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An investigation of speech sounds of patients applied to orthodontics clinic

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Abstract

The aim of this study is to determine the sound characteristics of speech sounds of patients applied to orthodontics clinic to understand how speech will be affected after orthodontic treatment. The study included 60 patients (35 females, 25 males; 13.60±2.35 years) Fricatives (/f/, /s/, /ş/) were selected for spectral center of gravity analysis. Sounds were examined under four groups: syllable-initial, syllable-final, /a/ context and /i/ context. The Shapiro Wilk test and Mann-Whitney U-test, were used for statistical evaluations. There was a statistically significant difference between syllable-initial and syllable-final measurements of /f/ sound (p=0.008). There was a significant effect of gender in all groups of /s/ sound and syllable-initial group of /ş/ sound (p<0.05). In conclusion, vowel environments and different positions within a word can affect the center of gravity of fricatives.

Keywords: Speech sounds, speech acoustics, orthodontics

Introduction

Speech, consists of sounds coming into play through the interaction of articulator and phonetic systems, is the most commonly used form of communication [1]. Speech sounds are formed at the speech articulation stage generated through breathing, phonation, resonance and articulation and dynamic movement of the tongue, lips, and teeth, resulting in partial or complete closure of the airway. Among the causes of speech disorders are articulation disorders, which accounts for 50%- 60% of cases [2].

Speech sounds are divided into two categories, vowels and consonants. There are about 200 different vowels and more than 600 consonant voices in languages used by the communities [3]. While the consonants are produced, the airstream is interrupted, either partially or completely in the vocal tract. In contrast, while the vowels are produced, the airstream is unobstructed in any way [4].

Spoken language, structural characteristics of language, characteristics of sounds in the language, speech characteristics of person, structural status of the vocal tract and sound quality can change the acoustic characteristics of voices. Thus, it is possible to determine the acoustical properties of the sound system [5]. In many acoustic studies, spectral moment measurements were used for analyzing fricatives [6-9]. Also, it is stated that the spectral center of gravity values, one of the spectral moments, has a descriptive attribute [6,7]. It is quite important to determine and know the sound characteristics of spoken language. If the language features are unknown, it will not be possible to predict which differences may lead to language and speech problems.

Nowadays computer-aided sound analysis programs are more preferred in sound analysis studies because they are objective, convenient, and repeatable. In this study, computer-aided sound analysis programs were used to determine the acoustic properties of Turkish fricatives (/f/, /s/, /ş/) and investigated whether the spectral center of gravity values differed according to vowel environment and syllable position.

Material and Methods

G*Power software version 3.1.2 (Franz Faul, Kiel University, Kiel, Germany) was used to determine the number of individuals to be included in the study. We determined that a total of 60 patients would be sufficient for a study with a significance level of 0.05, the statistical power of 0.80 and an impact size of 0.83.

Our study included 60 patients (35 female, 25 male, 13.60 ± 2.35 years) who applied to the Orthodontics Department of Gaziantep

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University Dentistry Faculty. Included patients were native Turkish speakers, and they had no speech or hearing problems. Exclusion criteria were having hearing loss or ear pathology, having a respiratory or neurologic disease and having congenital anomalies such as cleft lip and palate or those linked to the stomatognathic system. Approval was received from Gaziantep University Clinical Trials Ethics Committee for our study with decision no. 2016/322 dated 28/12/2016. Informed consent was obtained in writing from each patient and their guardians.

The sound recording procedure was performed in a soundproof dedicated sound recording room with acoustic insulation and a noise level of less than 30 dB. For this purpose, a desktop computer with an external sound card and a condenser microphone positioned 10 cm away from the patient were used. Using the Audacity program (version 2.0.5, http://audacity.sourceforge.net/) for audio recording, the sounds were recorded at a sampling rate of 44100 Hz and at a 16-bit quantization level, in mono, and in ".wav" format. Fricatives (/f/, /s/, /ş/) were selected for investigation. Sounds were examined under four groups: syllable-initial, syllable-final, /a/ context and /i/ context. The sounds were placed within a carrier sentence such as 'Mehmet …… said'. Table 1 shows the words used in our study. In the study, 720 sound data (3 fricatives x 2 positions x 2 vowels x 60 samples) were examined. Acoustic analysis was performed using the PRAAT program (version 5.3.57 Paul Boersma; David Weenink www.praat.org). The onset and offset of the fricative segmentation were conducted based on a visual inspection of the waveform and spectrogram. The point at which high-frequency energy first appeared and/or rapid increase in zero-crossings characterized the fricative onset. The fricative offset was defined prior to the onset of the vowel periodicity and/or absence of high-frequency energy. After segmentation, the spectral center of gravity (cog) was examined at the midpoint of the segment.

The compliance of the data with normal distribution was tested with the Shapiro Wilk test, and the Mann Whitney U test was used in the comparison of the characteristics without normal distribution in 2 independent groups. The consistency between measurements taken at different intervals was tested with the intraclass correlation coefficient. SPSS for Windows version 22.0 software package was used for statistical analyses and $p< 0.05$ was considered statistically significant.

Twenty sound recordings were randomly selected and reassessed by the same investigator (GBB) to rule out any measurement error. The consistency between measurements was tested with the intraclass correlation coefficient. The coefficients of reliability varied from 0.86 to 0.99. The results showed that the repeated measurements were reproducible and reliable.

