REVISTA CEFAC
SPEECH, LANGUAGE, HEARING SCIENCES AND EDUCATION JOURNAL
Rev. CEFAC. 2019;21(4):e19118 http://dx.doi.org/10.1590/1982-0216/201921419118

Original articles

Interference of dentofacial deformities in the acoustic characteristics of speech sounds

Janaina dos Santos Coelho[1]
https://orcid.org/0000-0002-8678-3821

Renata Christina Vieira[2]
https://orcid.org/0000-0003-2083-4988

Esther Mandelbaum Gonçalves Bianchini[1]
https://orcid.org/0000-0002-2878-4826

[1] Pontifícia Universidade Católica de São Paulo – PUC-SP, Programa de Estudos Pós-graduados em Fonoaudiologia, São Paulo – SP – Brasil.

[2] Pontifícia Universidade Católica de São Paulo – PUC-SP, Programa de Estudos Pós-graduados em Linguística, São Paulo, São Paulo, Brasil

Conflict of interests: Nonexistent

Received on: January 19, 2019
Accepted on: August 14, 2019

Corresponding address:
Janaina dos Santos Coelho
Rua Humaitá, 585, apto 114, Bela Vista
CEP: 01321-010 - São Paulo, São Paulo, Brasil
E-mail: janascoelho.jsc@gmail.com

ABSTRACT

Purpose: to verify speech characteristics regarding the production of fricative sounds in people with dentofacial deformities (DFD), through acoustic analysis, evaluating possible interferences of the variation of the osseous bases in the articulation of speech.

Methods: fifteen adults of both genders, aged between 17 and 42, participated in the study. They were distributed in three groups: GII (n = 5) Skeletal Class II, GIII (n = 5) Skeletal Class III, and CG (n = 5) without DFD. All of them had their voices recorded, with key words containing the fricative sounds of Brazilian Portuguese (BP), and acoustically analyzed; the parameters: duration, intensity, and formants F1, F2. The Mann-Whitney test was used to compare the groups.

Results: there were differences ($p < 0.05$) when comparing GII and GIII with CG. For the variable duration GIII obtained higher value in the fricative sound /z/ ($r = 0.016$, $p < 0.05$). The variable intensity was higher for GII in /z/ ($r = 0.028$, $p < 0.05$), and higher for GIII in /f/ ($r = 0.028$, $p < 0.05$), /v/ ($r = 0.028$, $p < 0.05$) and /ʃ/ ($r = 0.036$, $p < 0.05$). For the variable F1, GII obtained a higher value for the syllable /za/ ($r = 0.047$, $p < 0.05$). In the variable F2, GII obtained the lowest value in the syllable /ʒa/ ($r = 0.047$, $p < 0.05$).

Conclusion: the disharmony of the maxillomandibular osseous bases results in interference in speech acoustic characteristics regarding fricative sounds.

Keywords: Speech Acoustics; Maxillofacial Abnormalities; Orthognathic Surgery; Articulation Disorder; Speech, Language and Hearing Sciences

INTRODUCTION

The speech is one of the ways humans use to communicate. However, its production requires proper interaction between different structures of the vocal tract, such as maxillomandibular osseous bases, dental arches, teeth, and hard palate; and of soft tissue: soft palate, tongue, lips, cheeks, and organic spaces[1]. It's a complex task, which needs to be performed in coordinated, organized and planned fashion in order to guarantee full comprehension of what had been said by the interlocutor[2,3]. For the understanding of the adjustments that take place during the process of producing speech, it's necessary to use some resources, as the acoustic analysis[4-7].

The acoustic analysis is a tool which has been increasingly used in clinical practice, and many studies have been aiding in better understanding the production of speech. Since it's an evaluation of non-invasive technique, it permits the inference of the movements made during speech production, resulting in a sound signal. As this signal is decomposed, it's possible to detail the mechanisms that led to its production. Through the analysis of the formants, the behavior of the vocal tract during speech can be verified[4,7].

The formants are identified by the energy peaks in the acoustic spectrum, i.e., it's a resonator with response in frequency, and the formant's peak varies according to the adjustments in the vocal tract[4,5,7,8]. The formants F1 and F2 are the main ones for speech, for the formant F1 is influenced by the height of the tongue and opening of the jaw, and the F2, by the anteroposterior variations of the tongue[7-9].

