

# Voice changes and laryngo-video-stroboscopic findings in patients with vocal fold polyps and cysts

Aml S. Quriba<sup>a</sup>, Mohamed E. Darweesh<sup>b</sup>

<sup>a</sup>Unit of Phoniatics, ENT Department, Zagazig University, Zagazig <sup>b</sup>Unit of Phoniatics, ENT Department, Tanta University, Tanta, Egypt

Correspondence to Mohamed E. Darweesh, MD, Unit of Phoniatics, ENT Department, Tanta University, Tanta, Egypt  
Tel: +20 122 394 7970/+20 403 320 033;  
fax: 0020403313595  
e-mail: mohameddarwish@hotmail.com

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## Background

Vocal fold polyps and cysts are two disorders of the minimal associated pathological lesions of the vocal folds. These disorders may be misdiagnosed by a simple laryngoscopic examination. Laryngo-video-stroboscopic (LVS) assessment is required for proper differentiation.

## Objectives

This study aimed to examine the voice changes and LVS findings of vocal fold polyps and cysts and differentiate between them clearly, and also to determine which stroboscopic signs are correlated to the severity of dysphonia.

## Patients and methods

This study was carried out on 47 patients; 21 of these patients (45%) were diagnosed with vocal fold cysts (group 1) and 26 patients (55%) were diagnosed with vocal fold polyps (group 2). The results of auditory perceptual assessment, LVS evaluation, and acoustic analysis of the voice were compared in both groups. The correlation between the different parameters of LVS and the grade of dysphonia was tested.

## Results

Vocal fold polyps lead to more severe dysphonia than vocal fold cysts, proved by significant differences between both groups in the grade of dysphonia and in acoustic analysis. LVS findings differed significantly between both groups. Irregularity of the edge of the affected vocal fold, phase closure characteristics, and phase symmetry were found to be the most useful parameters for the assessment of the severity of dysphonia in these voice disorders than the amplitude of vibration.

## Conclusion

The results of assessment of voice in vocal fold cysts and polyps are related to the nature and the pathology of the disorder. Irregular vocal fold edges in cases of vocal fold polyps and absent mucosal wave over the lesion in cases of vocal fold cysts enabled clear differentiation between them. Irregularity of the vocal fold edges and symmetry between vocal folds were stroboscopic signs correlated to the severity of dysphonia in cases of vocal fold polyps and cysts.

## Keywords:

auditory perceptual assessment, cysts, laryngo-video-stroboscopic, polyps, vocal fold

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## Introduction

Vocal fold polyps and cysts are among the common lesions of the vocal folds encountered in voice clinics. They are related to the group of minimal associated pathological lesions (MAPLs) of the vocal folds. These disorders result from longstanding permanent changes affecting nonorganic voice disorders [1]. They are usually located at the junction of anterior and middle thirds of the vocal folds, the site of maximal vibratory mucosal excursion during phonation [2].

Vocal fold polyps are the most common benign vocal fold lesions removed surgically and are associated with vocal abuse or misuse. It has been proposed that laryngeal polyps represent injury to the basement membrane zone of the vocal fold. Repeated trauma from shearing forces produced by excessive or abusive phonation leads to basement membrane zone disruption and thickening. This thickening, along with vascular

changes, leads to the characteristic clinical appearance of the vocal polyp [3]. Vocal polyps are benign, round, sessile, or pedunculated lesions, which can be unilateral or bilateral. They are located on the free borders of the vocal fold and are mobile, when pedunculated (Fig. 1). Depending on their size and implantation site, they may compromise vocal quality markedly [4]. Polyps are further classified as translucent polyps (filled with edematous-appearing fluid), hemorrhagic polyps (with vascular changes), hyaline polyps (polyp filled with thick, myxoid-appearing fluid), or fibrotic polyps (filled with fibrous tissue) [5].

