OCCURRENCE OF LISPING IN VOICED AND UNVOICED FRICATIVES IN CHILDREN WITH OPERATED CLEFT LIP AND PALATE

Ocorrência de ceceio em fricativas vozeadas e não vozeadas em crianças com fissura labiopalatina operada

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ABSTRACT

Purpose: to investigate whether lisp, when identified, differs between voiced and unvoiced alveolar fricatives produced by children with cleft palate. **Methods:** a prospective study in which sentences comprising the consonants [s] and [z] produced by 32 children with cleft palate (mean age, 8 years, 8 months) were selected and after auditory judged. All children presented altered inter-relationship arches as evaluated by three orthodontists (inter-judge agreement almost perfect kappa = 0.81), performing analysis of dental casts. Three Speech-Language-Pathologists judged perceptually audio recorded productions. The inter-judges agreement ranged between 56% and 78% and between 59% and 93% for the phrases consisting of [s] and [z], respectively. **Results:** the lisp was identified in 69% of children, particularly, in 72% and 50% [s] and [z] sounds, respectively. There were significant differences between judgments for the fricatives [s] and [z], with higher prevalence of lisping in [s]. **Conclusions:** dentofacial deformities may favor the occurrence of lisp in population with cleft palate. The increased occurrence of lisp in [s] compared to [z], based on auditory perceptual identification, can be justified by acoustic and / or articulatory reasons. It is suggested that lisp is dependent of the phonetic-phonological context of the sentence and therefore must be considered for clinical and research purposes.

KEYWORDS: Speech; Cleft Palate; Malocclusion

INTRODUCTION

Several studies report that occlusal alterations may cause disorders in the production of alveolar fricative consonants[1-6]. In normal morphological and/or functional conditions, these consonants are produced with partial constriction of the airway between the tongue apex and the alveolus, and they may be voiced (with vibration of vocal folds, [z]) or unvoiced (without vibration of vocal folds, [s]). Acoustically, voiced fricatives are characterized by the presence of two sources, the glottal source (responsible for voicing) and the noise source (resulting from constriction of the vocal tract), while unvoiced fricatives are formed by a single noise source[7].

Morphological and/or functional changes may also cause a different sound than expected during the production of fricatives[8,9], a condition known as lisping (anterior or lateral)[8]. Previous studies on individuals without craniofacial malformations

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indicated that occlusal changes may cause damage to the production of alveolar fricative consonants[1,8-12], even though this relationship is not always observed[13] or even may not be directly related to the severity of occlusal alteration[14]. Some such studies investigated the occurrence of lisping when produced in words or other speech samples composed of alveolar consonants ([s] and/or [z])[8,9,12,13]. However, these studies did not investigate whether the production and/or auditory perceptual judgment of lisping differs between voiced and unvoiced alveolar fricatives.

Particularly, when considering changes in speech production in individuals with cleft lip and palate (FLP)[15,16], there are reports that deficiencies in midface growth may cause distortions/lisping in the production of fricatives[15,17]. In general, the literature reports that, when the mandible is protruded in relation to the maxilla, the tongue may be anteriorly positioned at rest, yielding changes in the airflow during production of alveolar fricatives, which would cause distortion in the production of these consonants. However, some studies[18,19] indicate that, when investigating the possible association between lisping (identified by audio and video analysis during production of sentence with recurrence of [s]) and the interarch relationship (observed by analysis of the occlusal yardstick of dental casts), no direct association was found between these two aspects in 106 children with operated cleft lip and palate, which led the authors to conclude that other factors (morphological, functional and/or sensorial) might influence the production of fricative sounds.

In general, the literature evidences great interest in investigating the possible relationship between lisping and morphological alterations in the oral cavity in children with and without craniofacial malformations. However, information on possible disorders in the production and/or perception of lisping, comparing voiced or unvoiced alveolar fricatives, are limited in the national literature.

Information on the acoustic and articulatory characteristics of voiced and unvoiced alveolar fricatives reported in the international literature indicate differences between these consonants, when produced by individuals with normal speech. These acoustic descriptions indicate that voiced fricatives present lower intensity and shorter duration, as well as greater amplitude of friction interval compared to their unvoiced counterparts[20]. These differences are related with coupling of the glottal and frictional sources occurring in the production of voiced fricatives[20]. It is assumed that the vocal folds abducted during the production of unvoiced fricatives allow a greater volume of airflow to pass through the glottis toward the oral cavity. Conversely, interruptions or restrictions of the airflow in voiced fricatives reduce the airflow volume and consequently the intensity of turbulence at the constriction point. However, so far, it has not been investigated whether these acoustic characteristics may influence the auditory perceptual judgment of lisping in the speech of individuals with craniofacial malformations, making its identification less audible in voiced compared with unvoiced fricatives.

