

Investigating the Effects of Glottal Stop Productions on Voice in Children With Cleft Palate Using Multidimensional Voice Assessment Methods

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Summary: Objectives. The aim was to investigate the effects of glottal stop productions (GS) on voice in children with cleft palate using multidimensional voice assessment methods.

Study Design. This is a prospective case-control study.

Methods. Children with repaired cleft palate ($n = 34$) who did not have any vocal fold lesions were separated into two groups based on the results of the articulation test. The glottal stop group (GSG) consisted of 17 children who had GS. The control group (CG) consisted of an equal number of age- and gender-matched children who did not have GS. The voice evaluation protocol included acoustic analysis, Pediatric Voice Handicap Index (pVHI), and perceptual analysis (Grade, Roughness, Breathiness, Asthenia, Strain method). The velopharyngeal statuses of the groups were compared using the nasopharyngoscopy and the nasometer.

Results. The total pVHI score and the subscales of the pVHI were found to be significantly higher in the GSG. The F0, jitter, and shimmer were found to be numerically higher in the GSG with the difference being statistically significant in jitter ($P < 0.05$). Audioperceptual analysis revealed a difference in overall voice quality and roughness between the groups. Greater incidence of significant velopharyngeal insufficiency and higher nasalance scores were found in the GSG ($P < 0.05$).

Conclusions. These results may indicate that the vocal quality characteristics of children with GS differ from children who do not have this type of production. It is suggested that children with cleft palate who have GS should receive a comprehensive speech and language pathology intervention including voice therapy techniques.

Key Words: Cleft palate–Glottal stop–Velopharyngeal insufficiency–Laryngeal compensation–Dysphonia.

INTRODUCTION

Cleft lip and palate is a congenital malformation seen in approximately 1 out of every 700 live births.¹ Many researchers have found that children with cleft palate have a tendency to experience voice problems.^{2–7} Hoarseness, breathiness, reduced loudness, abnormal pitch, and vocal fry are frequently reported in the literature.^{3,5,6} In addition to these symptoms, vocal-fold nodules, edema, inflammation, and hyperplasia are vocal-fold pathologies that are also reported in children with cleft palate.^{5,6,8–10} Many research studies have concluded that there is a clear relationship between velopharyngeal function and dysphonia.^{5,6,8} The laryngeal compensation hypothesis has been accepted widely as the underlying responsible mechanism.^{3,5,6,11} According to Warren,¹² when air pressure loss occurs due to velopharyngeal insufficiency (VPI), a compensation mechanism works to regulate pressure in the vocal tract by adducting the vocal folds abruptly.^{4,12,13} This phenomenon is known as glottal stop production. This type of production, which is one of the most common compensatory articulation errors, is a strategy used to ensure enough pressure in the vocal tract.¹⁴ When glottal stops are substituted for oral plosives, the manner remains the same

while the place of articulation changes.^{12,14,15} Glottal stops can replace all high-pressure consonants including oral fricatives and affricatives,¹⁴ and they can be coarticulated with oral placement.⁴ Even when the velopharyngeal structure is restored, these learned behaviors may still persist; therefore, speech therapy is required.^{16–18}

Studies examining the vocal characteristics of children with VPI included acoustic and perceptual evaluation methods.^{6,8,10,19,20} Van Lierde et al⁸ compared the dysphonia severity index score between the healthy and cleft palate children, and they found higher scores in children with VPI. Villafuerte-Gonzales et al¹⁹ found vocal abnormalities in F0, jitter, and shimmer, wherein they included 14 children with VPI with healthy couples. Lewis et al⁶ found more perturbation in the acoustic signal in their study and suggested that results may relate to compensatory articulation patterns. Two retrospective studies^{10,20} searched for a relationship between VPI and hoarseness^{10,20} and did not find a relationship between the two. Hamming et al²⁰ suggested that the laryngeal compensation mechanism may not create enough vocal trauma to cause an increase in vocal disturbances. Zajac and Linville⁷ found a relationship between hoarseness and shimmer.

Prior and recent studies examined vocal abnormalities in children with cleft palate by considering only the VPI status.^{6,8,10,19–21} However, it is clear that every child with VPI may not have glottal stops, and in those who do, the glottal stops may be caused by other factors such as dental malocclusion or fistula.¹⁵ Furthermore, there are differences across the studies in terms of the accepted criteria of VPI and the categorization of the VPI status.^{6,8,10,20} Some of them rely only on perceptual evaluation,

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and classify VPI and hoarseness as present or not.^{10,20} As we know, none of the study searching for the vocal quality characteristics in children with cleft palate included participants who have glottal stop productions.

The main purpose of this study is to determine the effects of glottal stop productions on voice. Our research question is: Are the vocal quality characteristics of children with glottal stop productions different from those who do not have that type of productions?

