

# The Effects of Size and Type of Vocal Fold Polyp on Some Acoustic Voice Parameters

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Received: 05 February 2017

Revised: 15 April 2017

Accepted: 14 May 2017

## What's Known

- Previous studies indicated increased voice perturbations in larger polyps compared to smaller ones.

## What's New

- In addition to the size of a polyp, the effect of its type on voice parameters is investigated.
- A novel method to measure the size of a polyp is described.

## Abstract

**Background:** Vocal abuse and misuse would result in vocal fold polyp. Certain features define the extent of vocal folds polyp effects on voice acoustic parameters. The present study aimed to define the effects of polyp size on acoustic voice parameters, and compare these parameters in hemorrhagic and non-hemorrhagic polyps.

**Methods:** In the present retrospective study, 28 individuals with hemorrhagic or non-hemorrhagic polyps of the true vocal folds were recruited to investigate acoustic voice parameters of vowel/æ/ computed by the Praat software. The data were analyzed using the SPSS software, version 17.0. According to the type and size of polyps, mean acoustic differences and correlations were analyzed by the statistical *t* test and Pearson correlation test, respectively; with significance level below 0.05.

**Results:** The results indicated that jitter and the harmonics-to-noise ratio had a significant positive and negative correlation with the polyp size ( $P=0.01$ ), respectively. In addition, both mentioned parameters were significantly different between the two types of the investigated polyps.

**Conclusion:** Both the type and size of polyps have effects on acoustic voice characteristics. In the present study, a novel method to measure polyp size was introduced. Further confirmation of this method as a tool to compare polyp sizes requires additional investigations.

Please cite this article as: Akbari E, Seifpanahi S, Ghorbani A, Izadi F, Torabinezhad F. The Effects of Size and Type of Vocal Fold Polyp on Some Acoustic Voice Parameters. *Iran J Med Sci*. 2018;43(2):158-163.

**Keywords** • Vocal cords • Polyps • Acoustics • Voice disorders

## Introduction

Vocal polyps are thought to result from vocal misuse or overuse, such as hard glottal attacks.<sup>1</sup> These small growths vary in size, shape, and color and may appear as pedunculated or sessile.<sup>2</sup> In severe conditions, polyps turn hemorrhagic and emerge as blood blisters on vocal cords.<sup>3</sup> This occurs when collision forces, generated during the oscillatory cycle of phonation, cause microtrauma within the basement membrane of epithelium and the superficial layer of the lamina propria. Consequently, oscillation of vocal folds leads to neovascularization and hemorrhagic events within the damaged tissue.<sup>4</sup> Depending on the size, position, and type of polyps, abnormal voice qualities including hoarseness, harshness, and breathiness would be different.<sup>3</sup> The size of polyps varies from small to large masses,<sup>1</sup> and a criterion to distinguish polyps from nodules is defined as mass bigger than 0.3 mm whereby bigger masses could be classified as polyps.<sup>5</sup>

Despite current knowledge on the pathological features of vocal fold polyps, available information regarding the correlation between the size and type of vocal fold polyps in relation to voice acoustic features is very limited. Sanada et al. reported that the voice of patients with greater polyps was damaged more than those with lesser polyps.<sup>6</sup> According to Petrovic-Lazic,<sup>7</sup> acoustic voice parameters can be used to differentiate patients with vocal folds polyp from healthy people. In addition, the analyzed parameters significantly improved after endolaryngeal phonosurgery in patients suffering from vocal fold polyp.<sup>7,8</sup> Using a vector machine algorithm, Wang et al. showed a stable performance to predict vocal fold polyp without using laryngoscopy.<sup>9</sup>

Acoustic evaluation is noninvasive, quantitative, economical, convenient, and rapid compared to other assessment methods such as electroglottography<sup>10</sup> and laryngeal stroboscopy.<sup>11</sup> Vocal fold polyps are noncancerous growths on the vocal cords that cause hoarseness by disrupting the glottal closure and vibration pattern. To better understand the effect of the size and type of vocal polyps on voice acoustic features, various frequently used acoustic parameters in patients with vocal fold polyp and other laryngeal disorders have been investigated.<sup>7,12-19</sup>

According to previous studies, one of the most investigated voice acoustic parameters has been voice perturbation.<sup>7,19-21</sup> Subsequently, we investigate parameters such as jitter, shimmer, and harmonics-to-noise ratio (HNR). Jitter is defined as cycle-to-cycle and short-term perturbation in the fundamental frequency of the voice. Local jitter is the mean absolute difference between consecutive periods divided by the mean period. The shimmer is a cycle-to-cycle, short-term perturbation in the amplitude of voice. The local shimmer is the mean absolute variation in amplitudes of consecutive periods divided by the mean amplitude. The other acoustic parameter (HNR) is influenced by both the shimmer and jitter and referred to as the mean ratio of harmonics to non-harmonics energy.<sup>22</sup>

Acoustic data provide predictive information regarding the size of the lesion and post-intervention vocal outcomes.<sup>12</sup> Accordingly, the present study aimed to define the correlation between the size of vocal fold polyps and acoustic parameters, including jitter, shimmer, and HNR. Furthermore, the above-mentioned acoustic parameters were compared between patients with hemorrhagic and non-hemorrhagic polyps.

