Original Article

A comparison of voice analysis results according to localization of vocal polyps in the vocal folds

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ABSTRACT

Objectives: This study aims to analyze the differences in voice acoustic analysis according to the localization of polyps in the vocal fold.

Patients and Methods: Between January 2017 and June 2018, a total of 52 patients (38 males, 14 females; mean age 40.5 years; range, 23 to 61 years) with a vocal polyp were retrospectively analyzed. The length of the vocal fold was measured and the location of lesions were classified as anterior, anterior-middle, and middle. Fundamental frequency (F0mean, F0min, F0max), jitter, shimmer, noise harmonic ratio (NHR), and maximum phonation time (MPT) were also recorded.

Results: Vocal polyps were localized in the anterior in 12, in the anterior-middle in 16, and in the middle in 24 patients. In the intra-group analyses, MPT, F0min, and NHR were found to be statistically significant. According to the overall average, MPT in the anterior group, shimmer and NHR in the anterior-middle group, and F0mean and F0min values in the middle group were found to be significant.

Conclusion: In vocal polyps, MPT was shorter in anterior lesions, the F0 mean value was high in middle lesions, and voice quality was more affected in the anterior-middle lesions, as the vocal fold vibration stability was disrupted and the noise parameter was high.

Keywords: Acoustic analysis, voice, vocal polyp, vocal fold.

Vocal polyps are typically single, isolated lesions formed in the vocal folds. It is basically a vascular pathology formed as an accumulation resulting from an increase in bleeding or localized subepithelial edema.[1] As they may have a wide base, they may be also in the stemmed form. These lesions are often associated with poor use of the voice and, as with other lesions of the vocal folds, they may lead to long-term loss of voice.[1] Some small-sized polyps may recover with conservative treatment, although surgical excision is required in most cases in the treatment of vocal fold polyps.

Objective voice analysis has been used for about two decades.[2] The results of voice analysis can be obtained with visual and numerical data. The most important vocal acoustic parameters used in clinical practice are noise-to-harmonic ratio (NHR) values, fundamental frequency (F0), jitter, and shimmer.[3,4] The F0 is the main parameter of the perception of voice tone of the speaker by the listener. It is determined by the flexibility, tension, and mass of the vocal folds.[5] Jitter and shimmer percentages show the effect of glottic vibration. Jitter shows the irregularity of pitch between short periods, and shimmer

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shows the wave amplitude irregularity between the periods.[6] The NHR is a parameter which indicates the increase in the irregular pattern against the regular component of the voice.[7]

To date, several studies have been conducted regarding the evaluation of vocal polyps following surgical treatment and therapy.[8-10] In these studies, alterations in the voice analysis parameters have been shown after treatment. However, to the best of our knowledge, there is no study regarding the change in voice analysis parameters according to the localization of the polyp in the vocal fold. Therefore, in the present study, we aimed to analyze the differences in voice acoustic analysis according to the localization of the polyp in the vocal fold in patients diagnosed with a vocal polyp.

PATIENTS AND METHODS

Between January 2017 and June 2018, a total of 52 patients (38 males, 14 females; mean age 40.5 years; range, 23 to 61 years) who were admitted to our Phoniatrics outpatient clinic with a vocal polyp and were under follow-up were retrospectively analyzed. Voice samples were recorded using a Shure 58 microphone (Shure Inc., Niles, IL, USA) with the Adobe audition program. The Praat v4.1 program was used for the voice sample analyses. The fundamental frequency (F0), jitter, shimmer, and NHR values were examined. The maximum phonation time (MPT) values were obtained from the recordings. The lesion site was determined measuring the vocal fold length in the Image J program (Figure 1). Based on the recorded images, lesions were classified as anterior (anterior group), anterior-middle (anterior-middle group), or middle (middle group) according to their localization.

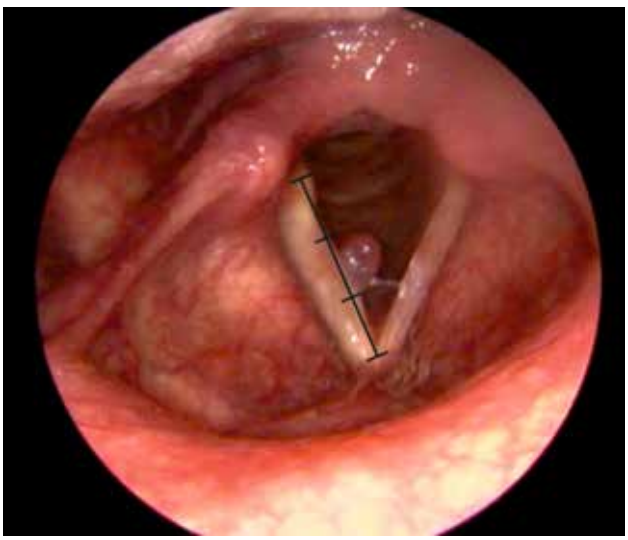

Figure 1. Videolaryngoscopic image of larynx showing lesion location by measuring length of vocal fold.