The modifications of facial proportions, such as occur in people with dentofacial deformities (DFD), may impair articulation in speech, causing alterations and distortions[10-14]. The DFD is characterized by the discrepancy between the maxillomandibular osseous bases modifying the intraoral space and originating malocclusions with skeletal association. Studies point to alterations in speech present in people with DFD[14-16], some of which occur in the production of fricative sounds. In the skeletal Class II face pattern, adaptations on alveolar fricative phonemes are mentioned, accompanying mandibular slide and/or tongue projection between the teeth for the sounds /s/ and /z/[1,17]. In the skeletal Class III face pattern, these same fricative sounds are produced with distortions due to elevation of the back or central part of the tongue. The labiodental fricatives may appear inverted regarding the articulators in which the lower incisors touch the upper lip when producing the sounds /f/ and /v/ [13].

The fricative sounds are the most described ones in literature as being altered in people with DFD[9,16,18,19]. For this reason, this research sought to contemplate the investigation of these sounds.

The production of fricative sounds is characterized by friction, duration, intensity and form of articulation. The air friction is generated by narrowing the articulators throughout the vocal tract, from the glottis, passing through the palate, tongue, teeth and getting to the lips. In Brazilian Portuguese, there are three places of articulation for producing fricative sounds: labiodental (/f v/), alveolar (/s z/) and postalveolar (/ʃ ʒ/), with opposite phonological voicing: voiced and voiceless[7,8].

The duration of friction in posterior fricatives (/ʃ ʒ/) is longer than in medial fricatives, while the anterior is shortest of all. Literature[6,7] points to acoustic difference in relation to the sonority trait, as the voiceless are 40 ms longer, in average, than the voiced. This happens because the voiceless fricatives are produced only by the action of frictional source, whereas the voiced ones join the efforts of glottal source to a frictional source.

The fricative sounds also have as a characteristic being the weakest sound of Brazilian Portuguese, i.e., the sounds with less intensity, being the voiceless stronger or more intense than the voiced ones. This is so because in the voiced, in order to keep its voicing, a drop of transglottal pressure is generated, losing the strength of glottal closure[6,7].

As to form of articulation in producing fricative sounds, one articulator is considered active and another, passive[9]. In the fricatives /s z/, which are alveolar, the active articulator is the tip of the tongue, and the passive articulator is the lower alveolar ridge. In the fricatives /f v/, which are labiodental, the active articulator is the lower lip, and the passive are the upper incisors. In the postalveolar fricatives /ʃ ʒ/, the active articulator is the anterior part of the tongue, and the passive is the central part of the hard palate[20,21].

The production of fricative sounds is also articulated in conjunction with the previous and posterior vowels, making it possible to analyze them acoustically. This coproduction changes the vocal tract, at the left margin of the following vowel and at the right margin of the vowel preceding the fricative sound, which may be observed by the acoustic signal in the movement of the formants. Thus, there are in the vowels acoustic hints of the fricative consonants, for they are changed by the place of articulation of the preceding and following sound[8].

There are few studies that used acoustic analysis to verify the speech in people with DFD. Lee[21] used it to complement the perceptive judgement of the production of the fricative /s/ before and after surgery, whereas Prado[10] sought to verify the relation between oral motor control and orofacial functions using acoustic analysis to investigate instability parameters in diadochokinesis.

Based on these facts, this research sought to analyze the possible interference of the position of the osseous bases in articulating fricative sounds in speech. Aiming at this, the following research hypotheses were developed:

People with DFD present difference in performing the duration of alveolar (/s z/), labiodental (/f v/) and postalveolar (/ʃ ʒ/) fricatives, and such difference is related to the configuration of the altered vocal tract, when compared to people without DFD.

People with DFD present difference in performing the intensity of alveolar (/s z/), labiodental (/f v/) and postalveolar (/ʃ ʒ/) fricatives, and such difference is related to the configuration of the altered vocal tract, when compared to people without DFD.

People with DFD present differences in the configuration of the vocal tract when performing the alveolar (/s z/), labiodental (/f v/) and postalveolar (/ʃ ʒ/) fricatives, related to the first formant (F1) of the stressed vowel "a" subsequent to the fricative sounds, when compared to people without DFD.

People with DFD present differences in the configuration of the vocal tract when performing alveolar (/s z/), labiodental (/f v/) and postalveolar (/ʃ ʒ/) fricatives, related to the second formant (F2) of the stressed vowel "a" subsequent to the fricative sounds, when compared to people without DFD.

The acoustic analysis of speech sounds is able to detect possible interferences caused by the variations in the osseous bases of people with DFD, when compared to people without DFD.

Hence, this study had the objective of verifying the characteristics of speech regarding the production of fricative sounds in people with dentofacial deformities by means of the acoustic analysis, seeking to analyze possible interferences of the variations in the osseous bases in articulating speech. This study aimed to contribute in understanding possible adaptations made in these cases and, thus, to define which is the best clinical procedure and prognostic.