## Materials and Methods

### Participants

In the present retrospective study, the archive of the voice clinic at the Speech and Language Pathology Department of Iran University of Medical Sciences (Tehran, Iran) during December 2005 and May 2011 was used. The archive contained 900 videolaryngostroboscopy and voice samples from patients with voice disorders. The inclusion criterion was patients with vocal fold polyp that had both vivid stroboscopic and voice recordings. The exclusion criteria were men over 65 years old, post-menopausal women, records with obscured stroboscopic imaging, and patients with vocal cord disorders other than polyp (e.g. vocal fold paralysis, functional dysphonia, etc.). Based on a previous study,<sup>16</sup> a sample size of 24 was considered sufficient according to the below formula:

$$n = [(Z_{1-\alpha/2} + Z_{1-\beta})^2 \times \sigma_d^2] \div d^2 + (Z_{1-\alpha/2}) \div 2$$

Eventually, based on the inclusion and exclusion criteria, 28 patients with vocal fold polyp were selected. The study was approved by the Ethics Committee of Iran University of Medical Sciences, Tehran, Iran (number 93/d/105/5113). To respect confidentiality, personal information about patients was effectively protected by using code numbers. Additionally, researchers involved in the present study were refrained from disclosing personal information.

### Procedure

The archived voice samples had been recorded digitally in a semi-anechoic room with a noise level lower than 30 dB. Their laryngoscope evaluations had been performed by a videolaryngostroboscopy set equipped with a 90-degree rigid scope (Karl Storz Laryngostrobe, Tuttlingen, Germany). The records with clear and vivid videolaryngostroboscopy were included and stroboscopic videos were reviewed independently by two speech language pathologists as well as two laryngologists to confirm the polyp diagnosis and to distinguish the hemorrhagic from non-hemorrhagic polyps clinically. The middle 3 seconds of recorded voice samples were analyzed by the Praat software, version 5.1.05 (Phonetic Sciences, University of Amsterdam, The Netherlands) on a laptop computer (VGN-SR590 GAB, Sony Inc., USA).

Three acoustic parameters in vowel production of /æ/ were measured, namely frequency perturbation (local Jitter [%]), amplitude perturbation (local shimmer [%]) and the HNR. The ratio of polyp length to vocal

fold length at rest voice was used as a scale to compare the size of polyps. For its calculation, the lengths of a vocal fold that included polyp and the polyp were measured in millimeters using an engineering ruler. Then, the ratio of the measured lengths was considered as the polyp size. The measurements were performed by 2 speech therapists and one laryngologist using panel data approach; obtaining the average of the measurements gathered from each rater. Based on this calculation, the ratio would be between 0 and 1. Figure 1 presents a vocal fold polyp sample and the procedure to compute the ratio.

### Statistical Analysis

Data were analyzed using the SPSS software (version 17.0) with significance level below 0.05. The independent samples *t* test was used to compare the mean of voice parameters between the hemorrhagic and non-hemorrhagic groups. The Pearson correlation test was used to show the amount of correlation of each voice parameter with the vocal fold polyp size.

## Results

In the present retrospective research, 28 clinical profiles with a diagnosis of true vocal fold polyps were studied. The patients aged between 25 and 64 years ( $39.46 \pm 9.72$ ). In total, 9 patients were diagnosed with hemorrhagic polyps (3 women and 6 men) while 19 had non-hemorrhagic polyps (6 women and 13 men). All patients had unilateral or sessile polyps, located on the edge and anterior to the middle part of the membranous true vocal fold.