Also, articulatory descriptions resulting from electropalatography indicate differences between the production of alveolar fricatives [s] and [z] in individuals with normal speech. The literature reports that, in general, production of the fricatives [s] and [z] in normal conditions is characterized by lateral contact of the tongue along the palate, as well as incomplete contact of the tongue at the anterior portion of the alveolar ridge, yielding a groove at this region[21]. However, by electropalatography, investigators[21] have identified inter- and intra-individual variability in productions of [s] and [z] in adults with normal speech. They also evidenced greater lingual/palatal contact for [z] compared to [s] in electropalatographic measurements obtained, as well as greater narrowing of the groove in [z] when produced at onset of the word. According to the investigators, a possible explanation for this difference would be the need of greater air volume for the production of [s], which would push the tongue laterally, in an attempt to create a wider passage for the airflow. Studies using magnetic resonance imaging also revealed differences in tongue positioning during the production of unvoiced and voiced fricatives. In general, there was a tendency of more anterior positioning of the tongue root/base in voiced fricatives compared to the unvoiced counterparts[22].

Considering that differences between fricatives [s] and [z] are expected in normal speech, when acoustic and/or articulatory procedures are used, it is interesting to verify whether lisping, when auditorily judged, is also different concerning the voiced and unvoiced alveolar fricatives produced by children with operated cleft lip and palate. A preliminary study involving preschool children with malocclusion (yet without craniofacial malformations) indicated greater occurrence of lisping in fricative [s] compared with [z], when auditory perceptual judgment was used[19]. However, so far, there is no information on possible differences in the articulatory characteristics of fricatives [s] and [z] in the presence of lisping in children with cleft lip and palate, as well as whether these characteristics may be perceived and/or influence the auditory perceptual judgment of lisping. The hypothesis initially adopted in this study is that lisping, when present, presents differently in voiced and unvoiced fricatives, with greater occurrence

for unvoiced compared with voiced alveolar fricatives. Thus, this study investigated whether lisping, when present, differs between voiced and unvoiced alveolar fricatives produced by children with operated cleft lip and palate.

METHODS

This study was approved by the Institutional Review Board of the Hospital for Rehabilitation of Craniofacial Anomalies under protocol n. 111/2009.

This study had a prospective design in which speech samples saved in a databank, after selected, were judged by speech-language pathologists as to the occurrence of lisping in voiced and unvoiced fricatives. These samples were obtained from 32 children with operated complete unilateral cleft lip and palate, aged 6 to 11 years (mean 8 years and 8 months), of both genders. All children included in the study presented mixed dentition and altered interarch relationship at the moment of data collection, as evaluated by three orthodontists (almost perfect inter-examiner agreement, kappa=0.81), based on dental cast analysis according to the criteria suggested by Mars et al (1987)[23].

Even though the Angle classification is among the most known and used for the evaluation of malocclusion in individuals without craniofacial malformations, this classification considers only the interarch tooth positioning in sagittal direction, besides being considered a qualitative rather than a quantitative malocclusion index[24]. Therefore, this study adopted the "Goslon Yardstick" occlusal index, which allows classification of the severity of malocclusion and the difficulty for its correction in individuals with cleft lip and palate. This occlusal index has been applied in many craniofacial centers because it is reliable and easily reproduced; is able to distinguish the quality of intercenter surgical outcomes, allowing early diagnosis of dental arch relationship in both anteroposterior, vertical and transverse dimensions; and provides identification of the prognosis, which allows early changes in the surgical protocol without the need to wait up to the permanent dentition[25].

The "Goslon Yardstick" presents five different occlusal scores; however, this study only included children presenting Goslon scores 4 and 5. Particularly, score 4 is characterized by (a) negative overjet with normal or buccally tipped incisors; (b) tendency to unilateral/bilateral crossbite; and (c) tendency to open bite at the cleft area (Figure 1). Conversely, score 5 is characterized by (a) negative overjet with buccally tipped incisors; (b) bilateral crossbite; and (c) poor maxillary dental arch morphology and palate anatomy (Figure 2). It should be emphasized that selection of occlusal scores 4 and 5 in this study was based on the greater involvement in expected interarch relationships (poor or very poor prognosis) in selected children, which might favor the identification of lisping in the fricatives of interest, whenever present.