METHODS

This is a comparative cross-sectional study, previously approved by the Research Ethics Committee of the Pontifical Catholic University of São Paulo - PUC-SP, CAAE 57943016.7.0000.5482, protocol: 1.676.819, carried out after pertinent ethical processes. All the participants (or the ones responsible for them), signed an Informed Consent Form.

Fifteen adults of both genders participated in this study, averaging 29.6 years of age, the youngest being 17, and the oldest, 42 years old.

The group being researched (GR) was composed of 10 people - 6 women and 4 men - 5 of which with skeletal Class II pattern (GII), and 5 with skeletal Class III pattern (GIII), who had been submitted to orthodontic documentation and complementary exams (cone beam computed tomography), to verify the maxillomandibular discrepancy. The subjects were enrolled spontaneously after referral by an oral and maxillofacial surgeon for speech-language-hearing evaluation in a speech-language-hearing clinic.

The inclusion criteria for the GR were: presenting DFD with finished orthodontic preparation, having immediate indication for orthognathic surgery, carrying out all the steps proposed for this research.

The control group (CG) was composed of 5 people - 3 women and 2 men - similar to the GR as to age. Inclusion criteria for the CG were: having dentofacial balance with natural dental elements at least until the second premolars, relation of the dental arches with vertical and horizontal trespass at around 2 or 3 mm, not presenting alterations in the soft tissue that might interfere with speech, not presenting disfluency, not performing switches, omissions or distortions in speech, and having as native and main language the Brazilian Portuguese.

The exclusion criteria were: presenting genetic syndromes or facial deformity secondary to facial trauma; presenting congenital or acquired morphological alteration of temporomandibular joint (TMJ); using removable orthodontic appliance; presenting functioning characteristics of chronic mouth breathing; having previously undergone orofacial and/or orthognathic surgery; presenting neurological and/or cognitive deficits.

All the participants were submitted to orofacial myofunctional clinical evaluation by a skilled speech-language-hearing therapist, with the purpose of investigating whether the participants met the inclusion and exclusion criteria adopted for this research. The clinic where they were evaluated used its own specific protocol: dental and skeletal occlusal pattern (Angle classification and facial pattern), measures of anterior dental-skeletal relation (overbite and overjet), and orofacial myofunctional patterns. All the documentation was recorded and photographed so that revision and verification of the data bank would be possible, as well as the image complementary exams regarding the presence or absence of DFD.

Acoustic analysis

The equipment used for recording the data was: Notebook Win brand CCE, model H125 with Processor Intel® Pentium™, Windows 8, HD of 500GB, Realtek onboard sound card model High Definition. The unidirectional headset and microphone model PC VoIP SHM1500 brand Philips were used, with frequency response of 20-15k Hz phone, phone impedance 32 Ohm, and maximum entry power of 100 mW; dynamic microphone with sensibility of 20-11,000 Hz, -42+/-3db Connectivity.

The program used for recording was the PRAAT version 5.3.14, developed by the linguists Paul Boersma e David Weenink, of the Phonetics Department of the University of Amsterdam, freely acquired through the website: http://www.fonologia.org/acustica_softwares_praat.php. The collected audios were saved and stored on the Google Drive cloud system.

For the data recording procedure, the following criteria were employed: The samples were recorded in single-channel on the wav format, with minimum frequency of 30Hz, and maximum of 24,000Hz to capture the frequency of the fricatives, since they are higher. The microphone was positioned at a fixed distance from the mouth, by the speaker's right lip commissure (between 10 and 15 cm) to avoid sound distortion from being excessively close to the microphone. All the samples were recorded in a silent room, by at least two speech-language-hearing therapists specialized in this field.

The corpus used for the analysis was composed of six words (logatomes) of Brazilian Portuguese (BP), obeying the following pattern: the participant was asked to read six words characterized as key words for the interest phonemes of the Brazilian Portuguese: *sassa*, *zaza*, *fafa*, *vava*, *xaxa* and *jaja*, inserted into the vehicle sentence "say (key word) low", stressing the first syllable of the word. After presenting the model, the participant was instructed to say each sentence at a time, continuously, without pausing in-between words, at the usual tone and intensity, starting after the command of the researcher.

Analysis of the acoustic data

The audio signals were analyzed by means of the PRAAT software, using the broadband spectrum and following these parameters: the stressed syllables of the words were segmented and used. The duration of the fricative sound was defined manually, observing the characteristics of the acoustic wave, marking the beginning of the fricative sound (wave peak) and continuing until its modification, transitioning from consonant to vowel. The measurements were taken automatically by the program itself. After the duration was defined, the intensity of the fricative sounds was also automatically measured by the program. For measuring the formants, the vowel succeeding the fricative of the stressed syllable was analyzed, looking for the stationary point of the vowel "a" for the automatic measurement of F1 and F2 by the program. The data acquired from the formants were normalized by Lobanov method through the website: http://lingtools.uoregon.edu/norm/norm1.php. This normalization is considered fundamental for the comparison between distinct speakers, as it minimizes the differences in vocal tract size of each one of them[7].

