Images of Benign Vocal Fold Lesions Using Videokymogram

Cheol-Min Ahn · Seon-Young Yoon · Duk-Hee Chung*

ABSTRACT

Examination of the vibrations of the vocal fold is very important in patients with voice changes. The newly developed videokymography (VKG) takes images in real time and records irregular vibrations of the vocal fold. However, there are few data on VKG findings. We studied VKG to evaluate the vibratory characteristics of the vocal fold in benign vocal fold lesions. Unique vibratory patterns, blurred demarcation of the mucosal propagation, decreased margin amplitudes, asymmetry in phase or amplitude, and a level difference of the contact site were observed in each benign vocal-fold lesion. We conclude that each type of laryngeal lesion has specific characteristic which are revealed by VKG examination, these parameters can be quantified and used to objectively evaluate VKG findings. Based on these results, VKG can be used as a supplementary diagnostic tool.

Keywords: Videokymography, vocal fold lesion-Vibration-Mucosal wave-Supple mentary

1. INTRODUCTION

Studies about the physiology of phonation or voice disorders have increased since it was revealed that the quality of voice was produced by vibrations of the vocal-fold mucosa [1]. Especially, in patients with voice changes, examination of the vocal folds has significance. However, the vocal folds are difficult to see because they are placed inside of the neck, so the visualization of the vocal folds is not easy. Laryngoscopic observation of the vocal folds allows effective visualization of vocal-fold vibration. Stroboscopy is also used to investigate the vibration of the vocal folds, but it has limitations of usage. Several methods of investigating vocal-fold vibrations, ultra-high-speed photography and digital high-speed imaging systems, have been (VKG) system (Model 8900, Kay Elemetrics, Lincoln Park, N.J., U.S.A.), which records developed, but are not commercially available [2-4]. Recently, a Videokymography real-time images and irregular vibrations of the vocal folds, was developed. Clinicians can benefit from the information regarding vocal-fold dynamics gained by using this

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powerful technique. However, objective and quantitative parameters will be required to evaluate the VKG findings in vocal-fold lesions, yet there are no known specific parameters or findings for subjects with normal or diseased vocal folds. As a pilot effort, we studied VKG to identify parameters that could be used to evaluate the VKG findings for subjects with normal or diseased vocal folds.

2. MATERIALS AND METHODS

The subjects consisted of two groups: Patients who visited our outpatient clinic because of voice changes, and normal persons. Each subject was evaluated by using stroboscopy prior to performing VKG to detect laryngeal lesions and mucosal pathologies. The laryngoscopic and stroboscopic images served as a basis for selecting the line image of interest in the VKG. One hundred (100) patients (54 males and 36 females, aged to 18 to 67 years old) with various functional and benign organic voice disorders and twenty (20) normal subjects (10 males and 10 females, aged to 21 to 45 years old) were examined. In the patients with voice changes, evaluated laryngeal lesions were as follows: laryngeal nodules (37 patients), laryngeal polyps (20 patients), sulcus vocalis (7 patients), Reinke edema (19 patients), functional dysphonia (9 patients), unilateral vocal-fold palsy (7 patients), and dysphonia plica ventricularis (1 patient).

The VKG recordings were performed using a two-mode system. Laryngeal lesions were visualized in the commercial video-camera mode, and a line-scan mode was used for the center of the lesion. All findings were recorded on an s-VHS video recorder (Panasonic AG 7355, Panasonic Matsushita Electric Industrial Co., Ltd., Tokyo, Japan) and were reviewed in detail with playback images. In the VKG images, the authors evaluated the vibration patterns by using the following parameters: the periodicity, which is defined as the period of the vocal-fold vibration; the degree of the demarcation between the upper margin and the lower margin, a sharp edge in the normal mucosa of the vocal folds or a blunt edge in a pathologic mucosa, with cysts, nodules, etc.; the propagation of mucosal waves, which indicates the presence of mucosal waves in the vocal folds; the amplitude ratio which is the ratio of the width of the lateral excursion of the upper margin to that of the lower margin; the asymmetry (in amplitude and in phase); the contact ratios of the upper and the lower margins, which are the ratios of the contact time of a margin to the total time that the same margin is seen during one vibration of the vocal folds; the site of the contact area, the lower margin, the lower to medial margin, the medial to upper margin, and the lower to upper margin; and the shape of contact area, a folded contact area or a non-folded contact area. The authors used the above parameters to describe the VKG findings, and the common VKG

findings were described for various benign lesions. However, only ease of phonation was used for evaluating laryngeal diseases in this study.

