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Temporal characteristics of nasalization in Persian speaker children with and without cleft palate

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ABSTRACT

Objectives: The purpose of this study was to measure and compare temporal patterns of nasalization in Persian children with and without cleft palate in three vowel contexts.
Methods: A Sample of 14 children with repaired cleft palates with or without cleft lip with moderate to severe hyper nasality and 14 children without cleft palate was chosen as subjects. The subjects were chosen from the ages of 4 to 12 years. The nasal onset interval, nasal offset interval and total nasalization duration were obtained from acoustic waveforms and spectrograms in three vowel contexts using Praat Software. For eliminating the effect of different speed of speech in the cleft palate group and control group, the ratio of nasalization duration was calculated.
Results: Total nasalization duration are demonstrated by acoustic signals which shows the total significant different temporal patterns in children with cleft palate and without cleft palate and across the vowel contexts ($P < 0.000$).
Conclusions: Longer nasalization durations in children with cleft palate in comparison to children without cleft palate show the delayed or deviant temporal patterns in children with cleft palate. The duration of nasalization reflecting temporal patterns of the oral-nasal acoustic impedance in children with cleft palate may have an influence on the perception of hyper nasality.

1. Introduction

Velopharyngeal insufficiency effects speech both in adults and children [1]. Hypernasality is one of the most common nasality disorders in children with cleft palate with or without cleft lip [2] that is related to excessive nasality in normal production of vowels [3]. Movements and gestures of articulators have natural temporal structures that overlap during speaking. This amount of overlap and coincidence depends on various factors including rate of speech and language limitations [4].

Production of oral consonants needs closure of velopharyngeal sphincter in order to separate oral and nasal cavities. In contrast with oral consonants, in production of nasal consonants, velopharyngeal sphincter should be open so that energy of sound could spread in nasal cavity. Nasal consonants are formed by two articulation gestures: (1) complete closure of oral cavity by movement of tongue or lips, and (2) descending of velum. Before lips and tongue begin the movement toward closure, velum begins to descend. When oral route is closed, velopharyngeal sphincter has been already opened. Meanwhile, when the velopharyngeal sphincter remains open, oral closure has been released and oral route is opened. This early onset and delayed offset of velum before and after oral closure results in nasalization of vowels produced before and after nasal consonant for certain durations. If the opening and closure of oral cavity is not coordinated, nasalization exceeds the normal range and excessive nasal resonance is

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perceived [5]. Therefore, poor timing of velopharyngeal movement while functioning coordinated with activity of other articulators; may be the reason of imbalanced oral-nasal resonance [6,7].

Warren et al. and Dalston found that in subjects with cleft palate, the duration of the airflow increased significantly as the degree of velopharyngeal inadequacy increased [8–10]. Dotevall et al. [11] demonstrated that the temporal pattern of nasal airflow during the velopharyngeal closing phase in speech appeared to be associated with perceived hypernasality [11]. Jones [12] investigated the relation between temporal aspects of oral-nasal balance of velopharyngeal mechanism and showed the excessive perceived nasalization could result from a mistiming of velopharyngeal movements related to voice onset and offset.

Zajac and Hackett [13] investigated temporal characteristics of aerodynamic parts of speech in adults and children without cleft palate using the pressure-flow technique. They concluded that there are different temporal patterns of speech aerodynamic in children and adults [13]. Jones [14] pointed out that subtle structural-motor differences between normal speakers versus cleft palate speakers may become clearer when spatio-temporal requirements of velopharyngeal movements get more complex. This could result in greater combination of oral-nasal impedance ratio [14]. Using nasometer, Bae et al. proved that vowels have a notable effect on temporal patterns of nasalization [15]. Ha et al. [5] and Ha and Kuehn [7,16] studied temporal characteristics of nasalization in children with and without cleft palate in American-English and Korean languages. They measured acoustic energy of oral and nasal cavity and demonstrated that children with cleft palate exhibit hypernasality that shows longer durations of nasalization than children without cleft palate [5,7,16].

