voiced allophones.

There are numerous reports aiming to clarify the acoustical and physiological properties that differentiate the three manner categories. Lisker and Abramson[1] reported in their comprehensive study of values of voice onset time (VOT) that the resolution of VOT values between the "lax" type and the "forced" type in Korean is not clear-cut but shows overlapping, despite the notion that VOT values provided the most useful measure in most languages for differentiating various conditions of voicing and aspiration in word-initial position.

Based on his cineradiographic studies, Kim[2] reported that the glottal width in each type of the Korean stops at the articulatory explosion correlated well to the length of aspiration.

Kagaya[3] made fiberscopic and acoustic studies on the Korean stops, affricates and fricatives and concluded that "forced" and "aspirated" types were characterized by some positive inherent laryngeal gestures. In particular, the "forced" type appeared to be characterized by the completely adducted state of the vocal folds before the explosion, stiffening of the vocal folds and their abrupt relaxation near the voice onset, associated with increasing subglottal pressure and/or lowering of the glottis immediately before the explosion.

Hirose, Lee and Ushijima[4] conducted an electromyographic (EMG) study on one subject of the Taegu dialect. They found that in the "forced" stop, the thyroarytenoid showed a sharp increase in activity before the stop release, which presumably resulted in an increase in inner tension of the vocal folds as well as in constriction of the glottis during or immediately after the articulatory closure.

These studies would suggest that, at least for Korean stops, laryngeal articulatory adjustment is not limited in a simple

Table 1. Result of t-test

	Postnasal segment		
		Subject 1	Subject 2
	padzida	1	1
	pʰadzida	0.96	1.114
	P'adzida	0.92	1.033
	tarida	1	1
	tʰarida	1.227	1.053
	t'arida	1.093	1.179
	pida	1	1
	pʰida	0.95	1.353
	p'ida	1.103	1.33
	tida	1	1
	tʰida	1.113	1.332
	t'ida	1.138	1.348

Postnasal segment	Subject 1 padzida	Subject 1 tarida	Subject 1 pida	Subject 1 tida	Subject 2 padzida	Subject 2 tarida	Subject 2 pida	Subject 2 tida	ave	sd
Lax	1	1	1	1	1	1	1	1	1	0
Aspirated	0.96	1.227	0.95	1.113	1.114	1.053	1.353	1.332	1.13775	0.144584
Fortis	0.92	1.093	1.103	1.138	1.033	1.179	1.33	1.348	1.143	0.134278

Paired t 0.019885 all subj. : lax / aspirated
0.012931 all subj. : lax / fortis
0.441644 all subj. : aspirated / fortis

dimension of adduction- abduction of the vocal folds, but that another dimension, represented by thryoarytenoid activity for example, can be taken into consideration.

The purpose of this study was to elucidate the underlying mechanism that possibly causes extreme difficulties in producing the forced stop among cleft palate patients for seeking a new way of improving their speech therapy.

Methods

Taking a note of the levator palatini activity for normal persons, we maid an attempt in a way of preliminary study to find out how the levator palatini muscles were involved in the production of postnasal syllables that include such three different types of stops as lax, aspirated and fortis. For the study subjects, two normal native Korean speakers in the mid-thirties were selected;

1. Subjects : two normal Korean persons
   man : Seoul dialect. 33 years old
   woman : chungchong dialect. 36 years old
2. Test utterances

They are all meaningful utterances with one exception and presented phonetic transcription. These test words were uttered in a frame "Igon ___".