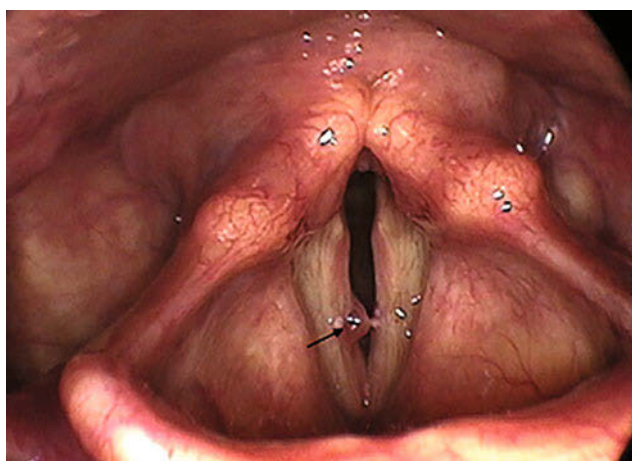
Cysts are unilateral submucosal masses arising from the Reinke's space at the junction of the anterior and middle third of the vocal fold [5]. Vocal cysts are classified into two subtypes: epidermoid or mucous-retention cysts. Epidermoid cysts have caseous content, and are implanted on the subepithelial layers

of the vocal folds. The vocal fold affected is bulged, congested, and shows a vascular ectasia on top of the lesion (Fig. 2). An epidermoid cyst may be acquired, secondary to vocal abuse or congenital, because of remaining epithelium trapped inside the lamina propria. The histological analysis of the epidermoid cyst shows that the lesion is covered by a stratified squamous and keratinized epithelium, making it resistant to manipulation. Mucous-retention cysts develop from the obstruction of the glandular ducts caused by voice overuse, laryngitis secondary to gastroesophageal reflux, or upper-airway infections. They are more common in adults, especially those with high vocal demand. The histological analysis of the mucous cyst shows that the cavity is covered by ciliated cylindrical epithelium [6].

Laryngo-video-stroboscopy (LVS), the imaging technique of choice, has received considerable attention over the last 20 years and has become a standard procedure in voice centers and even for the general otolaryngologist. Pathology of the vocal fold may produce changes in the appearance and vibratory characteristics observed during stroboscopic examination [7]. Interpretation of the stroboscopic examination typically involves systematic judgments of a series of parameters or 'signs'. These signs, identified by Hirano and Bless [8], included vocal fold edge, periodicity, amplitude, mucosal wave, glottal closure, vibratory behavior, and phase symmetry.

The aim of this work was to study the voice changes and LVS findings of vocal fold polyps and cysts differentiate between them clearly. Another objective was to determine which stroboscopic signs are correlated to the severity of dysphonia. These signs must have more importance during assessment of these disorders.

Figure 1



Right-sided vocal fold polyp.

## Patients and methods

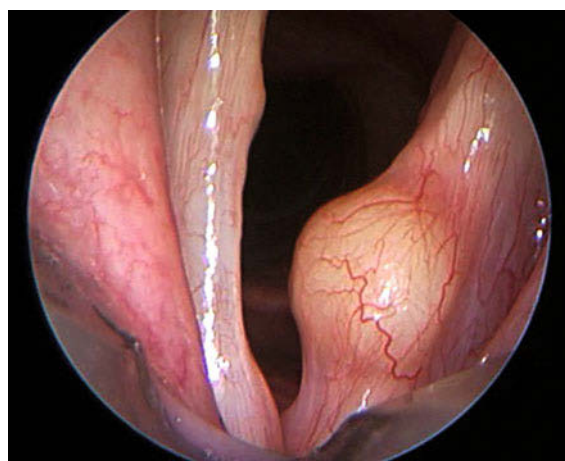
This study was carried out in Outpatient Units of Phoniatrics, ENT Departments of Zagazig and Tanta Universities. It was initiated in January 2010 and ended in December 2010. Patients in this study were examined and diagnosis was confirmed by three experienced phoniatricians and by a pathological examination.