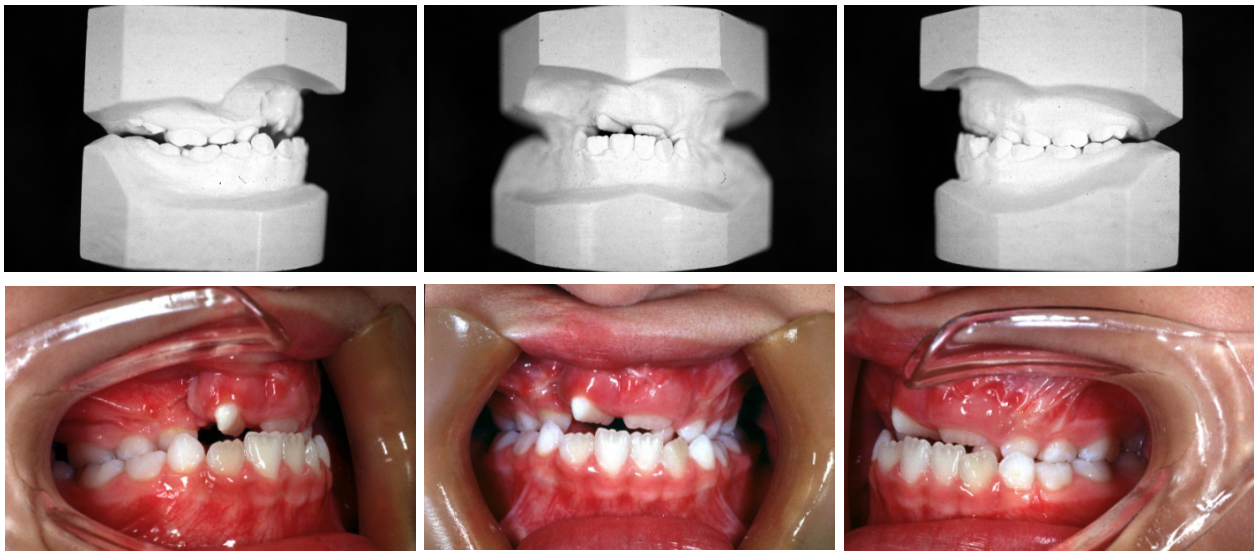

Figure 1 – Individual with complete unilateral right cleft lip and palate presenting Goslon Yardstick 4. Note the poor interarch relationship with negative overjet and normal inclination of maxillary incisors, bilateral crossbite, tendency to open bite at the cleft area and face tending to Angle Class III, with evident maxillary deficiency