3. RESULTS

In normal subjects, periodic and symmetric mucosal waves were seen in both vocal folds. The upper margin and the lower margin were clearly divided, and the upper margin had a wider amplitude. Contact sites were observed from the lower to the upper margin of the vocal folds, and the contact area was folded upward in the medial side of the upper margin. The amplitude ratio was 1/3 to 1/2 of the upper margin amplitude.

In cases of laryngeal nodules located in the lower margin of the vocal folds, the upper margins did not contact each other; contact was noticed in the middle and the lower margins of the vocal folds. Demarcation of the upper and the lower margins was clearly noted. Mucosal propagation was symmetric and periodic. A decreased amplitude ratio was found in comparison with the normal findings. Folded upper margins were observed.

In cases of laryngeal nodules spread through the upper and the lower margins of the vocal folds, the demarcation of the margins was obscured, and round-shaped mucosal waves were noted. Propagation of the mucosal waves was relatively symmetric and periodic. The amplitude ratio was also decreased, and the folded medial margin disappeared (Fig. 1).

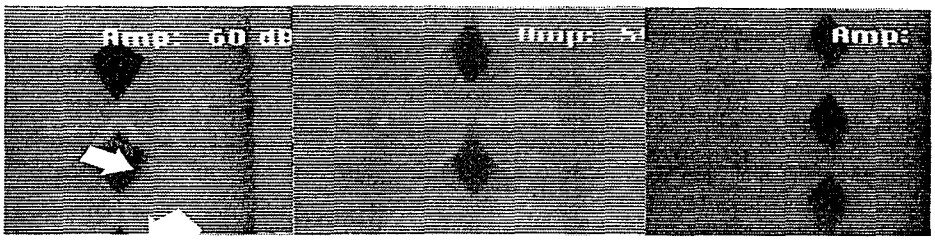

Fig. 1. Left The VKG findings in normal subjects. Middle: The VKG findings for a bilateral vocal-fold nodule located in the mid to lower surface of the vocal folds. A gap was noticed between both upper margins during contact. Right: The VKG findings for a bilateral vocal-fold nodule located in the lower to upper surface of the vocal folds. Loss of demarcation of the margins and a decreased amplitude were noticed. Small arrow: lower margin, Large arrow: upper margin.

In cases of large vocal polyps, no mucosal propagation occurred at the polyp site. A slightly obscured demarcation of the opposite site was noticed, and the mucosal

propagation was periodic. Asymmetries between the vocal folds were observed both in the amplitude and in the phase.

In cases of sulcus vocalis, a dark sulcus line was seen in the middle aspect of the vocal fold. A slightly obscured demarcation of the upper margin and a decreased amplitude ratio were noticed. Also, an asymmetry in the amplitude was noticed, and the mucosal propagation was relatively periodic.

In cases of Reinke's edema, multiple lobulated and diffuse swellings were observed on both upper margins. A movement of the edema, instead of the mucosal waves, was observed on both vocal folds. The amplitude ratio was markedly decreased. During one cycle, we could see mostly the upper margin of the vocal folds. The lower margin was noticed only for a short time (Fig. 2).

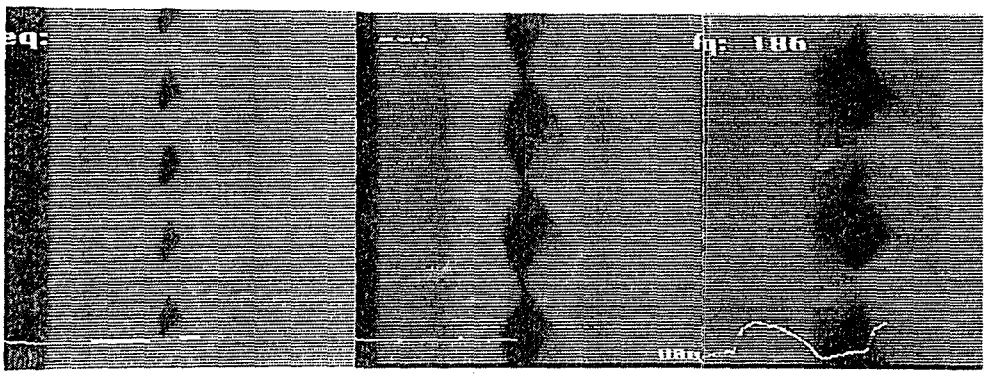

Fig. 2. Left: The VKG findings for a right vocal-fold polyp. Propagation of the mucosal waves disappeared totally in the polyp site. Asymmetry of the amplitude was revealed. Middle: The VKG findings for left sulcus vocalis. A dark sulcus line was noticed. Rigit: The VKG findings for Reinke's edema. Propagation of the mucosal waves disappeared. Loss of demarcation and a decreased amplitude were noticed.

