

Chapter 23

The role of VSK in the assessment of voice disorders

Agata Szkiełkowska & Beata Miaśkiewicz

Abstract

Imaging techniques of the vocal fold (VF) vibration include laryngovideostroboscopy (LVS) and now high-speed digital imaging (HSDI). To obtain parametric assessment of the vibratory process, new supplementary techniques based on kymography are being developed. Currently these are: 1) digital kymography (DKG), 2) videokymography (VKG), and 3) videostrobokymography (VSK). Kymography enables assessment of vibrations of the VF at the selected glottic locations. Therefore, kymography creates a new diagnostic potential for the objective documentation and monitoring of VF vibrations.

Keywords: *laryngovideostroboscopy, HSDI, kymography, dysphonias*

Introduction

For over 150 years clinicians tried to capture the behavior of the VF to understand more completely how they behave in dysphonia and in health. This quest began in 1855 with the first observations of the larynx with a mirror during phonation by Manuel Garcia, a Spanish voice teacher. Two years later, Ludwig Turck, a neurologist from Vienna, and Johann Czermak, a physiologist from Prague, introduced mirror laryngoscopy into clinical practice [1]. In 1878, Max J. Oertel in Belgium was the first to use a stroboscopic principle to examine the human larynx in action. He used a perforated disk illuminated with a candle and a laryngeal mirror, which allowed him to view the vibrating, enabling visualization of open and closed phases. Because of the technical difficulties with early stroboscopes, many decades elapsed before stroboscopy could be clinically feasible and useful [2]. A different breakthrough was made by researchers from Telephone Bell Company in 1937, who recorded the phonatory process using a high-speed camera at a frame rate of 4000 f/s. This achievement provided better understanding of the mechanism of VF vibration and initiated development of the high-speed imaging [3]. Later the ultra-high speed filmography work of Moore and von Leden (1956) revolutionized our understanding of glottic behavior and opened the road for the current HSDI technology. Applicability of these diagnostic methods, including their advantages and limitations are well appreciated [4]. Also, processing of the images remained cumbersome.

Hence, for an objective parametric assessment of the laryngeal function, supplementary techniques have been developed. For example, Gall and Hanson [5] first introduced photographic kymography (photokymography), which was not limited to periodic vibration. However, due to the extremely time-consuming examination process, their technique was not practical for routine clinical diagnostic procedures [6-7]. Further development of this technique led to the introduction of videokymography (VKG) and videostrobokymography (VSK) [8-9]. Depending on different techniques used to capture VF vibrations, different recording rates (30-16000 f/s) and methods of data analysis. Currently available kymographic techniques include DKG, VKG, and VSK.

The basic principle of kymography

The basic principle of kymography enables assessment of the vibrations of the selected part of the VF. Images are extracted from each video frame by placing a demarcation line over the area of interest and then displayed one by one in a zipper-like sequence (Figure 1). The vertical dimension of such image represents the time, the left and right VF are displaying as one-dimensional, horizontal oscillations representing the movements of the VF.

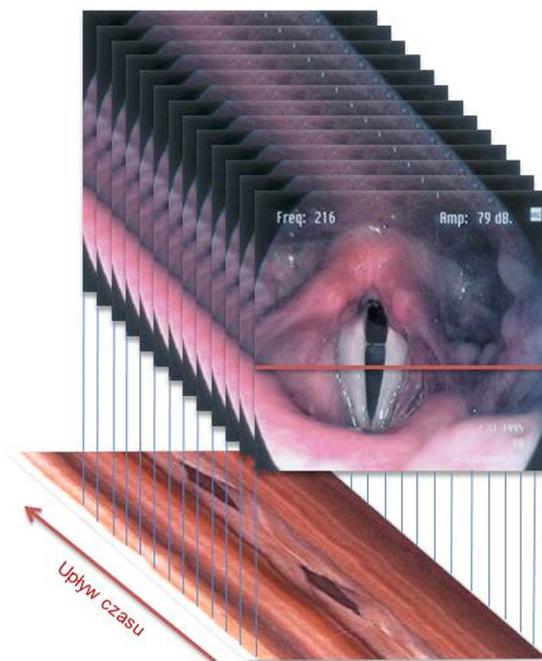


Figure 1. Kymogram image from the normal glottis. The arrow shows the direction of time.