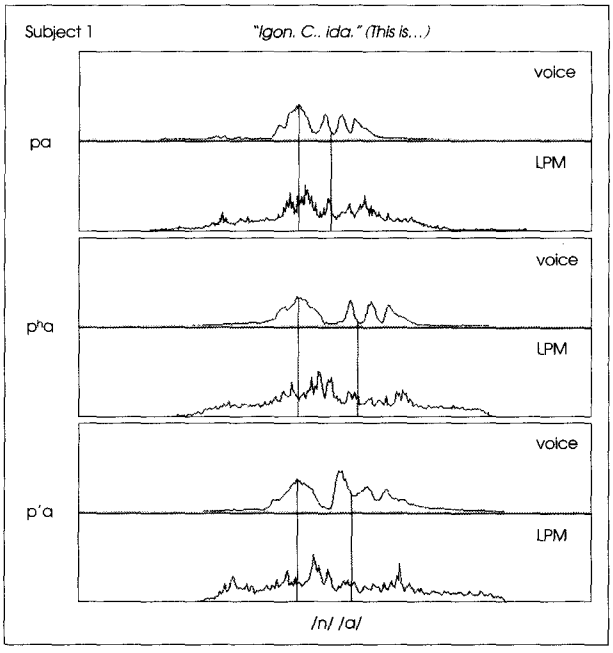

Fig. 1. Averaged EMG curves of LPM of Subject 1 for the utterance type "Igon C... ida". These sounds are [pa, pʰa, p'a] and, upper graph is a signal of the voice and, bellow is EMG pattern of levator palatini activity. From this figure we can see, the width of the EMG pattern of aspirated and fortis, which are more larger than lax. But they are very similar to each other. From next figures we can see similar results.

"Igon .C.. (i)da." (This is ....)

[padzida] (trousers)	[pida] (rain)
[pʰadzida] (waster paper)	[pʰida] (blood)
[p'adzida] (fall in)	[p'ida] (sprain)
[tarida] (a bridge)	[tida] ("non sense word")
[tʰarida] (a mask)	[tʰida] (a mote)
[t'arida] (a daughter)	[t'ida] (a belt)

a man from Seoul area designated as Subject 1 and a

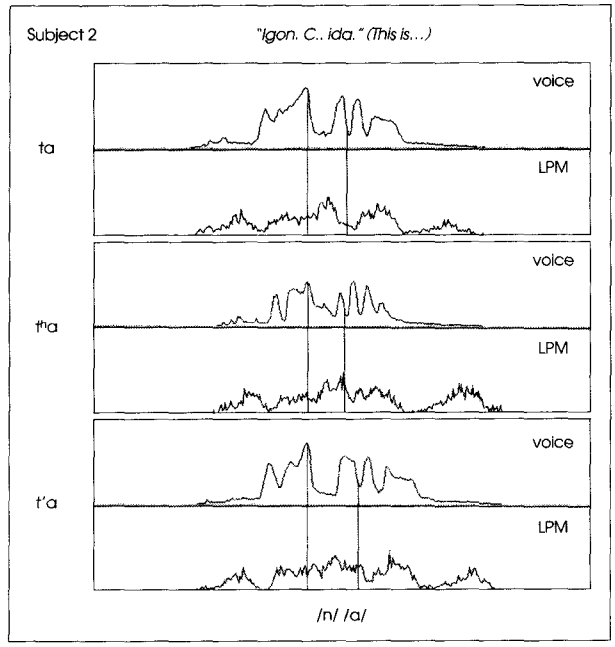

Fig. 2. Averaged EMG curves of LPM of Subject 2 for the utterance type "Igon C... ida".

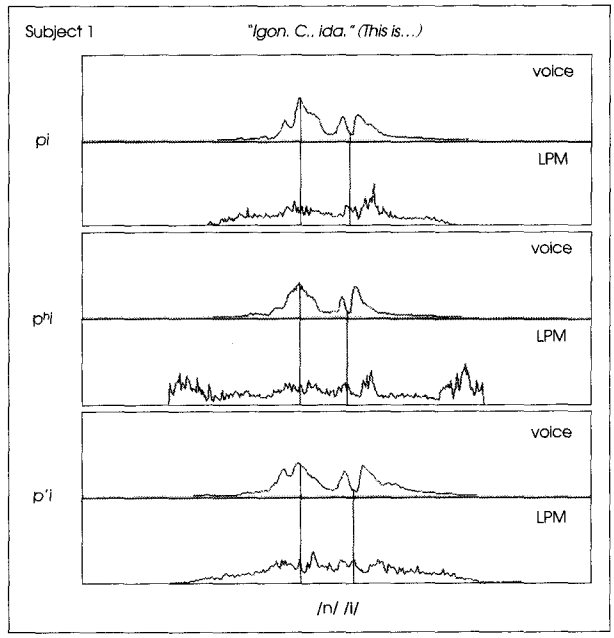

Fig. 3. Averaged EMG curves of LPM of Subject 1 for the utterance type "Igon C... ida".