Forty-seven patients with a diagnosis of a vocal fold cyst (group 1) or a vocal fold polyp (group 2) were included in this study. Each patient was subjected to an examination using the voice assessment protocol used in Ain-Shams University Hospitals. This protocol passes through the following levels.

## Elementary diagnostic procedures

This includes the patient's interview, the preliminary auditory perceptual assessment (APA) of the patient's voice, and careful laryngeal examination. Documentation of the APA was performed by high-fidelity voice recording. Patients' voices were recorded with a high-fidelity FM audio tape system (Akai system-Electronics Tokyo, Japan "Headquarters Singapore") using a cardioid dynamic microphone (Khaldi 4-2100, German, used a metallic strip attached to a vibrating membrane that would produce intermittent current). The speech material recorded included reading a standardized text, counting task and sustained vowel prolongation including /a/, /i/ and /u/ vowels. The recordings were performed in a sound-treated room to minimize environmental noise. The recorded materials for all patients were rated for APA by three experienced phoniatricians using a modified GRBAS scale [9]. The APA sheet comprised a four-point scale (0-3) to determine the

Figure 2



Left-sided vocal fold cyst.

items: overall grade of dysphonia and character of voice including strained, leaky, breathy, and irregular (0 for normal, 3 for severe).

#### Clinical diagnostic aids

This includes augmentation and documentation of the glottic picture and high-fidelity voice recording. Augmentation of the glottic picture was performed with LVS using either the rigid oral 70 telescope or a flexible nasofibroscope, connected to a camera in association with stroboscopic light. Videostroboscopic recording was done by using a computer integrated Rhino-laryngeal Stroboscope from Xion medicals (Berlin, Germany). The following stroboscopic signs were evaluated in all patients:

- (1) Edge of the vocal fold: irregularity of each vocal fold, rated individually.
- (2) Amplitude of vibration: lateral distance of movement from the midline of each vocal fold, rated individually.
- (3) Mucosal wave: extent of wave propagation across the superior surface of each fold, rated individually.
- (4) Vibration characteristics: amount of vibratory activity of the vocal fold, rated individually.
- (5) Phase symmetry: opening and closing of each fold mirrors the other.
- (6) Periodicity: regularity of successive vibrations.
- (7) Phase closure: the proportion of time during the vibratory cycle that the folds are open and closed.

For correlation with the severity of dysphonia, stroboscopic signs were measured on the side of the lesion and rated as follows:

- (1) Sign: irregularity of the edge
  - (a) Smooth
  - (b) Slightly rough
  - (c) Moderately rough
  - (d) Extremely rough
- (2) Sign: amplitude of vibration
  - (a) Normal
  - (b) Slightly decreased
  - (c) Moderately decreased
  - (d) Severely decreased
  - (e) Absent movement
- (3) Sign: mucosal wave
  - (a) Normal
  - (b) Slightly decreased
  - (c) Moderately decreased
  - (d) Severely decreased
  - (e) Absent
- (4) Sign: vibration characteristics
  - (a) Always fully present
  - (b) Partial absence sometimes
  - (c) Partial absence always

- (d) Complete absence sometimes
- (e) Complete absence always
- (5) Sign: periodicity of successive vibrations
  - (a) Periodic
  - (b) Sometimes aperiodic
  - (c) Always aperiodic
- (6) Sign: symmetry between vocal folds
  - (a) Symmetric
  - (b) Sometimes asymmetric
  - (c) Always asymmetric
- (7) Sign: phase closure
  - (a) Normal
  - (b) Open phase predominates sometimes
  - (c) Open phase predominates always
  - (d) Closed phase predominates sometimes
  - (e) Closed phase predominates always

#### Additional instrumental measures

In this level, acoustic analysis was carried out using the multidimensional voice program (MDVP model 4305) from Kay Elemetric Corporation (Lincoln Park, New Jersey, USA). The sampling rate was set to 50 000 Hz. In a quiet room, the patient was asked to sustain a vowel/ $\alpha$ /for 3–4 s at a comfortable pitch and loudness after he/she was instructed to clear the throat. A dynamic microphone was positioned at a constant mouth-to-microphone distance of 10–15 cm. A 2 s mid-vowel segment was selected and analyzed (Fig. 3).