In order to verify whether people with DFD present differences in performing alveolar (/s z/), labiodental (/f v/) e postalveolar (/ʃ ʒ/) fricatives, measurements were taken, and the following variables of interest were analyzed: duration; intensity; formants F1 and F2 of the vowels succeeding the fricative sounds, in order to verify the characteristics of the vocal tract presented by people with DFD, when compared to the CG.

Aiming at analyzing possible interferences according to the type of DFD, the analyses of data were carried out considering: GII: subjects with DFD of the skeletal Class II pattern type; GIII: subjects with DFD of the skeletal Class III pattern type; CG: control group whose subjects didn't have DFD.

To investigate the differences between the groups regarding acoustic characteristics of speech, each variable was analyzed for the three groups, looking for the existence of statistical difference.

The statistical analysis used was the non-parametric Mann-Whitney test, used in small samples when the samples are independent for the comparison of variables two by two. The median was also used as central tendency measure. To obtain the result of each comparison, the p-value$<$0.05 (5%) was used.

RESULTS

Fifteen adults of both genders took part in this study, averaging 29.6 years of age, the youngest being 17, and the oldest, 42 years old.

Based on the collected data, the results referring to the comparison between the groups analyzed: GII, GIII and CG, with analyses (Mann-Whitney test) in each one of the stressed syllables for the acoustic variables studied are found on Tables 1 to 4.

The data referring to the analyses concerning duration (in ms) in performing the alveolar (/s z/), labiodental (/f v/) and postalveolar (/ʃ ʒ/) fricatives are found on Table 1. The statistical analysis showed significant difference in the comparison of the duration of voiced fricative sounds /z/, with longer duration for GIII, when compared to CG, and tending to significance in /ʒ/ (Table 1). It can be verified, in general, that the duration of all sounds in GII and GIII was longer than that of the CG, except for the fricative sound /f/. The voiceless sounds were presented with longer duration than the voiced ones in all groups.

Table 1. Analysis of the duration of fricatives (in ms) when performing alveolar (/s z/), labiodental (/f v/) and postalveolar (/ʃ ʒ/) fricatives, in stressed syllable, in the three groups studied.

Duration (ms)		Median	Min	Max	Standard deviation	N	CI	P-value
/S/ (SAssa)	CG	163.0	153.0	184.0	22.3	5	19.5	- x -
	GII	183.0	148.0	196.0	19.1	5	16.8	0.251
	GIII	175.0	144.0	211.0	25.3	5	22.2	0.347
/Z/ (ZAza)	CG	111.0	83.0	123.0	15.2	5	13.3	- x -
	GII	125.0	82.0	148.0	26.8	5	23.5	0.347
	GIII	135.0	122.0	174.0	20.5	5	18.0	0.016*
/F/ (FAfa)	CG	172.0	124.0	204.0	32.5	5	28.4	- x -
	GII	163.0	136.0	198.0	23.0	5	20.2	0.917
	GIII	125.0	121.0	165.0	18.8	5	16.5	0.117
/V/ (VAva)	CG	113.0	80.0	128.0	17.6	5	15.5	- x -
	GII	109.0	95.0	144.0	19.4	5	17.0	1.000
	GIII	120.0	86.0	190.0	40.5	5	35.5	0.602
/ ʃ / (XAxa)	CG	161.0	124.0	203.0	30.2	5	26.5	- x -
	GII	178.0	145.0	200.0	25.1	5	22.0	0.917
	GIII	167.0	144.0	190.0	16.8	5	14.7	0.917
/ʒA/ (JAja)	CG	106.0	92.0	139.0	17.7	5	15.5	- x -
	GII	128.0	94.0	167.0	30.2	5	26.5	0.602
	GIII	132.0	118.0	144.0	10.3	5	9.0	0.076**

Key: CI: confidence Interval; *statistically significant p-value; **p-value close to the statistically significant, indicating statistical tendency (Mann-Whitney test).

The data referring to the analyses regarding the intensity (in dB) when performing alveolar (/s z/), labiodentals (/f v/) and postalveolar (/ʃ ʒ/) fricatives in stressed syllable are found on Table 2. The parameter intensity showed significant differences between the groups with DFD in relation to the CG, with higher intensity for GII in the fricative /z/ and for GIII for /f/, /v/, /ʃ/. However, for all sounds analyzed, GII and GIII obtained very similar intensity averages. The presence of significant differences and statistical tendencies to significance appear reflected by the characterization of the standard deviation and confidence interval.