The acoustic parameters and the ratio size scale of vocal polyps are shown in table 1. The ratio size scale of vocal polyps was 0.16

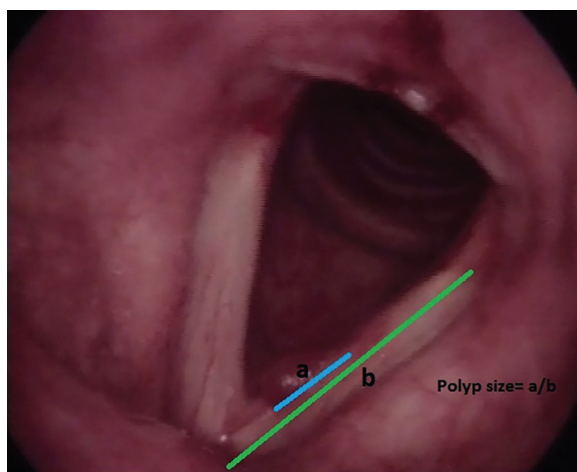


Figure 1: Measurement method to calculate the ratio of polyp to vocal fold lengths.

to 0.81 ( $0.41 \pm 0.15$ ). The statistical Pearson correlation test was used to investigate the correlation between polyp size scale and acoustic voice characteristics. Based on Pearson correlation test, as shown in table 2, the results indicated that polyp size had a significant positive correlation with jitter ( $P=0.01$ ) while there was a significant negative correlation with HNR ( $P=0.01$ ). On the other hand, there was a 0.15% correlation between the polyp size and shimmer, which was not statistically significant ( $P=0.44$ ). Furthermore, in comparison with non-hemorrhagic polyps, the ratio size scale of vocal polyps, shimmer, and jitter was higher in hemorrhagic polyps, although the differences were only statistically significant for Jitter (table 3). HNR decreased significantly in patients with hemorrhagic compared to non-hemorrhagic polyps (table 3).

## Discussion

The results of the present study show that larger polyps cause increased jitter and reduced HNR. With respect to these acoustic parameters, patients with hemorrhagic polyp had a higher level of voice abnormality compared to those with non-hemorrhagic polyp. However, in terms of the size and type of polyp, differences in shimmer were not statistically significant. Past studies have suggested higher voice abnormalities in patients suffering from vocal fold polyp compared to normal people<sup>7</sup> as well as those after surgical removal of the polyp.<sup>7,8</sup>

There are a few published studies on the relationship between the size or type of polyp with vocal acoustic parameters.<sup>6</sup> Wang et al.<sup>9</sup> attempted to predict vocal fold polyp without applying laryngoscope instruments. They used a signal processing theory called “compressing

Table 1: Acoustic voice parameters and the polyp size (the ratio of polyp to vocal fold lengths) in 28 patients with vocal fold polyp

Acoustic voice parameters	Mean±SD
Jitter (%)	1.38±1.38
Shimmer (%)	10.61±5.03
HNR (dB)	13.12±4.27
Polyp size ratio	0.41±0.15

Table 2: The correlation between the mean of acoustic voice parameters and vocal folds polyp size scale

Acoustic voice parameters	Pearson correlation	P value
HNR (dB)	-0.45	0.01
Shimmer (%)	0.15	0.44
Jitter (%)	0.46	0.01

**Table 3:** Acoustic voice parameters and the polyp size (the ratio of polyp to vocal fold lengths) for patients with hemorrhagic and non-hemorrhagic polyps

Acoustic voice parameters	Hemorrhagic polyps	Non-hemorrhagic polyps	P value
HNR (dB)	10.51 (4.99)	14.36 (3.36)	0.02
Shimmer (%)	13.18 (4.82)	9.39 (4.77)	0.06
Jitter (%)	2.16 (1.67)	1.01 (1.08)	0.03
Polyp size ratio	0.44 (0.17)	0.40 (0.15)	0.58

Data presented as mean (standard deviation)

sensing theory” and a vector machine algorithm. They showed that the performance of prediction was stable, but the correct rate of prediction was low due to the small number of patients.<sup>9</sup> Although this method is quantitatively accurate, its deployment in clinical centers is extremely complicated. Consequently, the present study aimed to analyze more convenient voice acoustic parameters such as jitter, shimmer, and HNR to gain a better understanding of patients’ voice in relation to the size and type of their polyps.

Previous researchers indicated increased jitter in patients with vocal fold polyp compared to the normal people.<sup>7</sup> This is in accordance with the elevated jitter observed in the present study. Our result is also in agreement with previous reports that suggest voice features depend on the polyp size.<sup>3,6,12</sup> In this regard, it has been shown that Jitter, which is one of the main criteria to investigate short instability in vocal fold vibration rhythm,<sup>23</sup> might increase due to larynx inflammation or growth of very small masses on vocal folds.<sup>24</sup> Inconsistent glottal closure and poor vocal fold median edge contact result in increased shimmer.<sup>24</sup> This is further confirmed in a study reporting increased shimmer in patients with vocal fold polyp compared to the healthy people,<sup>7</sup> which agrees with the high shimmer results of the present study. However, the high shimmer in our study was not significantly different according to the size or type of the polyps. Consequently, further research on the correlation between shimmer and the size of polyp is required to confirm the results.