The following parameters were measured and automatically calculated:

- (1) Average fundamental frequency ( $F_0$ ): this represents the average fundamental frequency for all extracted pitch periods.
- (2) Jitter percent (jitt%): this represents the relative period-to-period (very short term) variability in frequency [10].
- (3) Shimmer percent: this represents the relative period-to-period (very short term) variability of the peak-to-peak amplitude [10].
- (4) Noise to harmonic ratio: this is the ratio of the energy of the aperiodic component in the speech signal to the energy in the speech signal [11].
- (5) Relative average perturbation (RAP): this enables an evaluation of the variability of the pitch period within the voice sample analyzed at a smoothing factor of three periods [10].
- (6) Amplitude perturbation quotient: this enables an evaluation of the variability of the peak-to-peak amplitude within the voice sample analyzed at a smoothing factor of 11 periods [10].

Data was analyzed using SPSS (Statistical Package for Social Sciences) version 17 (predictive business intelligence “PBI” company in South Africa and

Saharan Africa). Qualitative data of both groups (grade of dysphonia and LVS signs) were presented as number and percent. Comparison between both groups was carried out using the  $\chi^2$ -test. The Mann-Whitney test for independent samples, which is a nonparametric test, was used to compare quantitative data (acoustic parameters) of both groups. For this comparison, both groups were further divided into subgroups according to sex; comparison between the same sexes of the two groups was performed. This was done because of the normal variation of fundamental frequencies between men and women, which may lead to errors during comparison of acoustic parameters. The Pearson correlation coefficient was used to test the correlation between different LVS signs and the grade of dysphonia.

**Results**

Of the 47 patients in the study, 21 were diagnosed with a vocal cyst (group 1) and 26 were diagnosed with vocal fold polyps (group 2). The first group (vocal cyst) included 12 men and nine women, age range 19–42 years and mean age  $30.048 \pm 7.2$  years. The second group (vocal polyps) included 15 men and 11 women, age range 22–51 years and mean age  $34.731 \pm 8.834$  years.

Evaluation of the 47 patients who participated in this study using the voice assessment protocol yielded the following findings.

Table 1 and Fig. 4 show very highly significant differences between grades of dysphonia in the group of patients with vocal cysts and vocal fold polyps.

Comparison between the group of patients with vocal cysts and vocal fold polyps in the male and female

subgroups in terms of acoustic parameters showed significant differences in the following: average fundamental frequency ( $F_0$ ) (in the male subgroup), jitt% (in both subgroups), and the RAP (in both subgroups) (Table 2).

**Table 1 Comparison between group 1 and group 2 in the overall grade of dysphonia**

Items	N (%)		
	Grade I	Grade II	Grade III
Group 1 (n = 21)	12 (57)	6 (29)	3 (14)
Group 2 (n = 26)	3 (11.5)	12 (46)	11 (42.5)
P-value	<0.001		

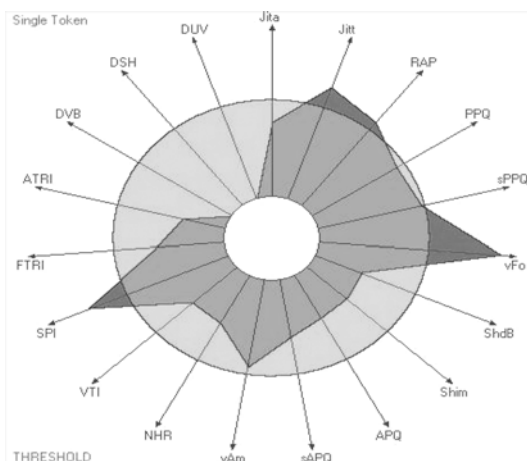
P < 0.001 (very highly significant difference).