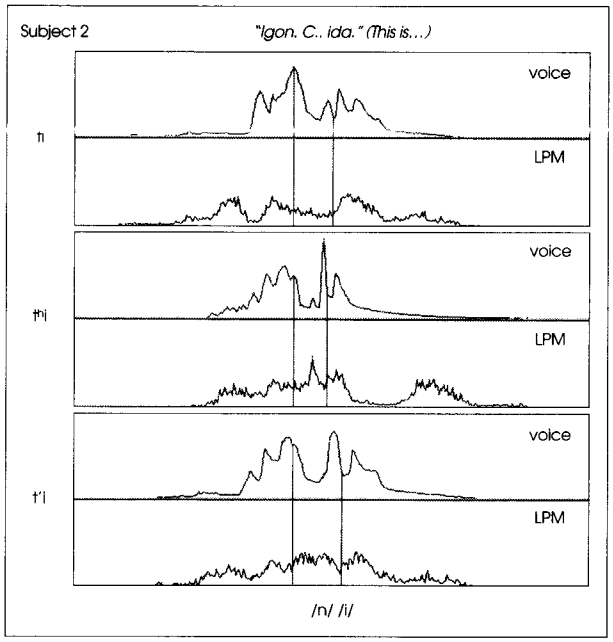

Fig. 4. Averaged EMG curves of LPM of Subject 2 for the utterance type "Igon C... ida".

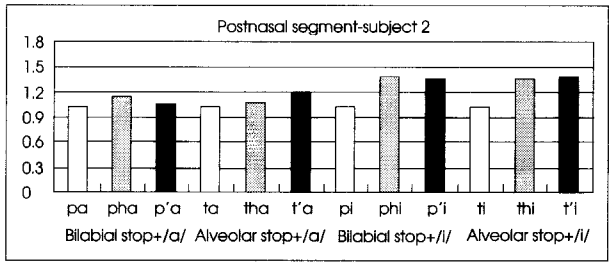

Fig. 5. Graphic comparisons of the result of t-test among the 3 types. This is graphic comparison of the result of t-test among the 3 types of stops. From this graph, we can see the difference more clearly. From all the segments, we can see aspirated and fortis stops are more active than lax. But they are also similar to each other.

woman from Chungchong Province designated as Subject 2. They were required to utter the test Korean sentence at natural speed as; *"Igon .C.. (i)da." (This is ....)* that begins with the initial stops(C) of lax, aspirated and fortis. For EMG recordings, hooked wire electrodes were inserted perorally into the LPM through the oral mucous membranes in each subject, and the EMG signals were recorded on the two-channel data recorder along with acoustic signals. As physical noises can be mixed with the EMG signals during recordings, subjects were required to repeat the test sentence for ten times each in order to eliminate such noise and observe overall trend as needed. Later the recorded signals were reproduced and fed to a computer through an integrator, and the resultant data were rectified and averaged in accordance with a specific time axis of acoustic signals. The computer-processed EMG values for the three types of postnasal syllables were obtained and statistically compared using 't' test.

Results

There was a significant difference in levator palatini activity for the postnasal syllable between the lax type and the other two types. But no appreciable difference was found between aspirated and fortis.

Comment and Conclusion

The present study revealed that the levator palatini activity significantly increased more for the production of the post-nasal syllables with forced and aspirated stops than it did with lax. It was also found, however, that there was no appreciable difference between aspirated and forced stops in the levator palatini activity. Further studies employing a larger number of subjects should be necessary to reaffirm the present data, and search for differentiating factors between forced and aspirated stops in Korean.

In a considerable number of cleft palate patients having articulatory problems, different types of consonants, plosive consonants in particular, tend to be replaced by a glottal stop. Previous EMG studies[4] indicated that thyroarytenoid muscle showed high activity during the production pronunciation of Korean fortis stops. Therefore, if it is replaced by glottal stop in the case of fortis stop, it may be very difficult to correct this type of compensatory articulation.

Possibly, the rate of compensatory replacement of fortis stop to a glottal stop could be higher than other stop types.

These points should be clarified in the next step of this research. The present study only proved that there was the velopharyngeal closure for fortis was as strong as for aspirated. Thus, other factors including the tendency of compensatory glottal stop pronunciation should be considered for elucidating the difficulty in correction of fortis stop in cleft palate patients.

KEY WORDS : Cleft palate patient · Forced stop · Electromyographic study · Syllables with initial stops · The levator activity.

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