

Research Paper

Acoustic Voice Measures in Benign Mass Lesions



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ABSTRACT

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Objectives: The present study aims to compare acoustic voice parameters in patients with vocal cord nodules, polyps, and normal subjects.

Methods: In this cross-sectional case-control study, the participants were selected by convenience sampling, including 30 patients with vocal polyps for the first group, 38 patients with vocal nodules for the second group, and 42 participants without voice pathologies as the control group. For each group, participants were examined by a speech and language pathologist (SLP) using an Endo-vision laryngoscope. Acoustic voice parameters were measured by MDVP software in Visi-Pitch; then, these parameters were compared in groups in terms of sex.

Results: Three groups showed significant differences in terms of fundamental frequency ($P < 0.001$), jitter ($P < 0.001$), shimmer ($P < 0.001$), and noise-to-harmonic ratio (NHR) values ($P < 0.001$). Women in three groups had the substantial differences in terms of fundamental frequency ($P < 0.001$), jitter ($P < 0.001$), shimmer ($P < 0.001$), and NHR ($P < 0.001$). For men, the three groups showed a significant difference for jitter ($P < 0.001$) and shimmer ($P = 0.001$), but for NHR ($P = 0.024$), and fundamental frequency ($P = 0.93$) no significant difference were observed.

Discussion: It seems that the existence of benign mass lesions, such as vocal cord nodules and polyps affects the acoustic parameters of the voice. The measurement of acoustic voice parameters may help us to differentiate between the voices of normal people and patients with vocal cord nodules and polyps as a supplementary assessment in clinical procedures.

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Highlights

- Acoustic voice parameters were measured and compared in three groups of individuals, including healthy people, patients with vocal nodules, and polyps.
- We measured acoustic voice parameters with MDVP software.
- Acoustic voice parameters were compared in terms of sex.

Plain Language Summary

This research aimed to investigate acoustic voice measures in patients with vocal fold nodules and polyps. Three groups differed in values of acoustic measures consisting of the fundamental frequency, jitter, shimmer, and noise-to-harmonic ratio (NHR). The women obtained different values for acoustic measures in three groups of participants but men differed for jitter and shimmer.

1. Introduction

Polyps and nodules are identified as the most common benign lesions [1] of vocal cords caused by vocal disturbances [2, 3]. The most common clinical symptoms are different degrees of roughness and feeling of a foreign body [4]. These voice pathologies are not life-threatening disorders but may limit communication activities and consequently, voice disorders can affect the quality of life [5]. Therefore, an assessment of different dimensions of voice in these pathologies seems necessary.

The use of specific instruments to investigate voice and its physical parameters is known as acoustic analysis, which comprises an assessment procedure for patients suffering from mass lesions, including polyps and nodules [6]. Acoustic analysis of voice is a non-invasive, quantitative, economical, convenient, and rapid procedure compared to other assessment methods, such as electroglottographic [7] and video-laryngostroboscopic evaluations [8, 9].

The computerized multidimensional acoustic voice analysis enables visual and numerical analysis of the voice samples. Such analysis programs provide objective data and support subjective voice evaluation [2], which helps monitor clinical procedures and compare the results pre and post-intervention in experimental studies. The acoustic parameters measured in the most of studies are fundamental frequency (F_0), amplitude perturbation or shimmer, frequency perturbation or jitter, and noise-to-harmonic ratio (NHR).

In terms of physiological characteristics of vocal folds, F_0 as one of the most important voice parameters for the acoustic voice measures shows the number of vocal cords' cover layer vibrations per second [10]. The intensity corresponding to loudness is the other acoustic voice measure frequently reported in the literature. Jitter and shimmer have been designed to measure two important aspects of acoustic voice parameters in a signal, frequency, and amplitude perturbation, respectively. In terms of physiological characteristics, the rate of perturbation increases with advancing the disturbances of the vocal folds. A close relationship exists between the increase in perturbation and the change in voice quality, such as breathiness and hoarseness [11].

It appears that the existence of vocal cord polyps and nodules contributes to changes in voice quality and acoustic voice parameters. Petrovic-Lazic et al. studied the acoustic voice parameters of patients with vocal fold polyps and healthy individuals using MDVP software. They reported that jitter (%), shimmer (%), and NHR values significantly differentiated the patients with vocal fold polyps from the vocally healthy group [2]. Kandogan and Ozuer also observed the values of jitter and shimmer increased in people with vocal folds lesions, such as vocal cord polyps, nodules, Reinke edema, and cysts using MDVP. They investigated 25 patients with vocal nodules, 29 patients with vocal cord polyps, 15 patients with Reinke edema, and 8 patients with vocal cord cysts [12]. Two studies demonstrated that NHR values in patients with vocal cord nodules were not statistically different from the control group [6, 13].