**Table 2 Comparison between group 1 and group 2 in acoustic parameters**

Parameter	Group 1 (12 men and nine women)		Group 2 (15 men and 11 women)		P	Significance
	Mean	SD	Mean	SD		
$F_0$						
Male	126	17.6	183	27.9	<0.05	S
Female	201	22.7	265	25.4	>0.05	NS
Jitt%						
Male	2.1	0.9	2.4	1.5	<0.05	S
Female	1.2	0.52	2.9	0.5	<0.05	S
Shim%						
Male	5.6	1.14	6.7	2	>0.05	NS
Female	5.19	2.2	6.24	2.4	>0.05	NS
NHR						
Male	0.17	0.1	0.25	0.2	>0.05	NS
Female	0.2	0.2	0.27	0.1	>0.05	NS
RAP						
Male	1.4	0.7	3.2	0.57	<0.05	S
Female	1.3	0.7	3	0.9	<0.05	S
APQ						
Male	2.9	1.3	3.3	1.1	>0.05	NS
Female	3.6	1.9	2.6	0.76	>0.05	NS

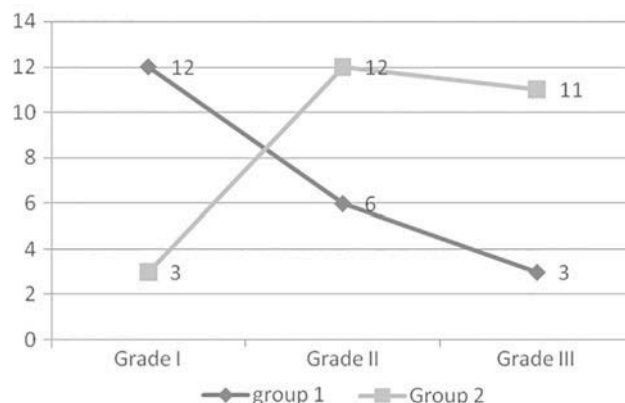
APQ, amplitude perturbation quotient; NHR, noise to harmonic ratio; NS, non significant difference; RAP, relative average perturbation; S, significant difference.

**Figure 3**



MDVP radial graph showing the patient's voice parameters plotted on a circle of normative thresholds. MDVP, multidimensional voice program.

**Figure 4**



Distribution of the overall grade of dysphonia in both groups.

LVS assessment showed that the most common stroboscopic findings in the patients in group 1 with cysts were as follows:

- (1) Smooth edge of the affected vocal fold over the lesion.
- (2) Decreased amplitude of vibration on the affected side.
- (3) Absent mucosal wave over the lesion.
- (4) Successive vibrations are often aperiodic.
- (5) Vibrations are asymmetric on both sides.
- (6) Closed phase predominates in most of the cases.

However, the most common findings in the patients in group 2 with polyps were as follows:

- (1) Irregular edge of the affected vocal fold over the lesion.
- (2) Decreased amplitude of vibration on the affected side.
- (3) The lesion may move with a slight lag behind the vocal fold, presenting with coupled vibration.
- (4) Normal or decreased mucosal wave (in hemorrhagic and fibrous polyps) over the lesion.
- (5) Successive vibrations are often aperiodic.
- (6) Vibrations are asymmetric on both sides.

Comparison between the group of patients with cysts (group 1) and the group of patients with polyps (group 2) in LVS indicated highly significant differences in irregularity of the vocal fold edge and absence of the mucosal wave, and significant differences in decreased amplitude of vibration and predominant closed phase (Table 3 and Fig. 5).