Results

There was a statistically significant difference between syllable-initial and syllable-final measurements of /f/ sound ($p=0.008$). There were no statistically significant differences between syllable-initial and syllable-final measurements of /s/ and /ş/ sounds and different vowel environments values of all sounds ($p>0.05$) (Table 2). There was a significant effect of gender in all groups of /s/ sound and syllable-initial group of /ş/ sound ($p<0.05$) (Table 3).

Table 1. List of words used in the study

Fricatives		
/f/	**/s/**	**/ş/**
fal	saf	şak
saf	yas	kaş
fil	sim	şirk
lif	mis	diş

Table 2. Comparison of the groups in different vowel environments and different positions

Fricatives	Syllable-initial Mean ±SD	Syllable- final Mean ±SD	p	/a/ context Mean ±SD	/i/ context Mean ±SD	p
f	5764±2855	4784±2790	0.008	5080±2954	5468±2760	0.316
s	9152±1447	8820±1551	0.117	8906±1464	9065±1550	0.362
ş	5383±909	5400±971	0.732	5391±946	5392±936	0.835

*Mann-Whitney U Test; p<0.05; SD: Standard deviation

Table 3. Comparison of the groups between the genders

Fricatives	Groups	Female	male	p
		Mean ±SD	Mean ±SD	
f	Syllable-initial	6108±2625	5518±3003	0.338
	Syllable- final	5060±2917	4585±2699	0.431
	/a/ context	5498±2859	4781±3006	0.217
	/i/ context	5670±2787	5323±2750	0.523
s	Syllable-initial	9789±1221	8259±1263	0.001
	Syllable- final	9378±1396	8038±1423	0.001
	/a/ context	9479±1307	8103±1292	0.001
	/i/ context	9688±1340	8193±1405	0.001
ş	Syllable-initial	5583±976	5085±717	0.004
	Syllable- final	5534±1097	5211±732	0.088
	/a/ context	5606±1013	5090±753	0.115
	/i/ context	5510±1061	5209±694	0.082

*Mann-Whitney U Test; p<0.05; SD: Standard deviation

Discussion

One method of determining the properties of the fricatives is to examine the spectral center of gravity. The average energy distribution from any point (beginning, middle, and end) of the fricative sound shows the spectral center of gravity value [10]. The fricative spectrum is dependent on the size of the oral cavity, and if a difference occurs in the narrowing area, a change occurs in the average distribution in the spectrum of the fricative [11]. In this study, the spectral center of gravity value of /s/ is higher than /ş/ (Table 2). There are also many studies indicated that the spectral center of gravity values of /s/ sound is higher than /ş/ sound [12-14]. Sounds' place of articulation can explain this situation. /ş/ is produced with a more posterior place of articulation than /s/ and consequently the front oral cavity is longer. For this reason, /ş/ has lower resonant frequencies.

In our groups, each fricative occurred in different vowel environments and different positions within a word [15]. Therefore, this changes the speaking effort. The spectral center of gravity varies not only with front oral cavity size but also changes in speaking effort. When our groups are evaluated, the cog values in /s/ sound were found to be higher than in /ş/ and /f/ sounds. Similarly, Jongman et al. found that spectral center of gravity was highest for alveolar sounds (for our study /s/) and lowest for postalveolar sounds (/ş/). Additionally, labiodental sounds (/f/) were between them [8]. Ertan reported that /s/ sound has the highest spectral center of gravity values, followed by /ş/ sound, and /f/ sound has the lowest values [9].

The vowel environment is evaluated, and the values of the center of gravity are compared in our study. Tabain stated that any changes in articulation, due to vowel environment, are generally reflected in the spectrum [11]. Oral cavity size is dependent on the vowels. For example, if /s/ sound were produced with rounded vowels, the oral cavity size would increase, and the spectral center of gravity would lower relative to produce with unrounded vowels [16]. Nittrouer reported that the spectral center of gravity values of the front vowel /i/ is higher than the back vowel /a/ [17]. Although our study findings were not statistically significant, /i/ context values of the center of gravity were higher (Table 2).

Nirgianaki evaluated acoustic properties of fricatives and reported that the spectral center of gravity values could be affected by positions of sounds [18]. Ertan investigated the effect of syllables number and position within a word on the center of gravity. She concluded that the center of gravity value was higher in single syllable and syllable-initial position. In addition, the number of syllables did not affect the spectral center of gravity [9]. In our findings, syllable position values of /f/ sound were statistically significant, and syllable-initial values were found higher.

There was a main effect of gender on the spectral center of gravity values. Females have significantly higher values than males. Many researchers also indicated that the center of gravity values of females have higher values [8,12,15]. Higher frequencies in females could originate from smaller vocal tract sizes [15].

In many languages, the speech sounds were examined acoustically [8,9,14,18]. The determined features will form the basis of studies on language and speech disorders. As 80% of specific speech movements occur at the front of the mouth, whether or not speech problems will improve after orthodontic treatment in individuals with speech impairment is an issue of curiosity for both the orthodontist and the patient [19]. It is thought that speech will be positively affected by the correction of the malocclusion. It is important to know the language features to understand how speech will be affected after orthodontic treatment.

Conclusion

In conclusion, the center of gravity of /f/, /s/ and /ş/ sounds can be affected by vowel environments and different positions within a word. It is important to determine the sound characteristics of spoken language to understand how speech will be affected after orthodontic treatment.

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Competing interests
The authors declare that they have no competing interest

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Ethical approval
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