A written informed consent was obtained from each patient. The study was approved by the Kahramanmaraş Sütçü İmam University, Local Medical Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max), or number and frequency. Conformity of the data to normal distribution was examined using the Shapiro-Wilk test. For the comparison of three groups of non-normally distributed variables, the Kruskal Wallis H-test was used. Multiple comparisons were made using the Dunn-Sidak test. The difference between overall median values and individual median values of each group was evaluated using the one-sample signed ranks test. A p value of <0.05 was considered statistically significant.

RESULTS

Vocal polyps were localized in the anterior in 12, in the anterior-middle in 16, and in the middle in 24 patients. Of the total patients, 50.8%

Table 1. Baseline demographic characteristics of patients

	n	%	Mean±SD
Age (year)			40.5±11.8
Groups			
Middle	24	46.2	
Anterior	12	23.1	
Anterior-middle	16	30.8	
Gender			
Male	38	73.1	
Female	14	26.9	

SD: Standard deviation.

Table 2. Acoustic analysis results according to localization of vocal polyps

	Groups						
	Middle (n=24)		Anterior (n=12)		Anterior-middle (n=16)		
	Median	Min-Max	Median	Min-Max	Median	Min-Max	*p*
MPT	6.95	4.30-12.10	5.40	3.80-8.75	7.45	4.30-10.80	0.040*
F0 mean	180.791	80.715-375.310	136.718	98.791-302.966	128.993	71.737-208.817	0.108
F0min	167.496	78.291-361.122	114.409	84.841-179.137	113.819	70.295-193.611	0.005*
F0max	189.358	82.524-388.595	141.795	103.712-615.719	175.020	72.730-529.056	0.804
SD	1.530	0.736-53.135	1.983	0.803-227.581	4.927	0.610-123.647	0.239
Jitter	0.399	0.193-2.150	0.692	0.182-6.642	0.619	0.161-9.198	0.090
Shimmer	2.558	0.902-10.507	3.901	1.177-35.706	6.256	1.296-38.078	0.086
NHR	0.0044	0.0011-0.0766	0.0117	0.0028-0.7959	0.0180	0.0021-0.8667	0.013*

Min: Minimum; Max: Maximum; MPT: Maximum phonation time; SD: Standard deviation; NHR: Noise harmonic ratio; Kruskal-Wallis H test; α: 0.05;
* Difference is statistically significant.

used their voice professionally in occupations such as teacher, journalist, or musician, while 20.1% were housewives with more than one child. Cigarette smoking was reported by 66.3% of the patients, and there was a history of allergy in 50.3% patients. Baseline demographic characteristics of the patients are shown in Table 1.

According to the acoustic analysis results, the anterior group had a MPT of 5.4, F0mean of 136.71, F0min of 114.4, F0max of 141.79, jitter of 0.69, shimmer of 3.9, and NHR of 0.0117. In the anterior-middle group, these values were as follows: MPT 7.45, F0mean

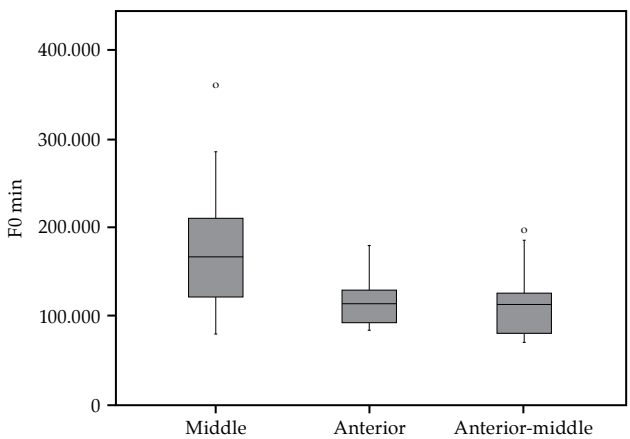

Figure 3. *Distribution of F0 min values according to localization of vocal polyps.*