Table 2. Analysis of the intensity of the fricative (in dB) when performing alveolar (/s z/), labiodental (/f v/) and postalveolar (/ʃ ʒ/) fricatives, in stressed syllable, in the three groups studied

Intensity (dB)		Median	Min	Max	Standard deviation	N	CI	P-value
/S/ (SAssa)	GC	61.0	37.0	72.0	12.8	5	11.2	- x -
	GII	68.0	65.0	75.0	3.8	5	3.3	0.075**
	GIII	65.0	61.0	82.0	8.7	5	7.6	0.072**
/Z/ (ZAza)	GC	59.0	41.0	65.0	9.1	5	8.0	- x -
	GII	67.0	61.0	73.0	4.5	5	3.9	0.028*
	GIII	65.0	58.0	77.0	8.4	5	7.4	0.140
/F/ (FAfa)	GC	57.0	34.0	61.0	11.3	5	9.9	- x -
	GII	70.0	57.0	75.0	8.3	5	7.3	0.093**
	GIII	65.0	59.0	75.0	6.1	5	5.3	0.028*
/V/ (VAva)	GC	54.0	37.0	63.0	9.6	5	8.4	- x -
	GII	67.0	53.0	71.0	7.0	5	6.1	0.075**
	GIII	65.0	57.0	77.0	8.3	5	7.3	0.028*
/ ʃ / (XAxa)	GC	68.0	47.0	75.0	11.0	5	9.6	- x -
	GII	79.0	68.0	83.0	6.0	5	5.3	0.059**
	GIII	76.0	72.0	83.0	4.2	5	3.7	0.036*
/ʒ/ (JAja)	GC	66.0	43.0	72.0	11.2	5	9.8	- x -
	GII	71.0	62.0	83.0	8.8	5	7.7	0.251
	GIII	72.0	65.0	84.0	7.1	5	6.2	0.094**

Key: CI: confidence Interval; *statistically significant p-value; **p-value close to the statistically significant, indicating statistical tendency (Mann-Whitney test).

The data referring to the analyses concerning the first formant (F1) (in Hz) of the vowel "a" in performing alveolar (/s z/), labiodental (/f v/) and postalveolar (/ʃ ʒ/) fricatives are found on Table 3. Significant difference for GII was found in the syllable [za], in that F1 appears more elevated in relation to CG. The F1 of syllable [va] appears more elevated and tending to significance in GIII. In syllable [xa], the tendency to significance occurred in both groups (GII and GIII), in which F1 appears with lower frequency in relation to CG.

The date referring to the analyses regarding the second formant (F2) (in Hz) of the vowel "a" in performing alveolar (/s z/), labiodental (/f v/) and postal-veolar (/ʃ ʒ/) fricatives are found on Table 4. Significant result was found only in the syllable [ʒa] for GII, and tendency to significance in GIII, in which F2 appears with lower frequencies in relation to CG.

Table 3. Analysis of the values of F1, of the vowel "a" in stressed position, when performing alveolar (/s z/), labiodental (/f v/) and postalveolar (/ʃ ʒ/) fricatives in the three groups studied

F1 (Hz) In		Median	Min	Max	Standard deviation	N	CI	P-value
[SA] (SAssa)	GC	518.7	503.6	556.3	20.1	5	17.6	- x -
	GII	456.3	368.4	574.2	80.6	5	70.6	0.117
	GIII	504.6	444.4	550.5	44.9	5	39.4	0.175
[ZA] (ZAza)	GC	317.3	284.9	419.3	54.5	5	47.8	- x -
	GII	394.0	374.5	467.0	41.2	5	36.1	0.047*
	GIII	315.4	293.2	367.4	33.6	5	29.5	0.754
[FA] (FAfa)	GC	548.2	483.6	640.2	60.6	5	53.1	- x -
	GII	531.1	414.6	687.1	102.8	5	90.1	0.602
	GIII	554.2	508.1	678.0	69.1	5	60.6	0.754
[VA] (VAva)	GC	416.1	383.1	510.8	48.7	5	42.7	- x -
	GII	459.6	365.1	506.2	54.4	5	47.7	0.602
	GIII	456.4	417.5	610.5	79.4	5	69.6	0.076**
[XA] (XAxa)	GC	526.8	523.1	635.9	48.2	5	42.3	- x -
	GII	482.6	398.7	602.0	73.7	5	64.6	0.076**
	GIII	478.5	423.5	556.2	62.6	5	54.8	0.076**
[JÁ] (JAja)	GC	345.5	250.0	380.4	57.7	5	50.6	- x -
	GII	297.9	252.7	437.0	69.4	5	60.8	0.917
	GIII	355.6	274.6	455.0	79.0	5	69.3	0.465

Key: CI: confidence Interval; *statistically significant p-value; **p-value close to the statistically significant, indicating statistical tendency (Mann-Whitney test).