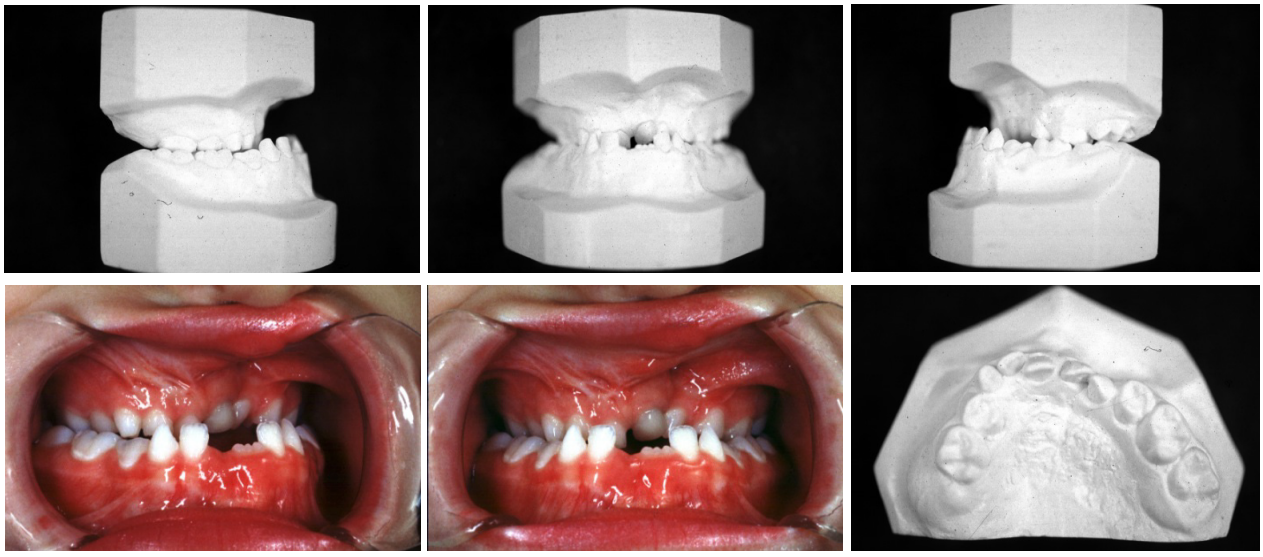

Figure 2 – Individual with complete unilateral right cleft lip and palate presenting Goslon Yardstick 5. Observe the very poor interarch relationship with markedly negative overjet, total crossbite, morphology of the maxillary dental arch and poor anatomy of the palate. The face is excessively concave with very poor orthodontic-surgical prognosis

The study excluded children with history or presence of hypernasality, nasal air escape, weak intraoral pressure or compensatory articulation, at least to partially control the variables that might affect the identification of speech sound distortions. None of the selected children had been submitted to orthodontic or orthopedic treatment before data collection.

The speech productions analyzed were obtained from a databank. For their achievement, during recording, each child was asked to perform two consecutive repetitions of two different phrases, one composed of fricative [s] and one comprising the fricative [z] ("O saci saiu cedo" and "Zizi pousou na casa da Zezé", respectively). It was decided to use sentences with recurrence of the same phoneme, since this recurrence might favor the auditory perceptual identification of the presence or absence of speech distortion.

The children's productions were randomly recorded in a single day, in an acoustic booth available in the same institution, using high-fidelity digital equipment. A condensed/unidirectional head microphone model AKG C420 was used, positioned at approximately 5 cm from the lip commissure. This microphone was connected to an audio capture plate Sound Blaster Audigy 2 installed in a computer, in which the audio recordings were saved in files in WAV format, using the software *Sony Sound Forge,* version 8.0.

The recordings of interest for this study were edited using the same software *Sony Sound Forge,* version 8.0, and then saved in a DVD. The phrases produced by the 32 children were randomly stored in this DVD. Overall, 128 phrases were initially selected for this study, being 64 corresponding to two consecutive repetitions of the phrase composed of fricative [s] and 64 corresponding to two consecutive repetitions of the phrase composed of fricative [z], produced by the 32 individuals.

Thereafter, judgments were independently performed by three speech-language pathologists experienced in the evaluation of speech disorders associated with cleft lip and palate, including those classified as dento-occlusal distortions, using the software Windows Media Player (Microsoft), in a personal computer and earphones. The speech-language pathologists were asked to auditorily judge whether, during two consecutive repetitions of each phrase, at least one fricative segment inserted in these two repetitions was produced according to the target (absence of lisping) or if there was lisping (i.e. when the fricative segment was produced with some type of distortion/noise). At completion, a single judgment was obtained for each of the two consecutively repeated phrases, yielding a total of 64 judgments (32 related to the phrase composed of [s] and 32 related to the phrase composed of [z]).

Examples of productions with and without lisping were offered to the speech-language pathologists before the study for calibration. After listening to

each sentence, the speech-language pathologists indicated one alternative (target or lisping) for each speech sample analyzed, in a worksheet especially designed for that purpose. It should be highlighted that the speech-language pathologists were not asked to characterize the type of lisping, but rather to identify its presence or absence at least in one fricative segment that constituted each of the two phrases, based on the auditory judgment.

The judgments were then combined and a single judgment was obtained for each child, indicating the presence or absence of lisping in phrases with voiced and unvoiced fricatives, according to the agreement of most examiners. That is to say, the child's production was considered as presenting lisping during the production of [s] or [z] when at least two speech-language pathologists identified lisping in at least one fricative consonant composing each phrase. The agreement between the three examiners for phrases composed of [s] ranged between 56% and 78%, with 17 out of 32 judged samples with 100% of agreement. For phrases composed of [z], the agreement varied between 59% and 93%, with 19 samples judged with 100% of agreement.

The binomial exact test was applied to verify differences between the employed categories of fricatives (unvoiced x voiced) produced by the total of children. To analyze the hypotheses, a significance level of 5% ($p<0.05$) was adopted.

RESULTS

After the three speech-language pathologists judged the phrases composed of fricatives, lisping (regardless of the alveolar fricative) was identified in 23 (72%) children. Particularly, when investigating differences in the occurrence of lisping between voiced and unvoiced fricatives, it was observed that lisping in the fricative [s] occurred in 23 (72%) out of 32 children, while in fricative [z] lisping was present in 16 (50%) of children. Table 1 presents the occurrence of lisping in voiced and unvoiced alveolar fricatives in the children investigated. When the judgments of lisping were compared between the fricatives produced, a significant increase in lisping was observed for the alveolar fricative [s] compared with the alveolar fricative [z].