In cases of voice changes for which laryngeal lesions had not been visualized by using stroboscopy (functional dysphonia), asymmetries in the amplitude and in the phase were noticed. Propagation of the mucosal waves was periodic, and the shape of the right mucosal waves was different from that of the left mucosal waves. The closing time of the left upper margin was longer than that of the opposite site. Demarcation of the margins was obscured, and the amplitude ratio was decreased in one side.

In cases of unilateral vocal-fold paralysis because of recurrent laryngeal nerve injury, propagation of mucosal waves was periodic in normal vocal folds, and the amplitude had a normal appearance.

However, at a paralysis site, a markedly decreased amplitude ratio and an obscured

demarcation between margins were noticed. Asymmetries in the phase and the amplitude were also noticed.

In cases of dysphonia plica ventricularis, only mucosal waves of false vocal folds were noticed (Fig. 3). The results for the contact ratio were variable and depended on the scanning site and the phonation type in all cases.

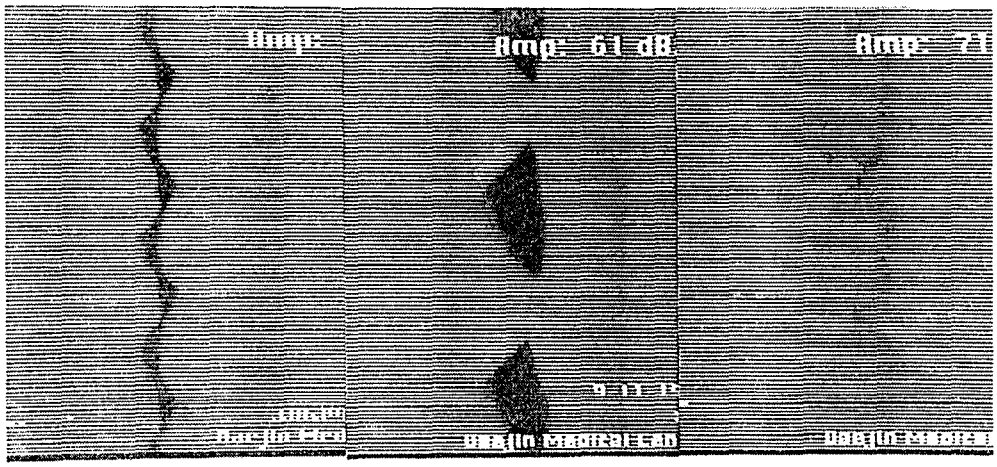

Fig. 3. Left: The VKG findings for functional dysphonia. Asymmetry in the phase was noticed. The closing time of the right upper margin was longer than that of the opposite site. Middle: The VKG findings for left recurrent laryngeal nerve paralysis. Total loss of the mucosal waves was revealed at the paralyzed site. Asymmetry in the amplitude was revealed. Right: The VKG findings for dysphonia plica ventricularis. The mucosal waves of the true vocal were not seen. Only the propagation of false vocal

4. DISCUSSION AND CONCLUSIONS

Voice quality is determined by the vibrations of the vocal folds. Therefore, visualization of the vibratory characteristics of the vocal folds is very important when clinicians want to know the causes of voice changes or want to evaluate the dynamics of the vocal-fold mucosa. However, vibrations of the vocal folds are too fast for the delicate movements to be seen with the naked eye. Therefore, the laryngologists and researchers need special equipment to be able to see the fast vibrations of the vocal folds. Stroboscopy made it possible for many clinicians and researchers to investigate the vibration patterns of vocal folds. However, the most important limitation of stroboscopy is that it can be used only for periodic vibrations of the vocal folds. Also, the records are not real-time images. Since the frequency range of the human voice is

70 to 1,000 Hz and since commercial video cameras can record 50 or 60 images in a second [1,3], stroboscopy with some technical manipulation was used to create a false slow-motion image of the vocal folds [5,8]. Several methods for directly visualizing the vibrations of the vocal folds have been developed; however, none of them are commercially available or widely used.

Recently, VKG was developed for direct observation of vocal-fold vibratory characteristics. VKG achieves a frequency of 7812.5 Hz, which is enough to cover the whole frequency range of the human vocal folds [1]. Also, the VKG camera can work in two modes. In the first mode, the system functions as a normal commercial video camera and records 50-60 images in a second. In the second mode, it is possible to record images of a chosen cross-section of the vocal folds at a rate of 7812.5 images in a second [3]. VKG allows direct observations of vocal-fold vibrations, voicing initiation, diplophonia, biphonia, vocal fry, creaky voices, and aperiodicity with real-time images and depicts the pattern in one image.