Table 4. Analysis of the values of F2, of the vowel "a" in stressed position, when performing alveolar (/s z/), labiodental (/f v/) and postalveolar (/ʃ ʒ/) fricatives in the three groups studied

F2 (Hz) In		Median	Min	Max	Standard deviation	N	CI	P-value
[SA] (SAssa)	GC	1,392.2	1,239.0	1,551.4	114.4	5	100.3	- x -
	GII	1,408.8	992.9	1,627.4	240.5	5	210.8	0.754
	GIII	1,392.2	1,350.8	1,578.5	89.2	5	78.2	0.834
[ZA] (ZAza)	GC	1,512.4	1,398.5	1,710.2	114.9	5	100.7	- x -
	GII	1,464.1	1,375.9	1,693.6	132.9	5	116.5	0.465
	GIII	1,431.7	1,193.7	1,622.3	158.5	5	138.9	0.465
[FA] (FAfa)	GC	1,111.3	990.5	1,354.1	149.9	5	131.3	- x -
	GII	1,113.9	908.9	1,714.2	340.8	5	298.8	1.000
	GIII	969.6	919.2	1,410.0	207.7	5	182.1	0.251
[VA] (VAva)	GC	1,103.4	861.8	1,143.2	114.0	5	99.9	- x -
	GII	1,044.8	871.7	1,261.1	149.1	5	130.7	0.917
	GIII	950.0	925.5	1,050.3	62.7	5	55.0	0.117
[XA] (XAxa)	GC	1,678.2	1,605.4	2,010.5	163.9	5	143.6	- x -
	GII	1,791.8	1,483.1	1,914.1	199.8	5	175.2	0.754
	GIII	1,705.7	1,583.1	1,875.8	106.6	5	93.4	0.917
[JA] (JAja)	GC	2,030.4	1,976.0	2,097.5	47.6	5	41.7	- x -
	GII	1,759.2	1,726.5	2,048.2	132.7	5	116.3	0.047*
	GIII	1,914.1	1,907.5	2,054.6	63.2	5	55.4	0.076**

Key: CI: confidence Interval; *statistically significant p-value; **p-value close to the statistically significant, indicating statistical tendency (Mann-Whitney test).

DISCUSSION

This research had the purpose of verifying acoustically speech modifications in people with DFD already described in literature, and contribute to broadening the understanding of changes that may occur in speech as a result of structural modification of the vocal tract and adaptation due to vocal adjustments.

In literature, there are references to acoustic changes related to the speech of people with Class II and Class III[10,21]. The changes described are related to the acoustic parameters regarding the duration of the fricative, intensity and formants of the vowels which analyze the position of the tongue and the movement of the jaw[10,16,17,22]. The acoustic analysis aids in the comprehension of articulatory adjustments modifications of people with DFD[21], as it has been carried out in this study.

Regarding the duration of the sounds, it was noted that GIII presented longer duration in the alveolar /z/ and postalveolar /ʒ/ fricative sounds, when compared to the CG, indicating difference in performing these sounds. Literature points out that the duration of the friction is related to the place where the sound is articulated, as the central and the posterior last longer[6,7]. It was noted that in Class III DFD, due to anteroposterior discrepancy, more airflow may escape by reducing friction especially in these fricatives, creating the need of adapting the position of the tongue to block the escape[1,9,10] and possibly leading to a longer duration.

In general terms, more duration in the voiceless fricatives /f/, /s/, /ʃ/ was found in this study for the three groups analyzed, in agreement with what is found in literature, which defines these sounds as the longest lasting in relation to the voiced ones[6,7].

Concerning the variable intensity, it seems interesting to observe that, for all sounds analyzed, the CG always had sound intensity averages lower than GII and GIII, in which the resulting average of intensity were found to be very similar. In general terms, it may be inferred that there's a greater speech effort on the part of the groups with DFD, in view of the disharmony of the maxillomandibular relation[13,23]. The necessary adjustments as a consequence of the discrepancy of the osseous bases may demand more effort and airflow and thus increase the intensity of the sounds.

Nonetheless, statistically significant differences appear only for one or the other type of DFD, when compared to the CG, even though several results with statistical tendency to the presence of differences occur. These situations may perhaps be explained by the characterization of the standard deviation and confidence interval observed especially for the CG.