Considering contradictory results for NHR, we decided to conduct this study. Additionally, the acoustic voice parameters of patients with vocal cord nodules and polyps and healthy controls were compared in terms of sex.

2. Materials and Methods

Study design

The present project was a cross-sectional case-control study. Sixty-eight patients with vocal cord nodules and polyps who visited the speech therapy clinic of Ayatollah Rouhani Hospital in Babol City, Iran, in 2016-2017 were recruited in the current research.

Participants

A total of 110 participants in three groups, including patients with nodules, patients with polyps, and healthy subjects were recruited in the current research. [Table 1](#) presents the distribution of the subjects in terms of sex. The video-laryngostroboscopic examination was performed by the experienced speech and language pathologist (SLP) by corresponding author and the diagnosis of vocal nodules and polyps was confirmed by an otolaryngologist. In the healthy group, individuals who had no history of voice disorders and had intact larynx were included based on video-laryngostroboscopic examination. The exclusion criteria for all groups included other structural disorders, such as Reinke's edema, cysts, sulcus vocalis, granuloma, neurological disorders, such as vocal cord paralysis, multiple sclerosis, Parkinson's disease, psychological problems, and history of cold and flu before 2 weeks ago.

Ethical approval

The current study was approved by the Ethics Committee of [Babol University of Medical Sciences](#) (MUBABOL.HRI.REC.1396.60). The participants were given the signed consent form and requested to complete it before the sampling procedure.

Procedure

The participants' demographic data were gathered via an interview and a questionnaire containing demographic information and the medical history of the subjects. We asked the participants to sit in an upright posture and produce prolonged /â/ vowel (at least 5 seconds) with habitual intensity and pitch three times. The procedure was conducted in the sound-attenuated

room. MDVP software (MDVP, Elemetrics K. Kay Elemetrics Visi-Pitch IV model 3950 instruction manual) was utilized to measure the traditional acoustic voice parameters. The recorder (Model: Lincoln Park, NJ) was applied to record the voice samples of the participants using the microphone (model: SM48, assembled in Mexico) with a 20 cm constant distance [14].

In case of any unwanted sampling error, the test was repeated. In this step, the clearest voice sample of each subject was chosen for analysis. We removed the onset and offset of each segment and the middle part of the segment was exposed to measure the acoustic voice parameters. Then, the acoustic voice parameters (jitter, shimmer, fundamental frequency, and NHR) were analyzed.

Measures and analyses

The SPSS software v. 18.0 (SPSS, Inc., Chicago, Illinois) was applied for the statistical analysis of data. Descriptive statistics were used to report the age, group, and sex of the participants. After investigating the normality of the distribution of the data by Kolmogorov Smirnov test, we used 1-way analysis of variance (ANOVA) test to compare each variable (jitter, shimmer, fundamental frequency, and NHR) in three groups. Moreover, 1-way analysis of variance (ANOVA) test was applied to compare the acoustic voice parameters among three groups in males and females. The significance level was considered ($P < 0.05$).

3. Results

As provided in [Table 2](#), three groups showed a significant difference in the fundamental frequency ($P < 0.001$). Women had a significant difference in the fundamental frequency in the three groups ($P < 0.001$), but the difference was not statistically evident in men ($P = 0.93$).

In [Table 3](#), the two groups had statistically significant differences for the jitter ($P < 0.001$). Also, for jitter measurement, men ($P < 0.001$) and women ($P < 0.001$) had a significant difference in the three groups.

[Table 4](#) presents the mean and standard deviation values of shimmer in three groups. As found in [Table 4](#), they had a statistical difference for the shimmer ($P < 0.001$). In addition, men had a significant difference in shimmer ($P = 0.001$). Evident differences were observed for the shimmer in the women ($P < 0.001$) and men ($P = 0.001$).

Table 1. Demographic statistics of the subjects

Groups	No.		
	Female	Male	Total
Nodules	25	13	38
Polyps	9	21	30
Healthy	25	17	42
Total	59	51	110

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Table 2. Comparison of fundamental frequency among three groups

Groups	Mean±SD		
	Female	Male	Total
Nodules	206.189±32.54	157.11±38.04	189.39±42.79
Polyps	199.76±48.29	152.38±47.26	166.59±51.59
Healthy	249.56±25.31	155.17±24.99	211.36±53.08

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Moreover, according to Table 5, the NHR was significantly different among the three groups. Men did not have a significant difference in NHR ($P=0.24$), but women showed substantial differences ($P=0.01$).

4. Discussion

In the current study, four acoustic voice parameters were analyzed, such as F_0 , jitter, shimmer, and NHR which are the most common acoustic voice measures in most studies.