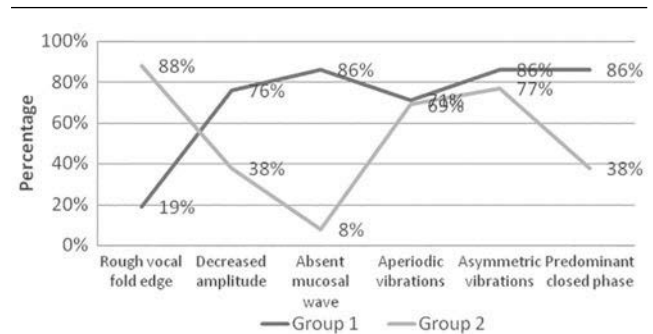
The results of the correlation between the rated LVS signs and the grade of dysphonia indicated that irregularity of the vocal fold edges and symmetry between vocal folds showed a highly significant correlation to the grade of dysphonia, whereas phase closure was significantly correlated to the grade of dysphonia (Table 4).

**Discussion**

Accurate history taking, clinical examination and up-to-date investigations allow for the accurate diagnosis and documentation of various voice disorders. Benign vocal fold lesions such as polyps and cysts impair patient’s quality of life and need dealing with urgently.

Proper differentiation between vocal fold cysts and vocal fold polyps cannot be achieved, except by a careful detailed assessment. The results of this assessment can be well understood when associated with the pathology or the nature of the voice disorder.

**Figure 5**



Distribution of LVS signs in both groups. LVS, laryngo-video-stroboscopic.

**Table 3 Comparison between group 1 and group 2 in LVS signs**

Stroboscopic signs	N (%)		P	Significance
	Group 1 (n = 21)	Group 2 (n = 26)		
Irregular vocal fold edge	4 (19)	23 (88)	<0.01	HS
Decreased amplitude	16 (76)	10 (38)	<0.05	S
Absent mucosal wave	18 (86)	2 (8)	<0.01	HS
Aperiodic vibrations	15 (71)	18 (69)	>0.05	NS
Asymmetric vibrations	18 (86)	20 (77)	>0.05	NS
Predominant closed phase	18 (86)	10 (38)	<0.05	S

Measured on the side of the lesion; HS, highly significant difference; LVS, laryngo-video-stroboscopic; NS, nonsignificant difference; S, significant difference.

**Table 4 Correlation between the rated LVS signs and the grade of dysphonia**

Stroboscopic signs	Grade of dysphonia	
	R	P
Irregularity of the edge	0.82	<0.01**
Amplitude of vibration	-0.26	0.077
Mucosal wave	0.21	0.15
Vibration characteristics	0.23	0.12
Periodicity	0.16	0.28
Symmetry	0.62	<0.01**
Phase closure	0.37	<0.05*

Measured on the side of the lesion; LVS, laryngo-video-stroboscopic; \*Significant P < 0.05; \*\*Highly significant P < 0.01.

The results of the present study showed a significant difference in the grade of dysphonia between groups of patients with vocal fold cysts and those with vocal fold polyps. This could be attributed to the different histopathological origin and the hyperfunctional vocal behavior of the patients.

As is known, there are two common types of vocal fold cysts: mucus-retention cysts, which result from obstruction of a glandular duct, and epidermoid cysts (congenital and acquired), in which epithelial cells are buried in the superficial layer of the lamina propria. Thus, both types arise from the superficial layer of the lamina propria (Reinke’s space) [8], leaving mucosa over them usually intact or just stretched. This can

explain the mild or the moderate degree of dysphonia that usually accompanies vocal fold cysts. The reverse occurs in case of vocal fold polyps that arise from the vocal fold mucosa itself, leading to more severe mucosal changes and more severe degrees of dysphonia [12].