METHODS

In this study, participants were recruited from the Hacettepe University Hospital Cleft Lip and Palate Council where people applied for examination from November 2014 to February 2015. The effects of glottal stops on voice were prospectively researched using a case-controlled design methodology. All the evaluations were carried out in the Department of Ear, Nose, and Throat and the Audiology and Speech Pathology Unit at Hacettepe University Hospital. This study was approved by the Ethics Committee of Hacettepe University (Approval Number: GO 15/26-17). All of the children's parents gave informed consent for participation, consistent with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Participants

Participants with all types of repaired cleft palate, ranging from 4 to 12 years of age, were included in the study. Children were excluded from the study if they had undergone secondary VPI surgery, had fistula, had accompanying syndromes/hearing loss, or had flu on the day of the evaluation. Hearing loss was determined as having more than mild hearing loss in the worse ear, based on the results of an audiometric test that had been conducted within the previous 3 months. Speech therapy history was questioned. The participants who received speech therapy were followed up in the same center. The speech therapy involved standard articulation therapy principles for establishing correct articulatory placement, and none of them included any voice therapy techniques. Speech therapy was received postoperatively once a week for a minimum of 2 months.

A total of 60 eligible children with glottal stop ($n = 20$) and without glottal stop ($n = 40$) underwent video laryngoscopy evaluation. Participants who had vocal-fold lesions were excluded from the study. In total, glottal stop group (GSG) consisted of 17 children who had glottal stop productions, and control group (CG) consisted of an equal number of age- and sex-matched children who did not have glottal stop productions. The median age of the participants was 6 years and 3 months in the CG, and 5 years and 9 months in the GSG. The upper age limit in this study was determined based on the fact that puberty (after age 12) is a critical period for voice changes.

Assessment protocol

Articulation assessment

This evaluation was conducted using a standardized Turkish Articulation and Phonology Test.²² The subunit of this test, the "Articulation Screening Sub Test," was performed by a speech

language pathologist (SLP) in a silent room. Digital audio and video recordings were taken using Sony handycam HDR-CX11E (Sony Corporation, Tokyo, Japan) with a built-in microphone. During the evaluations, the children's utterances were recorded phonetically as much as possible. Evaluations were completed in approximately 15–30 minutes. Later, the recordings were listened to again, in a silent room to check for International Phonetic Alphabet coding and symbols used for cleft-related errors.²³ This articulation test was done to determine whether the children had glottal stop errors. Compatible with this study's purpose, the consonant errors were classified into three categories, as advised by Henningsson et al.²⁴ These categories were compensatory articulation errors, developmental/phonological errors, and other articulation errors. Because it is difficult to differentiate the substitution or coarticulation of glottal stops, both were accepted as examples of glottal stop.¹⁶

Reliability. Before every rating session, a training evaluation session was performed by listening to compensatory error production education samples (Misarticulation examples: excerpts from Trost-Cardamone [1987]) as found in the compact disc contained in Peterzone et al's book.⁴ In addition to these samples, the investigators listened to recordings of two Turkish children with cleft palate. These recordings had been previously edited by two SLPs who agreed that one child had glottal stops and the other had normal articulation. Every recording was analyzed live and with the audio recording by the first author. Intrajudge agreement between the two conditions was determined to be between 92% and 100%. As defined in Henningsson et al's study,²⁴ error production had to occur more than once in the controlled sampling context for the error type to be considered a reliable error. In addition to the articulation test, conversational speech samples and flexible fiber-optic videoendoscopy images were performed to confirm glottal stops.

Voice evaluations

Subjective evaluation. Subjective evaluation of voice was conducted using Grade, Roughness, Breathiness, Asthenia, Strain (GRBAS) method²⁵ and Pediatric Voice Handicap Index (pVHI).²⁶ The Turkish pVHI, which is a valid and reliable instrument, includes 23 questions about the functional, physical, and emotional effects of a voice disorder.²⁶ Parents were instructed to answer the questions by considering their child's voice status during the previous month.²⁶

Speech and voice samples were gathered audiovisually by the SLP in a sound-isolated room. Samples that consisted of recordings that were at least 2 minutes long included counting from 1 to 10, sustaining /a/ phonation, and connected speech.²⁷ Recorded samples were evaluated in another session by two SLPs who were experienced in voice disorders. Recordings were listened to many times until the SLPs agreed on the values of G (grade), R (roughness), and B (breathiness) parameters.²⁵ Grade represents the overall voice quality, roughness represents irregular fluctuations, and breathiness represents the turbulence of airflow in the voice sample.²⁵ Those parameters were evaluated as they were thought to be more reliable in children.^{28,29}

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