Table 1 – Distribution of frequencies of absence (target production) and presence of lisping in voiced and unvoiced fricatives, produced by 32 children

Variable	Unvoiced		Voiced		Significance (p)
	N	%	N	%	
Lisping	23	72	16	50	0.020 (*)
Target	9	28	16	50	
Total	32	100	32	100	-

*Binomial exact test

DISCUSSION

The present results demonstrated that, based on the auditory perceptual judgment, lisping was identified in most (72%, N=23) children with operated cleft lip and palate and significant alterations in interarch relationship. Particularly, when children produced phrases composed of [s], lisping was identified in the speech of 72% das of children. When the same children produced phrases composed of the fricative [z], lisping was identified in the speech of 50% of the population. In general, these findings indicate that dentofacial deformities favor the auditory perception of distortions (lisping) in the speech of children with operated cleft lip and palate, confirming previous descriptions for this population[15,17].

It should be highlighted that not all children in this study presented distortion/lisping in the fricatives investigated, even though all of them presented unfavorable dentofacial deformities, with poor or very poor prognosis for orthodontic treatment, according to criteria in the literature[23]. These data confirm a previous study that revealed a lack of direct association between lisping and occlusal scores (with variation in the degree of severity, i.e. Goslon index between 1 and 5) during production of [s], when the auditory perceptual and visual (simultaneous) evaluations were used to investigate the speech of 106 children (mean age 8 years and

8 months) with operated cleft lip and palate[18]. The present findings also agree with previous information in the literature[10,14] for children without craniofacial malformations, in which lisping was not observed in all preschool children with malocclusion. In these studies, the presence of morphological alterations (malocclusion) was considered a factor that favors the presence of lisping, yet it should not be considered determinant.

In general, the results observed for children with or without craniofacial malformations indicate that other factors, in addition to dentofacial alterations, should be considered when investigating the occurrence of lisping in the child population, including immaturity of the oral motor sensory system[26]; reduced tongue tonus due to obstructive mouth breathing, in the case of cleft palate[27]; sensorial differences due to tissue handling (scars) in the case of cleft lip and palate[28] and hearing losses frequently observed in the child population, especially those with history of cleft palate[29,30]. Conversely, the possibility of efficient adaptation of children to the different structural conditions[31] may cause a less distorted speech, which would impair the auditory perception of lisping in the presence of facial deformity.

This study evidenced that the selection of fricative consonants interfered with the auditory perception of lisping, with greater occurrence of lisping in the alveolar fricative [s] compared to [z]. The same tendency was observed in a previous study involving preschool children with occlusal alterations, in whom lisping was more noticed for [s] in controlled speech conditions[19]. The greater occurrence of lisping in [s] based on the auditory perceptual evaluation may be explained by several factors. First, acoustic descriptions indicate that voiced alveolar fricatives present lower intensity and duration than their unvoiced counterparts, due to coupling of the glottal and frictional sources[20]. It is assumed that the vocal folds abducted during production of unvoiced fricatives allow a greater volume of airflow to pass through the glottis toward the oral cavity. Conversely, interruptions or restrictions of the airflow in voiced fricatives reduce the airflow volume and consequently the intensity of turbulence at the constriction point. This may have contributed to the greater auditory identification of lisping in unvoiced alveolar fricatives.

Also, studies involving electropalatography indicate differences in lingual-palatal contact during the production of [s] and [z] in individuals with normal speech, with greater lingual-palatal contact in individuals with normal speech, with greater lingual-palatal contact for [z], as well as greater narrowing of the groove in [z] when produced at onset of the word[21]. Therefore, it may be suggested that articulatory differences between [s] and [z] may also occur in the presence of lisping, yet to a lower degree for [z], allowing greater auditory perception compared with [s]. Also, the occurrence of [z] at onset of the word is restricted in Brazilian Portuguese, which may influence the listener's production and perception of listeners on deviations in the production of this sound.

Similar to electropalatography, data obtained by magnetic resonance imaging also indicated differences between unvoiced and voiced fricative consonants (including alveolar fricatives), produced by North American adults with normal speech. This evaluation revealed a tendency of more anterior tongue root positioning in voiced fricatives compared to the unvoiced counterparts[22]. Considering the occurrence of differences in tongue root positioning between voiced and unvoiced fricatives in the production of normal speakers, this difference is also expected, though less marked, in the presence of lisping (in which there is variability in the production of fricatives).