Polyp creates a gap between vocal folds and increases air escape from glottal chink (acoustically referred to as noise) and consequently reduces HNR.<sup>24</sup> In line with previous studies,<sup>6,7</sup> our result also indicated that reduced HNR is related to larger polyps. Therefore the larger the size of polyps, the more airflow would escape across vocal folds, which results in a dramatic drop of HNR. Since the larger size of such excess mass on vocal folds would lead to higher interference in the oscillation of vocal fold, it consequently increases the vocal effort to close the glottis. The consequence of such vocal abuse and misuse is that the vibration of vocal

folds becomes more irregular, and more noise and less harmony will be produced, leading to elevated jitter and shimmer and reduced HNR. In line with the present study, other studies have indicated similar consequences in people suffering from polyp.<sup>7</sup>

Sanada et al. indicated that the polyp size has a positive correlation with the pitch perturbation quotient, amplitude perturbation quotient, and normalized noise energy.<sup>6</sup> They also investigated the correlations of some other vocal variables, such as maximum phonation time and mean airflow rate, with the size of polyps.<sup>6</sup> Since these additional vocal variables were not recorded in our patients, they are excluded from the current investigation. However, Sanada et al. did not investigate the effect of polyp type on voice parameters. Hence, the main strength of the present study is the inclusion of the effect of both the type and size of polyp on voice acoustic parameters.

Current results indicated that both the jitter and shimmer were higher and HNR was lower in patients with hemorrhagic compared non-hemorrhagic polyps, although, the difference in shimmer was not statistically significant. Such increased perturbation and reduced HNR might be due to the difference in polyp texture, as it consists of liquid-rounded solid texture with jelly-shaped movement in hemorrhagic polyps. Therefore, such texture creates more instability in the vibration behavior of vocal cords in patients with hemorrhagic polyps. On the other hand, patients with non-hemorrhagic polyps have more solid texture and less instability in glottal vibration.

Qing et al.,<sup>25</sup> using voice assessment as a diagnostic test, showed that acoustic voice parameters (e.g. jitter, shimmer, and HNR) were different between patients with vocal fold polyp and laryngeal cancer. Therefore, applying these acoustic parameters may have a complementary prognostic value to assist differentiation between hemorrhagic and non-hemorrhagic polyps. Although acoustic features can be applied to predict the type of a polyp, laryngoscopic examination is still a valid tool to distinguish between hemorrhagic and non-hemorrhagic polyps.

The main strength of the present study is that, for the first time, voice acoustic parameters have been used to distinguish hemorrhagic from non-hemorrhagic polyps. However, despite the novelty, its achievement with respect to previous studies was limited. Hence, further research is required to reinforce our findings. There are some other studies that have investigated additional parameters of vocal fold polyp<sup>26</sup> (i.e. airflow) which are not addressed in the current research. Thus, their findings are not comparable to our results.

The result of the present study has shown that polyp size has a significant effect on acoustic parameters; larger polyps deteriorate acoustic parameters more than small ones. Therefore, polyp size may be considered as an important factor for diagnosis, prognosis, and voice therapy to improve acoustic characteristics. Complementing laryngoscope examination, it is recommended that clinicians use the novel technique of the current study to predict voice abnormalities. Additional application of the technique is to compare voice acoustic parameters before and after a surgery. It would assist laryngologists to gauge the level of improvement due to the treatment.<sup>7,8</sup> The applied ratio scale in this study is a novel and noninvasive method for comparing polyp sizes and may also be used to determine the size of additional vocal fold masses other than polyp.

The main limitation of the present study is related to the sample size. Although we obtained the records of 900 patients from the archive of the voice clinic, only 28 records fulfilled the inclusion criterion. Considering the high number of patients with vocal fold polyp, the majority are immediately operated after diagnosis without being referred for speech therapy at voice clinic centers. Consequently, a limited number of patients could be included in the present study.

## Conclusion

A correlation between both the size and type of polyps with jitter and HNR has been shown. The findings of the present study would encourage clinicians to consider voice acoustic parameters as a complementary tool to laryngoscopic examination in assessing vocal cord polyps. It also allows determining the extent of improvements after a surgery or voice therapy. Additionally, the method could be used to compare polyps in research studies and to improve treatment decision-making process.

## Acknowledgment

We would like to thank the Speech and Language

Pathology Department of Iran University of Medical Sciences for allowing access to the archive.

**Conflict of Interest:** None declared.

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