Many studies showed that the patterns of coarticulatory nasalization and timing of velopharyngeal movement may differ through languages [5,6]. The purpose of the present study was to identify and compare temporal characteristics of nasalization by measuring acoustic energies from the oral and nasal cavities in Persian-speaking children with cleft palate and children without cleft palate.

2. Method

2.1. Participants

This descriptive-analytic cross-sectional study was conducted on 14 children with repaired cleft palate with or without cleft lip with moderate to severe hyper nasality (11 males and 3 females) and 14 children without cleft palate (11 males and 3 females) who lived in Tehran, Iran. The age range of the subjects was 4 to 12 years. The age distribution among the subjects with and without cleft palate is presented in Table 1. The primary diagnosis among children with cleft palate is presented in Table 2.

The study inclusion criteria for the group with cleft palate were as follows: The children with cleft palate had normal perceptual language according to speech and language pathologists' or parents' report, also based on medical records and audiologist report on the audiogram their hearing was normal. The other inclusion criteria for the group with cleft palate included having moderate to severe hyper nasality, which was determined by Temple Street Scale of Nasality and Nasal Airflow Errors [17] and consensus of two speech pathologists. As the mentioned test is not available in Persian, for assessing hypernasality in current study, the words and sentences of the Persian version of the Global Parameters test with the validity of 0.92 to 1 were used [18]. Children with cleft palate who were rated by two listeners as mild hypernasality or as having normal resonance were excluded. No co-morbid conditions were observed on Children with cleft palate.

Table 1
Age means and SD and ranges of each group.

Group	Cleft palate	Noncleft
Mean	6.95	6.88
SD	1.88	1.7
Ranges	5.1–10.5	5.2–10

Table 2
Primary Diagnosis of Cleft Palate Subjects Employed in This Study.

Sex	Bilateral complete cleft of primary and secondary palate	Unilateral complete cleft of primary and secondary palate	Soft palate cleft	Submucous cleft
Boy	2	8	0	1
Girl	1	1	1	0
Total	3	9	1	1

Inclusion criteria for the control group were having no history of hearing, language and speech impairments and orofacial anomalies. Also in both groups, subjects and their families were monolingual (Persian) and speech tasks of the study were performed in standard Persian accent of Tehran. Any sign of a cold or deviation in septum were considered as exclusion criteria. Based on these criteria, 40 children were included in study and 12 children were excluded.

The research procedures were in accordance with the ethical guidelines of the Tehran University of Medical Science, where the study was conducted.

2.2. Speech sample

The Speech sample consisted of three CVNVC disyllables: /pumup/, /pimip/ and /pamap/. A series of /m/ and /p/ consonants of speech tasks before and after vowels helps opening and closing of velopharyngeal sphincter. Lips are the place of articulation in both nasal consonant of /n/ and oral consonant of /p/. Such contexts are appropriate for measuring temporal characteristics, because under this condition the influence of the change of articulation placement on nasal resonance has been controlled so that the focus of study is inclined only on temporal characteristics of nasalization [5]. Although the primary cause of hypernasality is the coupling of the oral and nasal cavities, but the positioning of the tongue and the degree of tension in the subglottal, glottal, and supraglottal structures effects oral–nasal resonance balance [5]. Therefore, all of the vowels may not be affected to the same degree. Some vowels are more vulnerable to the oral-nasal coupling than others [19]. Therefore, to investigate different timing variables among vowels, three vowels – /i/, /u/, and /a/ – were selected. These vowels are produced in different places of constriction within the vocal tract.

2.3. Data collection

Sampling of the normal group performed in accessible schools and kindergartens and sampling of the cleft palate group occurred in speech therapy clinics of Tehran. Recording of speech sample was performed individually in an acoustic room. After explaining the process of examination for the case, he/she was asked to produce speech samples exactly similar to auditory model of the first author with conventional pitch and loudness. Auditory model has been recorded and presented a maximum of three times. Then, a set of high-quality microphone (Beta 54, Shure, USA) was mounted on the head of the case consisting of two microphones one for mouth and one for nose. The oral microphone was located 3 cm away from the right side of subject's mouth, while the nasal microphone was located under the right nostril. These kinds of electrical condenser microphones are mounted on head. Acoustic