In general, comparison of the present findings with previous information is difficult due to the lack of studies in the national and international literature addressing the presence of lisping in individuals with cleft lip and palate. Also, information on possible distinctions in the production and/or perception of lisping, comparing voiced and unvoiced alveolar fricatives, are limited in the national literature, even for individuals with malocclusion without cleft lip and palate. However, a previous study involving preschool children with malocclusion (yet without history of craniofacial malformations)[19] revealed greater occurrence of lisping in [s] compared with [z]. Despite the different population (preschool children without craniofacial malformations), the findings of this preliminary study indicate the same tendency. Future studies are necessary to widen the knowledge on the presence of lisping in voiced and unvoiced fricatives in individuals with and without craniofacial malformations.

Data of this study may contribute to the clinical practice, since they indicate that lisping may be more easily noticed by the speaker and/or examiner when occurring in unvoiced compared to voiced alveolar fricatives. Therefore, it is observed that the fricative [s] favors the identification of lisping by the examiner and may be used both for screening and clinical speech evaluations. The results further indicate that words composed of unvoiced alveolar fricative may favor the onset of therapy (because they allow greater perception of deviations in the production), while words composed of voiced alveolar fricative may be used at later periods, since they are syllable contexts that seem more difficult to monitor during

therapy, because they minimize the auditory effect of lisping. Also, selection of the phonetic-phonological context of the word may allow the patient a greater perception of lisping, which may favor the therapeutic process when searching for contrast between the presence and absence of this deviation in speech.

In addition to the contributions derived from the present study, future investigations providing information on the production of unvoiced and voiced alveolar fricative consonants based on acoustic measurements may further expand the knowledge on the speech of children with lisping. Previous studies demonstrated the importance of acoustic analysis to understand the pathological speech[22,26]. Also, articulatory measurements (ultrasonography / electropalatography) may collaborate to the understanding on the production of fricative consonants (voiced and unvoiced) produced by adults and children with and without lisping. The literature reports the importance of ultrasonography[32] and electropalatography[33-35] for better understanding of the pathological speech involving fricative consonants, including those related with cleft lip and palate[33].

CONCLUSION

The present findings suggest that unfavorable dentofacial conditions may favor the occurrence of lisping in voiced and unvoiced alveolar fricatives, when identified by auditory perceptual judgment. This study also evidenced the influence of speech sample selection in the auditory perceptual judgment, since the fricative [s] tends to favor the identification of lisping when compared with its voiced counterpart [z]. In general, these findings present additional information on the influence of the phonetic-phonological context in the production and perception of alveolar fricative phonemes integrating the Brazilian Portuguese phonological system. This information may contribute for clinical and research purposes in the field of orofacial motricity.

RESUMO

Objetivo: investigar se o ceceio, quando identificado, difere entre as fricativas alveolares não vozeadas e vozeadas produzidas por crianças com fissura labiopalatina operada. **Métodos:** estudo prospectivo, em que frases constituídas pelas consoantes [s] e [z] produzidas por 32 crianças com fissura labiopalatina operada (idade média, 8 anos, 8 meses) foram selecionadas de um banco de dados e posteriormente julgadas auditivamente. Todas as crianças apresentavam relação inter-arcos alteradas, conforme avaliação ortodôntica realizada por três ortodontistas (concordância inter-juiz quase perfeita, kappa= 0.81), a partir da análise de modelos de gesso. Três fonoaudiólogas julgaram auditivamente as produções áudio gravadas. A concordância inter-juízes variou entre 56% e 78% e entre 59% e 93% para as frases constituídas de [s] e [z], respectivamente. **Resultados:** o ceceio foi identificado em 69% das crianças e, particularmente, em 72% e 50% das produções envolvendo [s] e [z], respectivamente. Houve diferença significante entre os julgamentos para as fricativas [s] e [z], com maior ocorrência de ceceio em [s]. **Conclusões:** deformidades dentofaciais podem favorecer a ocorrência do ceceio na população com fissura labiopalatina. A maior ocorrência do ceceio em [s] em comparação à [z], a partir da identificação auditiva, pode ser justificado por razões acústicas e/ou articulatórias. Sugere-se que o ceceio é dependente do contexto fonético-fonológico da frase devendo o mesmo ser considerado para fins clínicos e de pesquisa.

DESCRITORES: Fala; Fissura Palatina; Má Oclusão

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