Acoustic analysis is an objective tool for the assessment of voice, whereas APA is a subjective tool. The results of comparison between the group of patients with vocal fold cysts and the group of patients with vocal fold polyps in terms of acoustic parameters confirmed the results of comparison of the grade of dysphonia, which is an item from APA. There were significant differences in some acoustic parameters, especially those related to frequency such as fundamental frequency ( $F_0$ ) (in the male subgroup),  $jitt\%$  (in both male and female subgroups), which refers to a very short period-to-period variability in frequency, and the RAP (in both male and female subgroups), that enables an evaluation of the variability of the pitch period within the voice sample analyzed at a smoothing factor of three periods. Therefore, in this study, both subjective and objective tools for voice assessment showed significant differences between both groups of patients with voice disorders. These differences can also be attributed to the different histopathological origin of the disorder. Jitter is one of the main measures for microinstability in vocal fold vibrations. Even very small growths on vocal folds, such as small polyps, may influence frequency perturbation, which increases as control and is related to perceived vocal effort and the hyperfunctional vocal behavior of the patient [13,14].

Although LVS assessment has been an important feature of the assessment of voice disorders for more than 100 years, it is still used routinely. Common stroboscopic signs are assessed in all cases without deciding which stroboscopic signs are more clinically relevant to certain types of voice disorders [12,15]. In this study, not all of the stroboscopic signs showed significant differences between both groups. Irregular vocal fold edges and absent mucosal wave over the lesion showed highly significant differences. Decreased amplitude of vibrations and predominant closed phase showed significant differences. The rest of the LVS signs measured showed nonsignificant differences. These signs are asymmetric vibrations and aperiodic vibrations. These results indicate that the signs that show significant or highly significant differences can be used for differentiation between vocal fold cysts and polyps. The rest of the signs cannot be used for differentiation as they have the same common findings in both groups.

Finally, in this study, the results of the correlation between the rated LVS signs and the grade of dysphonia showed that not all LVS were correlated to the degree of dysphonia. Irregularity of the vocal fold

edges and symmetry between vocal folds showed a highly significant correlation to the grade of dysphonia, whereas phase closure was correlated significantly to the grade of dysphonia. These results are useful for identification of the factors responsible for dysphonia and its severity in cases of vocal fold cysts and polyps and any voice disorder with the same or a similar nature, for example other MAPLs. It appears that ratings of amplitude of vibration, mucosal wave, vibratory characteristics, and periodicity were not important. This is a surprising finding, especially as ratings of the mucosal wave have always been reported to be useful in the assessment of vocal fold function and dysfunction. This can explain the fact that, although the mucosal wave over the lesion is usually absent in vocal fold cysts, the degree of dysphonia is usually mild or moderate.

Although these signs are not important in this type of voice disorders (MAPLs), they may be more useful for other kinds of voice disorders including paralysis, functional voice problems, or neurological problems of the voice [12].

On the basis of these results, it is clear that some of the LVS signs are related to vibrations and some are related to edge (vibration and edge). This classification can be used to differentiate between different categories of vocal fold pathology [7]. Vibration factors may be more responsible for the severity of dysphonia in cases of vocal fold paralysis, functional voice problems, and neurological problems, whereas edge factors may be more responsible for the severity of dysphonia in cases of MAPLs.

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## Conclusion

The results of assessment of voice in vocal fold cysts and polyps are related to the nature and the pathology of the disorder. Irregular vocal fold edges observed in cases of vocal fold polyps and absent mucosal wave over the lesion in cases of vocal fold cysts were highly significantly different between the two groups. Stroboscopic signs correlated to the severity of dysphonia in cases of vocal fold polyps and cysts were irregularity of the vocal fold edges and symmetry between vocal folds. However, vibration factors may be more responsible for the severity of dysphonia in other cases not included in the present study such as cases of vocal fold paralysis, functional voice problems, and neurological problems.

## Recommendation

On the basis of this study, we can recommend classification of LVS into fewer signs that can

effectively describe the dysphonia of different MAPLs. Further studies on other types of voice disorders are required to clarify this possibility.

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## Acknowledgements

### Conflicts of interest

There are no conflicts of interest.

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