Objective parameters should be used to quantify the VKG findings. Since the VKG images reflect important properties of the vocal-fold vibrations, including the open and the closed phases of the glottal cycle, the opening and the closing movements, the displacements of the upper and the lower vocal-fold margins, and the propagation of mucosal waves, the important observable parameters are the frequency, the amplitude of a vocal-fold vibration, the left-right asymmetries, the open and the closed phases of the glottal cycle, and the propagation of mucosal waves. Peculiar VKG characteristics were investigated for each benign vocal-fold lesion, and several parameters were identified. However, the contact time showed too much variation, depending on the type of phonation or the scanning site, so we could not use the contact time as a parameter. Other parameters were noticed to have some variation, but the deviations were not so great. The VKG findings can differ, depending on the scanning site. The vibratory pattern changes along the glottal length in both cases of organic pathology and cases of a normal larynx. The authors tried to obtained VKG findings from a scan in the center of the lesion in order to decrease the variation with the scanning site. The authors thought VKG should be studied to identify the proper parameters based on types of phonation, scanning sites, etc.

The site of the lesion, especially in the upper or the lower margin of the vocal folds, was difficult to classify because light reflection from the mucus of the vocal folds disturbed the observation or because demarcation was difficult to see when viewing from above with stroboscopy. VKG examination helped distinguish the site of lesion, whether the lesion was in the upper margin or the lower margin. VKG findings for lesions demonstrated a gap on the medial aspect of the upper margin in cases with vocal nodules located in the mid to lower margin of the vocal folds. The amplitude ratio

between the upper margin and the lower margin could be calculated separately. However, this ratio showed some variation with the type of lesion and from subject to subject even though the subjects had the same type of lesion.

Obscured demarcation, round-shaped mucosal folds, and a decreased amplitude ratio can be used to distinguish between normal vocal folds and slightly edematous vocal folds which are difficult to diagnose in a general examination. The common findings of slightly edematous vocal folds were loss of demarcation of the margins, a decreased amplitude ratio, and asymmetries in the phase and in the amplitude. In cases of patients with voice changes, but for whom no specific findings had been noticed during the usual examination, we found some characteristic findings when we observed the vocal folds by using VKG: for example, asymmetry in the phase or in the amplitude during sustained vowels, and different starts for the mucosal waves on the voice onset period. Those specific VKG findings were easily detected.

The authors think that VKG can be a helpful diagnostic tool, especially in cases with minimal lesions that can be difficult to detect with general diagnostic tools. In the future, the minimal differences between the left and the right vibration patterns might help to explain in more detail the pathophysiological mechanisms in voice disorders. The VKG approach considerably enriches stroboscopy by clarifying, as well as adding precision to, the stroboscopic results [3]. Various and specific VKG findings were observed in every case of laryngeal disease.

The authors conclude that VKG can be used as a supplementary diagnostic tool for various laryngeal diseases, not as a single diagnostic tool. Also, multiple, specific parameters can be quantified and used as objective parameters for evaluating VKG findings.

REFRERENCES

[1] Svec J. G., Schutte H. K. 1996. "Videokymography: High-speed line scanning of vocal fold vibration." *J. Voice 2,* 201-205.

[2] Hirose H. 1998. "High speed digital imaging of vocal fold vibration." *Acta Otolaryngol (Stockh)* Suppl. 458, 151-153.

[3] Schutte H. K., Svec J. G., Sram F.1998. "First results of clinical application of videokymography." *Laryngoscope* 108(8), 1206-1210.

[4] Hess M. M., Gross M. 1993. "High-speed, light-intensified digital imaging of vocal fold vibrations in high optical resolution via indirect microlaryngoscopy." *Ann Otol Rhinol Laryngol* 102, 502-507.

[5] Casiano R. R., Zaveri V. Lundy D. S., 1992. "Efficacy of videostroboscopy in the diagnosis of voice disorders." *Otolaryngol Head Neck Surg* 107, 95-100.

[6] Colton R. H., Woo P., Brewer D. W., Griffin B., Casper J. 1995. "Stroboscopic signs associated with benign lesions of the vocal folds. *J. Voice* 9, 312-325.

[7] Woo P., Casper J., Colton R., Brewer D. 1994. "Aerodynamic and stroboscopic findings before and after microlaryngeal phonosurgery." *J. Voice* 8, 186-194.
[8] Yanagisawa E., Yanagisawa K. 1993. "Stroboscopic videolaryngoscopy: a comparison of fiberscopic and telescopic documentation." *Ann Otol Rhinol Laryngol* 102, 255-265.

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