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Influence of high and low intraoral pressure consonants on the speech nasality and nasalance in patients with repaired cleft palate

Influência das consoantes de alta e baixa pressão intraoral sobre a nasalidade e nasalância da fala em pacientes com fissura de palato reparada

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ABSTRACT

Introduction: In the cleft palate, the accurate diagnosis of speech disorders helps the rehabilitation process by directing the treatment of velopharyngeal dysfunction. **Purpose:** To verify the influence of pressure consonants on speech nasality and nasalance, comparing high and low intraoral pressure stimuli in individuals with cleft palate. **Methods:** Forty-four subjects with repaired cleft palate±lip, both genders, aged 6 to 59 years were simultaneously submitted to nasometry and audio speech sample recording. Nasalance scores were determined for speech samples with high-pressure consonants (HP) and low-pressure consonants (LP). Three experienced raters classified speech nasality in both samples (HP and LP) according to a 4-point scale (1 = absent hypernasality, 2 = mild hypernasality, 3 = moderate hypernasality, 4 = severe hypernasality). **Results:** Nasalance scores±SD obtained for HP and LP samples were 31±15% and 31±12%, respectively, with no difference (p=1.0). The inter-rater agreement was higher for HP sample. The average rate of nasality between both samples showed difference (p=0.05). HP samples presented strong correlation between nasalance scores and hypernasality and LP samples presented substantial correlation. **Conclusion:** The HP speech sample was shown to be more effective in identifying hypernasality, as it provided greater agreement among examiners in the perceived nasality analysis, had a strong correlation between the two methods used and allowed diagnosis of velopharyngeal disfunction in a larger number of individuals.

Keywords: Cleft palate; Speech; Velopharyngeal insufficiency; Speech perception

RESUMO

Introdução: Na fissura de palato, a realização de um diagnóstico preciso das alterações de fala auxilia o processo de reabilitação, direcionando o tratamento para a disfunção velofaríngea. **Objetivo:** Determinar o estímulo de fala que melhor identifica a hipernasalidade, comparando a nasalidade da fala e a nasalância em estímulos de alta e baixa pressão intraoral, em indivíduos com fissura palatina. **Métodos:** Quarenta e quatro indivíduos com fissura de palato±lábio operada, de ambos os sexos, com idades entre 6 e 59 anos, foram submetidos, simultaneamente, à nasometria e gravação de fala. A nasalância foi determinada utilizando amostras de fala com consoantes de alta pressão intraoral (AP) e consoantes de baixa pressão intraoral (BP). Três examinadores experientes classificaram a nasalidade nas duas amostras (AP e BP), de acordo com uma escala de 4 pontos (1=hipernasalidade ausente, 2=hipernasalidade leve, 3=hipernasalidade moderada, 4=hipernasalidade grave). **Resultados:** Os escores médios ±desvio padrão de nasalância obtidos para as amostras AP e BP foram 31±15% e 31±12%, respectivamente, sem diferença (p=1,0). A concordância entre os examinadores foi maior para as amostras AP. A média de nasalidade entre as duas amostras apresentou diferença (p=0,05). As amostras AP apresentaram forte correlação entre os escores de nasalância e hipernasalidade e as amostras BP apresentaram correlação substancial. **Conclusão:** A amostra composta por consoantes de alta pressão intraoral mostrou maior eficácia na identificação da hipernasalidade, pois proporcionou maior concordância entre os examinadores na análise perceptual da nasalidade, apresentou forte correlação entre os dois métodos utilizados e permitiu o diagnóstico de hipernasalidade em maior número de indivíduos.

Palavras-chave: Fissura palatina; Fala; Insuficiência velofaríngea; Percepção da fala

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INTRODUCTION

Speech production can be impaired in the presence of a cleft palate. The disorders related of velopharyngeal dysfunction (VPD) may remain even after primary surgical closure of the palate[1]. The VPD speech symptoms are hypernasality, nasal air emission and compensatory articulation[2,3,4]. The accurate diagnosis of speech disorders is fundamental for the rehabilitation process allowing definition of proper therapeutic procedures. Clinical evaluation involves morphological and functional analysis of the palate, perception of nasality and instrumental assessment[1,5].

The auditory-perceptual evaluation is considered the gold standard method for speech assessment in patients with cleft palate, as it provides characteristics regarding sounds production and information on the velopharyngeal function[4,6]. Thus, it is considered gold standard in the analysis of speech disorders in individuals with cleft lip and palate[7]. However, the use of instrumental assessment complements the subjective analysis, verifying treatment outcomes more thoroughly, and its use is highly recommended[8,9,10,11].