More intensity was found for GII in relation to the CG only in the sound /z/ and tendency to difference in the sound /ʃ/. This datum may be associated to the need to protrude the jawbone, broadening the space to organize the tongue, enabling the organization of the airflow[9,12,13], leading to the intensification of the sound.

More intensity was also verified in GIII in relation to the CG in the sounds /f/, /v/, /ʃ/. The anteroposterior modification of the osseous bases, as in GIII, with negative dental-skeletal overjet, leads to the need of modifying the position of articulators in which the lower incisors touch the upper lip, inverting the articulatory point as described in literature[11,13,24], possibly causing more intensity.

As to the analysis referring to the formant F1, significant difference was found in GII in the syllable [za], in which F1 appears more elevated in relation to the CG. Considering that the formant F1 is influenced by the height of the tongue and opening of the jaw, and that the production of the syllable [za] is performed by the active articulator (tip of the tongue) touching the passive (lower alveolar ridge), a low-value production of F1 would be generated[20,21], as observed in the CG. Since the formant F1 is also related to the opening or closing of the jaw[6,7], the results in GII suggest a bigger opening of the mouth in order to produce this sound, thus possibly interposing the tongue between the teeth[6,7,25]. Hence, such result confirms the need for adjustment of the position of tongue and jaw in GIII, agreeing with literature concerning the functional characterization of speech in these cases[9,13,17,19,23].

The analyses of the formant F1 show tendency to significant difference in the syllable [va], which appears more elevated in GIII in relation to the CG. In the syllable [xa], the tendency to significance occurs in both groups (GII and GIII), as F1 appear with lower frequency in relation to the CG. In the people with skeletal Class III pattern, in which the jawbone is situated more towards the front in relation to the maxilla, the articulation of the [va] may be impaired by the inversion of articulators and closing of the jaw. In these people, the tongue is in a lower position in the front, which may justify the value of F1 in these two sounds in GIII[1,10,13].

Regarding the analyses of the formant F2, only lower frequency in the syllable [ja] was found in GII, when compared to the CG, indicating that the tongue is positioned more towards the back. It's believed that this finding results from the less anteroposterior space in the lower part[1,9,13,19]. There was also found a tendency to difference in GIII compared to CG in the same sound. It's suggested that people with DFD perform articulatory adjustments seeking to adapt the configuration and size of their vocal tract to produce certain sounds. This is in agreement with literature, which points to the articulatory production of these sounds more towards the back of the oral cavity[1,9-12].

A fact to be highlighted concerning the results of this study refers to the standard deviation observed. Particularly in syllable [ja], the standard deviations for the groups with DFD were greater than those obtained for the CG, being that the significant difference regarding the variable F2 appears in the comparison of GII with CG, even with GII being more dispersed around the average.

An important point to comment refers to the limitation of this study concerning the number of subjects. In this study, the number of subjects was reduced because of the intention of standardizing the sample, especially the subjects with DFD, in regard to possible discrepancies of the vertical patterns, trying to avoid predispositions as to the interference of this characterization combined with anteroposterior bone discrepancies (skeletal Class II and III patterns).

In general terms, another important item to be mentioned as a possible limitation of this study refers to the big standard deviation found in some of the analyses, which would justify the predominance of tendencies to significance. It may be inferred that a larger amount of subjects in future studies, maintaining the rigor in selecting the sample, may bring a larger number of significant results.

CONCLUSION

This research was able to verify the characteristics of speech in producing fricative sounds in people with DFD by means of acoustic analysis.

For the skeletal Class II dentofacial deformity, more intensity was found in the fricative sound /z/, higher values in F1 in the syllable [za] and lower values in F2 in syllable [ja].

For the skeletal Class III dentofacial deformity, longer duration of the fricative sound /z/ was found, as well as more intensity in the sounds /f/ /v/ e /ʃ/.

The present study concludes that there is interference in the acoustic characteristics of speech, regarding the fricative sounds, when the osseous bases are not in harmony. The types of adaptations associated with the dental-skeletal deformities were described, contributing to a better understanding of speech production of the fricative sounds in Brazilian Portuguese in these cases.