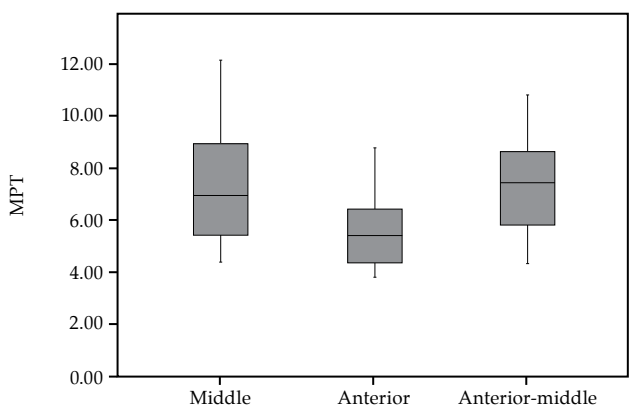

Figure 2. *Distribution of MPT values according to localization of vocal polyps.*
MPT: Maximum phonation time.

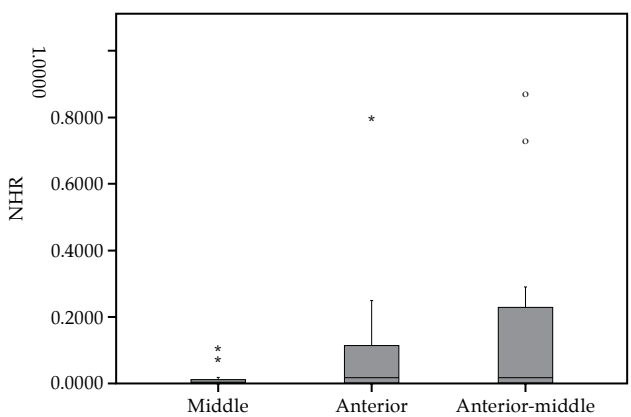

Figure 4. *Distribution of NHR values according to localization of vocal polyps.*
NHR: Noise harmonic ratio.

Table 3. Comparison of patient groups according to overall median values of acoustic analysis

	Groups								
	Middle (n=24)			Anterior (n=12)			Anterior-middle (n=16)		
	Median	Min-Max	*p*	Median	Min-Max	*p*	Median	Min-Max	*p*
MPT Median= 6.7	6.95	4.30-12.10	0.324	5.40	3.80-8.75	0.019*	7.45	4.30-10.80	0.300
F0mean Median= 140.115	180.791	80.715-375.310	0.009*	136.718	98.791-302.966	1.00	128.993	71.737-208.817	0.469
F0min Median: 122.577	167.496	78.291-361.122	0.004*	114.409	84.841-179.137	0.209	113.819	70.295-193.611	0.278
F0max Median: 184.561	189.358	82.524-388.595	0.954	141.795	103.712-615.719	0.388	175.020	72.730-529.056	0.717
SD Median= 1.803	1.530	0.736-53.135	0.977	1.983	0.803-227.581	0.272	4.927	0.610-123.647	0.039*
Jitter Median= 0.471	0.399	0.193-2.150	0.407	0.692	0.182-6.642	0.117	0.619	0.161-9.198	0.063
Shimmer	2.558	0.902-10.507	0.290	3.901	1.177-35.706	0.272	6.256	1.296-38.078	0.030*
NHR Median= 0.019	0.0044	0.0011-0.0766	0.310	0.0117	0.0028-0.7959	0.182	0.0180	0.0021-0.8667	0.044*

Min: Minimum; Max: Maximum; MPT: Maximum phonation time; SD: Standard deviation; NHR: Noise harmonic ratio; One sample sign test; α: 0.05; * Statistically significant difference according to the median of the relevant variable.

128.99, F0min 113.81, F0max 175.02, jitter 0.61, shimmer 6.25, and NHR 0.018. In the middle group, these values were as follows: MPT 6.95, F0mean 180.79, F0min 167.49, F0max 189.35, jitter 0.39, shimmer 2.55, and NHR 0.0044. The MPT (p=0.04), F0min (p=0.005), and NHR (p=0.013) were statistically significant in this group (Table 2) (Figures 2,3, and 4).

The comparison of the groups according to the overall median values showed that MPT in the anterior group (p=0.019), F0mean (p=0.009) and F0min (p=0.004) in the middle group, and shimmer (p=0.030) and NHR (p=0.044) in the anterior-middle group were statistically significant (Table 3).