The mean value of fundamental frequency is defined as the overall mean of all extracted period-to-period fundamental frequency measures in the voice sample [15]. In our study, the F_0 was lower in men than in women, as expected, according to the differences in vocal fold characteristics between men and wom-

en [16, 17]. Similar to Halawa et al work, our result showed that F_0 decreased in patients with vocal cord nodules and polyps. It can be attributed to the existence of extra mass on the surface of vocal folds thickening them [18]. Furthermore, the F_0 of female patients was significantly lower than in the control group.

Jitter is defined as the short-term and cycle-to-cycle perturbation in the F_0 of the voice [15]. The mean values of jitter showed a significant increase in both patient groups rather than the healthy group similar to some existing research [6]. Also, jitter increased in both females and males with nodules compared to the control group. This finding is consistent with some studies [3] but is not consistent with the result obtained by Chhetri et al. [6]. This significant increase can be caused by small growth on the surface of the vocal folds in mass lesions, such as polyps and nodules [2].

Table 3. Comparison of Jitter among three groups

Groups	Mean±SD		
	Female	Male	Total
Nodules	2.61±2.19	1.82±2.03	2.34±2.15
Polyps	2.92±1.94	3.04±1.97	3.01±1.93
Healthy	0.47±0.27	0.66±0.44	0.55±0.36

Note: Shimmer was calculated and reported in terms of %.

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Table 4. Comparison of Shimmer among three groups

Groups	Mean±SD		
	Female	Male	Total
Nodules	4.72±4.43	4.29±5.31	4.57±4.68
Polyps	7.26±6.51	6.69±3.54	6.86±4.52
Healthy	2.28±1.40	2.15±0.99	2.23±1.24

Shimmer was calculated and reported in terms of %.

Table 5. Comparison of noise-to-harmonic ratio (NHR) among three groups

Groups	Mean±SD		
	Female	Male	Total
Nodules	0.14±0.08	0.21±0.28	0.17±2.15
Polyps	0.19±0.11	0.17±0.06	0.17±1.93
Healthy	0.11±0.01	0.12±0.06	0.11±0.36

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Even very minimal growths on vocal folds may impact the jitter, and larger pathologies may result in more increased jitter [15]. It appears that increasing in jitter correlates with the number of active motor neurons and the increase in decreasing the control of muscle tone in the larynx [2].

Shimmer refers to the cycle-to-cycle, short-term perturbation in the amplitude of voice [15]. The mean values of shimmer showed a significant increase in the patients' group than the control one. In addition, the mean value of shimmer was significantly higher in both sexes of both case groups rather than the control group. This finding is consistent with several studies [2, 6]. This significant difference would be probably related to incompatible and weak contact of vocal fold edges due to glottis closure deficiency [15].

Based on the findings of the present research, the mean value of NHR in the group of patients with nodules increased significantly. While NHR values were increased in vocal polyps and nodules in both genders of patient groups, this increase was only significant in women with vocal polyps. These results were consistent with some studies [6, 13]. It can be caused by an incomplete closure of the glottis due to polyps leading to an air leakage [15] acoustically characterized as a noisy voice. The relative values of additional noise in the voice signal are quantified by NHR arising from the air-flow turbulence produced at the glottis during

the phonation process. Insufficient closure of vocal cords causes exceeding values of airflow in the glottis, resulting in turbulent airflow [19].

5. Conclusion

Every small variation of the mass, biochemical and biomechanical characteristics of vocal folds, can easily lead to rapid disturbances and cyclic changes in the intensity and frequency of voice resulting from the vibration of the vocal folds' cover layer. According to the findings of this study, it can be concluded that the weak and unstable closure of the glottis, resulting from the vocal fold nodules and or polyp, causes lower fundamental frequency and higher jitter, shimmer, and NHR values. Finally, by the computerized voice analysis procedures, one can provide an objective, accurate, and reliable examination of the vocal performance and quantitatively represent the voice quality.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article. The participants were informed of the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and if desired, the research results would be

available to them. A written consent has been obtained from the subjects. principles of the Helsinki Convention was also observed.

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Authors' contributions

Conceptualization and Supervision: Mehdi Dehghan, Keivan Kiakojouri; Methodology: Mehdi Dehghan and Hemmat Gholinia; Investigation: Mehdi Dehghan and Mohaddeseh Rostampourgonbaki; Writing—original draft: Mohaddeseh Rostampourgonbaki and Niloo-far Dehghanpour; Writing—review & editing: Mehdi dehghan, Mohaddeseh Rostampourgonbaki.

Conflict of interest

The authors declared no conflict of interest.

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