Nasometry is one of the methods used to confirm nasality judgment and complement speech diagnosis[10,11,12,13]. The technique estimates the velopharyngeal function indirectly, by measuring nasalance, a physical magnitude that corresponds to the relative amount of nasal acoustic energy during production of oral sounds[14], according to the spoken language. Nasalance scores must be obtained from standardized speech samples, which are composed of exclusively oral or predominantly nasal consonants, in order to diagnose hypernasality or hyponasality, respectively[15,16,17]. Speech stimuli may be of high pressure - containing plosive, fricative, and affricate consonants, or of low pressure - containing vowels and liquid consonants[18]. One must bear in mind that nasalance scores vary according to spoken dialect or language, thus the used speech stimuli and its control values must be previously determined in speakers with no structural or speech problems[19,20,21,22].

A common concern among clinicians and researchers in cleft palate regards to the determination of adequate and representative speech samples to be used in the evaluation of speech disorders. The accurate diagnosis of oral communication disorders in the presence of the cleft palate helps the rehabilitation process, directing the treatment of VPD. With that purpose in mind, the aim of this study was to verify the influence of pressure consonants on speech nasality and nasalance, comparing high and low-pressure stimuli in subjects with repaired cleft palate.

METHODS

Prospective study, approved by Local Ethics Committee, Hospital of Rehabilitation of Craniofacial Anomalies of *Universidade de São Paulo*, (207.008), with consent from parents and/or legal guardians.

Forty-four subjects with cleft lip and palate were evaluated - 21 male and 23 female. Among participants, 29 of them had unilateral cleft lip and palate, 9 had bilateral cleft lip and palate, and 6 of them had isolated cleft palate. The ages ranged from 6 to 59 years, the average being 24±11 years. All subjects had been born in Brazil and were native Brazilian Portuguese speakers. They were conveniently recruited from routine outpatient appointments in a hospital. The number of subjects was defined after the sample size was calculated. A significance level of 5% and a test power of 80% were adopted, as per data regarding averages and standard deviations from the study by Waterson et al., (1998), plus 10%.

The study has not included subjects with syndromes, very long residual fistulae in the palate that could not be sealed, signs of nasal congestion, dysphonia, hearing impairment, and nasometry values suggesting hyponasality. Subjects were analyzed for those problems through the assessment of nasalance while they read sentences which contained predominantly nasal sounds, before they executed their speech samples.

The nasometry was conducted with a nasometer of model 6200-3 IBM (Kay Elemetrics Corp®), which uses a computerized system that comprises two microphones, one on each side of a sound separation plate that is supported on the upper lip, all headpiece adjusted. The upper microphone captures nasal speech component signs, and the bottom one captures the oral speech component signs[8].

The subjects read or repeated two sets of standardized sentences in Brazilian Portuguese[23] that were shown on the computer screen. One of the sets comprised five sentences containing high intraoral pressure (HIP) consonants: "*Papai caiu da escada. Fábio pegou o gelo. O palhaço chutou a bola. Tereza fez pastel. A árvore dá frutos e flores*". The other set contained five sentences that exclusively comprised low intraoral lpressure (LIP) consonants: *"O louro ia olhar a lua. Laura lia ao luar. A leoa é leal. Lili era loira. Lulu olha a arara"*[23]. For subjects who were not capable of reading, each sentence was repeated after the examiner modeled it. Before each exam was conducted, the nasometer was calibrated through the use of an acoustic source in the device itself. The speech signs were filtered and digitized by electronic modules, and analyzed by a software in order to obtain nasalance, as calculated by the numeric ratio between the nasal acoustic energy and the total (nasal and oral) acoustic energy multiplied by 100[24].

Simultaneously to nasometry, the speech samples were recorded in an audio system through Wave studio – Sound blaster Creative software. They were captured by a unidirectional headset microphone (Karsect® Brand, model HT9) that was connected to a laptop and positioned beside the nasometry plate, between the mouth and the nose, at an approximate distance of 10 cm away from the mouth.

The samples were edited, randomized, inserted in flash memory devices and analyzed by three examiners who were experienced in perceptual evaluation of cleft lip and palate speech. Nasality was rated using a 4-point scale, where 1=absent hypernasality, 2=mild hypernasality, 3=moderate hypernasality, 4=severe hypernasality[11].

The examiners individually received the samples in two distinct stages, with a 32-day interval between each of the stages. In each stage, examiners received 54 speech samples, 44 of which with high and low intraoral pressure consonants and 10 repeated ones, which were randomized to be later analyzed for intra-rater reliability. Examiners were instructed to analyze the records individually - wearing headphones was allowed - in a silent environment, and as many times as necessary to rate hypernasality for each sample.