REFERENCES

1. Farias BUL, Bianchini EMG, Paiva JB, Rino Neto J. Muscular activity in class III dentofacial deformity. Cranio. 2013;31(3):181-9.
2. Barbarena LS, Keske-Soares M, Berti LC. Description of the articulatory gestures concerned in the production of the sounds /r/ and /l/. Audiol. Commun. Res. 2014;19(4):338-44.
3. Bogon J, Eisenbarth H, Landgraf S, Dreisbach G. Shielding voices: the modulation of binding processes between voice features and response features by task representations. QJEP. 2017;70(9):1856-66.
4. Oliveira RC, Teixeira LC, Gama ACC, Medeiros AM. Análise perceptivo-auditiva, acústica e autopercepção vocal em crianças. J Soc Bras Fonoaudiol. 2011;3(2):158-63.
5. Mendes AP, Ferreira LJL, Castro E. Softwares e hardwares de análise acústica da voz e da fala. Distúrb. Comum. 2012;24(3):421-30.
6. Behlau M. Voz – O livro do especialista. 3ed. São Paulo: Revinter, 2013.
7. Barbosa P, Madureira S. Manual de fonética acústica experimental: aplicação a dados do português. São Paulo, Cortez, 2015.
8. Costa-Guarisco LP, Fraga FJ, Iório MCM. Fricative Phonemes Identification Index: proposal for frequency compression evaluation. Audiol. Commun Res. 2016;21:e1728.
9. Pereira JBA, Bianchini EMG. Caracterização das funções estomatognáticas e disfunções temporomandibulares pré e pós cirurgia ortognática e reabilitação fonoaudiológica da deformidade dentofacial classe II esquelética. Rev. CEFAC. 2011;13(6):1086-94.
10. Prado DGA, Sovinski SRP, Nary-Filho H, Brasolotto AG, Berretin-Félix G. Oral motor controland orofacial functions in individuals with dentofacial deformity. Audiol. Commun Res. 2015;20(1):76-83.
11. Lima JAS, Luna AHB, Pessoa LSF, Alves GAS. Functional gains measured by MBGR and impact on quality of life in subject submitted to orthognathic surgery: case report. Rev. CEFAC. 2015;17(5):1722-30.

12. Trench JA, Araújo RPC. Dentofacial deformities: orofacial myofunctional ,characteristics. Rev. CEFAC. 2015;17(4):1202-14.
13. Leavy KM, Cisneros GJ, LeBlanc EM. Malocclusion and its relationship to speech sound production: Redefining the effect of malocclusal traits on sound production. Am J Orthod Dentofacial Orthop. 2016;150(1):116-23.
14. Dantas JFC, Neto JNN, De Carvalho SHG, Martins IMCLD, De Souza RF, Sarmento VA. Satisfaction of skeletal class III patients treated with different types of orthognathic surgery. Int J of Oral Maxillofac. Surg. 2015;44(2):195-202.
15. Torres KV, Pessoa LS, Luna AHB, Alves GAS. Quality of life after orthognathic surgery: a case report. Rev. CEFAC. 2017;19(5):733-9.
16. Migliorucci RR, Sovinski SRP, Passos DCBOF, Bucci AC, Salgado MH, Nary Filho H et al. Orofacial functions and quality of life in oral health in subjects with dentofacial deformity. CoDAS. 2015;27(3):255-9.
17. Ahn J, Kim G, Kim YHb, Hong J. Acoustic analysis of vowel sounds before and after orthognathic surgery. J Craniomaxillofac Surg. 2015;43(1):11-6.
18. Martinelli RLC, Fornaro EF, Oliveira CJM, Ferreira LMB, Rehder MIBC. Correlações entre alterações de fala, respiração oral, dentição e oclusão. Rev. CEFAC. 2011;13(1):17-26.
19. Jesus LM, Araujo A, Costa IM. Speech production in two occlusal classes. Onomázein. 2014;29(12):129-51.
20. Bassi A, Seara IC. A produção das fricativas alveolar, ápico-alveolar e palato-alveolar em de coda silábica no PB e no PE. Letras de Hoje. 2017;52(1):77-86.
21. Silva TC. Fonética e fonologia do português: roteiro de estudos e guia de exercícios. 10 ed. São Paulo, Contexto, 2010.
22. Lee ASY, Whitehill TL, Ciocca V, Samman N. Acoustic and perceptual analysis of the sibilant sound /s/ before and after orthognathic surgery. J Oral Maxillofac. Surg. 2002;60(4):364-72.
23. Mezzomo CL, Machado PG, Pacheco AB, Gonçalves BFT, Hoffmann CF. As implicações da classe II de Angle e da desproporção esquelética tipo classe II no aspecto miofuncional. Rev. CEFAC. 2011;13(4):728-34.
24. Gallerano G, Ruoppolo G, Silvestri A. Myofunctional and speech rehabilitation after orthodontic-surgical treatment of dento-maxillofacial dysgnathia. Prog. Orthod. 2011;13(1):57-68.
25. Meireles AR, Gambarini VP, Scherre MMP. Análise acústica e sociolinguística das vogais médias pretônicas faladas em Montanha – ES. Letras de Hoje. 2017;52(1):58-67.