DISCUSSION

Vocal fold polyps, which are at the free edge of the vocal fold, are benign masses that have a negative effect on the voice quality by disrupting the complete closure pattern of the vocal folds. In patients with incomplete glottal closure, the strength of the voice is affected and there is partial air loss while speaking. The occurrence of partial air leakage and incomplete glottal closure cause a series of changes in the voice quality and in the acoustic parameters of the voice. The results of the current study showed that MPT in the anterior group, F0mean, and F0min in the middle group, and shimmer and NHR in the anterior-middle group were statistically significant. Based on these findings, it can be suggested that the differences in incomplete closure patterns affect each acoustic parameter of the voice in different ways. These results provide information about the working mechanics of the vocal fold and the effect reflected in the acoustic parameters.

Overuse of the voice, excessive vocal hyperfunction, mechanical stress, and trauma may cause bleeding in the vocal fold membranes, leading to trauma. Cysts or polyps may form due to remodeling of the superficial layer of the lamina propria, while the bleeding resolves. Therefore, hoarseness lasting for longer than three months is the main symptom of laryngeal diseases and further tests must be done.

Vocal polyps are often seen in individuals who use the voice poor and have poor voice hygiene. In the current study, 66.3% of the patients were cigarette smokers and 50.8% used their voice professionally. The finding that vocal fold polyps were associated with poor voice use is also consistent with the findings reported in the studies of Doyle and Petrovic-Lazic.[11,12]

Acoustic voice parameters can be used to differentiate patients with vocal polyps from a healthy population. Fundamental frequency shows the number of vibrations per min of the vocal folds. Jitter is one of the basic measurements of microinstability of the vocal fold vibration.[13] Very small lesions similar to polyps in the vocal fold affect voice frequency perturbations. Shimmer show the amplitude difference between the voice waves, and it increases when the contact between the vocal fold edges is inadequate.[14] In the current study, the shimmer value was high in lesions localized in the anterior-middle region. However, no significant difference was found for the jitter value.

Acoustic evaluation is an appropriate, non-invasive, quantitative, cost-effective, and rapid method compared to other evaluation methods, such as electrography and laryngeal stroboscopy.[15,16] In the literature, there are many studies available regarding this topic. Petrović-Lazić et al.[12] compared acoustic voice analyses before and after surgery in patients with vocal polyps and reported that, it was useful in the evaluation of the phonosurgical procedure. Similarly, Cho et al.[9] suggested that there was a relationship between the size, location, and color of vocal fold polyps and the presence of hypopharynx reflux. In the comparison of patients with large polyps with patients with small polyps, Dursun et al.[17] showed that the jitter values were lower in patients with small polyps. Akbari et al.[18] also reported that the characteristics of acoustic voice parameters, particularly the jitter and NHR, were dependent on both the type and size of vocal polyps. In the current study, we found that shimmer in the voice acoustic parameters was more affected by the anterior-middle vocal polyps in the vocal folds.

Incomplete closure of the folds due to vocal polyps may also cause acoustic noise.[7] The NHR is the ratio of noise to harmonic spectral energy

and is directly proportional to the amount of nose in the voice.[19,20] In the current study, the NHR was higher in patients with polyps localized in the anterior-middle region. Thus, the ratio of noise in the voice in anterior-middle lesions was affected more associated with pathologies in the closure pattern of the vocal folds.

The MPT, which is important for continuous talking and long-term voice use, represents the strength and resistance in the glottic region. It is also important for extended speech and the maintenance of the speech.[7] An extended phonation rate associated with irregular closure of the vocal component is expected during phonation in patients with vocal polyps. In the current study, the duration of phonation was observed to be more affected in polyps localized in the anterior part of the vocal fold.

The main limitation of the present study is the lack of classification according to the polyp size and type. In addition, we were unable to show the acoustic changes from pre- to postoperatively. Therefore, further studies are needed to yield more accurate information on this topic.

In conclusion, multi-dimensional voice analysis provides more sensitive data regarding the acoustic structure of the voice, which can be recorded and examined more easily and rapidly. The results of the current study based on a multi-dimensional analysis of the /a/ sound show that there is a different acoustic structure according to the localization of vocal polyps. This study can be considered a further step taken to suggest that acoustic analyses can be used to determine the localization of lesions and to establish a definite diagnosis.

Declaration of conflicting interests

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