Thus, the inter-rater agreement was verified and a final classification concerning nasality was established for each subject in HIP and LIP samples. The final rating corresponded to the judgment of the majority of examiners. In the cases when the three examiners assigned different scores to the same sample, the rating from the examiner with the best intra-rater reliability coefficient was used, according to Kappa coefficient[25].

The comparison between the two speech samples (HIP and LIP) in order to check for the significance between nasalance scores was conducted through a paired t-test. In order to compare the final individual nasality scores for the two samples, Wilcoxon signed-rank test was used, with the adoption of a 5% significance level.

In the assessment of intra and inter-rater reliability in the evaluation of speech nasality, Kappa coefficient[25] was used, in which a coefficient below zero does not indicate agreement; from 0 to 0.20 it indicates poor agreement; from 0.21 to 0.40, it indicates slight agreement; from 0.41 to 0.60, moderate agreement; from 0.61 to 0.80, substantial agreement; and from 0.81 to 1.0, almost-perfect agreement. After that state, the shares of individual classifications in the assessment of nasality were compared through Z-test.

Furthermore, the correlation among perceptual and nasometric speech nasality data was verified through Spearman's rank correlation coefficient.

RESULTS

According to the nasometric evaluation, the average value±standard deviation (SD) of nasalance for the 44 subjects, in the production of HIP sample, was 31±15%; in the LIP sample, it was 31±12%, and no difference was found between the two samples (p=1.0).

The intra-rater agreement in the evaluation of speech nasality was almost perfect for rater 1, substantial for rater 2, and slight for rater 3. In the comparison among the intra-rater reliability results, a difference was observed between raters 1 and 3 (p=0.05). The remaining comparisons are shown in Table 1.

The medians regarding the nasality scores for the 44 subjects in the production of HIP and LIP samples were 2 and 3, respectively, with a difference (p=0.05) between the two speech samples. For the HIP sample, 25% of the subjects (11/44) were shown not to have hypernasality, 18% (8/44) had mild hypernasality, 43% (19/44) had moderate hypernasality, and 14% of them (6/44) had severe hypernasality. For the LIP sample, 34% of the subjects (15/44) were shown not to have hypernasality, 27% (12/44) had mild hypernasality, 32% (14/44) had moderate hypernasality, and 7% of them (3/44) had severe hypernasality. When final scores for both samples were compared, 57% of the subjects (25/44) were found to have the same nasality rating for both speech samples.

The correlation between nasality and nasalance according to the evaluation methods that were used for HIP and LIP samples was shown to be strong (p<0.001) across perceptual and instrumental evaluations for HIP samples, and substantial (p<0.001) for LIP samples.

DISCUSSION

Determining a proper and representative speech sample - to be used in clinically assessing and documenting speech production disorders - has been a common concern among national and international practitioners and researchers. In the presence of craniofacial abnormalities, as the cleft palate, this has been a subject that has generated cooperation initiatives between centers, for the discussion of themes such as choosing headsets, words and sentences, and types of emissions which must compose a significant speech sample that can be used in craniofacial centers, in order to make the comparison easier between the results from several services. Supporting that initiative, this study relates to the challenge of determining a speech sample that can reliably identify speech disorders

Table 1. Comparison among the inter-rater Kappa coefficients in the assessment of nasality from speech samples with high (HIP) and low intraoral pressure consonants (LIP)

Examiners	HIP Kappa Coefficient	LIP Kappa Coefficient	p-value	Interpretation
1 x 2	0.38	0.38	1.0	Not significant
1 x 3	0.51	0.20	0.005	Significant
2 x 3	0.45	0.23	0.051	Not significant
1 x 2 x 3	0.44	0.26	0.12	Not significant

HIP x LIP: Z-test

and minimize assessment subjectivity. It also seeks to support inexperienced speech-language pathologists in assessing the speech of subject with cleft palate.

Thus, a study that tested two different (already standardized) speech stimuli[23] was chosen. The stimuli were chosen on the basis of their production types: high and low intraoral pressure consonants. The effective use of samples containing high pressure consonants is significant, and it is routinely used in all services regarding cleft lip and palate treatment. However, in the clinical practice, the velopharyngeal function analysis using that kind of sample is hindered when compensatory articulations (related to the points of articulation, and somehow to intraoral pressure, such as glottal stops and pharyngeal fricatives) are present in turn, the effectiveness of low intraoral pressure speech stimuli in determining nasality has not been very explored, but they seem to allow perceiving symptoms and classifying velopharyngeal function levels in different articulatory conditions, which facilitates the evaluation. In low pressure consonants, the tongue controls the air flow in the oral cavity through the partial occlusion of the flow, and it may facilitate the identification of hypernasality[26].

According to the results of the present study, the nasalance values were not different between HIP and LIP samples, in average. In a similar study, nasalance was determined during the spoken production of plosive, fricative, affricate consonants, as well as vowels and liquid consonants; they found no significant differences either between the two speech stimuli used, in agreement with other studies[18,21,23,26].

Another factor which might have influenced nasalance in regards to higher scores in part of HIP samples is the possible presence of other speech alterations such as compensatory articulations, weak intraoral air pressure, audible emission air nasal, and nasal snoring - those variables were not controlled in this study. According to some authors, such symptoms may sensitize the nasal microphone of a nasometer, thus increasing nasalance scores. As an example, a study found that the presence of nasal snoring increased nasalance scores[26]. Besides that, variations among nasalance values may be influenced by the differences in speech stimuli themselves, which are used in the assessment[1], as samples are not identical.

Another recent study which compared nasalance scores for HIP and LIP speech samples in English from children without cleft palate and children with repaired cleft palate and proper velopharyngeal closure found that the children with cleft palate were shown to have higher nasalance scores - however, the significant difference was found for LIP samples. The study concluded that the children with surgically-repaired cleft palate performed velopharyngeal closure during the production of HIP samples; however, the same did not hold true in the production of LIP samples[27]. That is, the difference between the production of HIP and LIP samples may also be influenced by velopharyngeal closure patterns, which differ with each emission.

In the clinical practice, LIP speech samples are also observed to help identify hypernasality when there is, for example, contamination in almost all phones due to compensatory articulations, in a way to make vowels clear. According to another study - on the effect from vowels in different nasalance assessment instruments, including the nasometer - vowels may increase nasalance values, especially the high vowels[28]. The LIP samples that were used in this study were found to have a higher number of high vowels in the sentences, as compared to the HIP sample. Thus, vowels may have influenced the highest nasalance scores in 34% of LIP samples in this study.

The perceptual analysis of nasality was conducted by three experienced examiners in the speech assessment of subjects with cleft palate, and they were found to have variable intra-rater reliability scores (from slight to almost perfect). International studies regarding perceptual-auditory analysis have been warning that rater experience is an important factor, and that was enough, to a certain extent, for agreement coefficients to be high. However, presently, only using the criterion regarding the length of experience of an examiner does not seem to be sufficient anymore, training being a requirement[29]. In this study, no training was provided, neither reference samples were used, as the aim in the raters' assessments was to identify nasality in the subjects producing the two mentioned samples, which, theoretically, would use the same internal patterns of examiners.

In regards to inter-rater coefficients, lower values were observed, especially concerning the classification of the LIP sample, which caused the agreement to vary, from poor to slight. For the HIP sample, the coefficients were a little higher, generating agreement scores which ranged from slight to moderate. One of the factors which may account for the higher inter-rater agreement in the HIP sample is related to the characteristics of used sounds. In high pressure consonants, a trained listener may perceive emission differences more easily, in the presence of a velopharyngeal dysfunction, once the speech production will take place in a way that is very different from the usual, which makes the examiners' identification of hypernasality easier. Another causal factor is related to the more frequent use of high pressure consonants in speech samples of protocols for the assessment of cleft lip and palate treatments. Finally, one should also consider the influence of compensatory articulations on the assessment of nasality, a variable which was not controlled in this study.

According to the correlation results between nasometry and the perceptual assessment, there was a strong correlation between the two studied variables for HIP samples, and a substantial correlation between the variables for LIP samples, which consisted of yet another advantage to the HIP sample. The good correlation between the perceptual and instrumental assessment methods is described in the literature[6,10,12,13,18,26], indicating that quantitative evaluation methods should be used clinically and for research purposes, in order to complement qualitative data. The correlation showed that the increased nasalance values for the two speech samples used corresponded to the nasality values that were established by the examiners, which allowed more confidence in the speech results and more reliability to evaluation methods that were used.

Generally speaking, the nasometric evaluation has not identified differences between HIP and LIP, whereas the perceptual evaluation suggested that HIP sample was the one which most identifies hypernasality, and it should be used routinely in services regarding the rehabilitation of cleft palate. Even though, the low intraoral pressure consonants are part of the phonetic repertoire, and their production must be investigated in the speech of subjects with cleft palate, as speech intelligibility depends on the flawless production of all sounds in the spoken language.

CONCLUSION

The speech sample with the high intraoral pressure consonants was shown to be more effective in identifying hypernasality, once it provided higher agreement among raters in the perceptual analysis of nasality, was found to have strongly correlated results between the two evaluation methods used, and allowed diagnosing hypernasality in a higher number of subjects.

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