DKG uses full frame images obtained by HSDI and analyzes these frames by using specialized software that allow the placement of multiple lines perpendicular to the glottis. [10]. Some systems, allow for angle correction and the ability to check for camera view blockage by the epiglottis or by the arytenoids before selecting a line across the glottis. DKG is suitable for the qualitative and quantitative analysis and provides information about: 1) the open and closed quotient, 2) the left-right or the anterior-middle-posterior symmetry, 3) the phase differences, and 4) the vibratory amplitude.

VKG is yet another improvement of the basic kymography. VKG is the real-time imaging technique that uses a specially adapted video camera (i.e., charge-couple device) that can scan a single kymographic line placed across the glottic image at a high-speed rates. Instead of frame-by-frame display, the oscillations are displayed in a single picture. Basic qualitative features detected by using VKG are: glottal contour, opening and closing, medial and lateral peaks (or ventricular folds), and mucosal wave (e.g., frequency and amplitude of vibrations, left-right symmetry, phase differences). This system cannot select and display multiple lines during the monitoring of VF vibration, and thus does not allow assessment of vibrations of the different selected parts of the VF [8, 11].

VSK is a hybrid analysis system applying videokymography to laryngovideostroboscopic images (LVS) [12]. VSK enables making kymograms from multiple perpendicular lines placed on the recorded LVS image at the specific points of interest to calculate objective parameters of VF vibrations. These parameters are open quotient (OQ) and closed quotient (CQ). In some devices an asymmetry index (AI) can be obtained [9, 13].

Anterior–posterior symmetry can be measured by comparing kymograms from selected lines of the same video segment. However, since the LVS images are recorded at the rate of about 30 f/s, VSK cannot create kymograms of aperiodic vibrations because of the inherent problems of LVS [9-12]. VSK technology is however clinically useful, as it enhances diagnosis, reduces post-recording processing time inherent to HSDI, and provides a more in-depth analysis at a much reduced cost of equipment (Table 1).

VKG is less time-consuming and less expensive than DKG, but its diagnostic value and applications in clinical practice are inferior because: 1) VKG does not allow simultaneous assessment of vibrations from different parts of the VF and 2) calculation of objective parameters is not possible. Yet, VSK is a simple and cost-efficient diagnostic method despite its main limitation (i.e., lack of aperiodic vibration assessment) [9-10, 14].

Table 1. Comparison of current mucosal wave imaging techniques.

Technique	Frame rate	Time of analysis	Multi-slice assessment	Time of examination	Cost	Objective measurements
VKG	8000 f/s	During recording/examination	Impossible	Time consuming	High	Impossible
DKG	4000 f/s	Post recording	Possible	Very time consuming	Very High	Possible
VSK	25-30 f/s	Post recording	Possible	Time efficient	Feasible	Possible

Conclusions

Kymography creates new diagnostic potentials for the objective documentation and monitoring of VF vibrations in clinical practice.

References

1. Turck, L., Czermak, J., 1908. The Turck-Czermak jubilee. *Br. Med. J.* 1, 1059-1061.
2. Von Leden, H., 1961. The electronic synchron-stroboscope, its value for the practicing laryngologist. *Ann. Otol. Rhinol. Laryngol.* 70, 881-893.
3. Farnsworth, D., 1940. High speed motion pictures of the human vocal cords (and film). *Bell Lab. Rec.* 18, 203-208.
4. Larsson, H., Hertegård, S., Lindestad, P., Hammarberg, B., 2000. Vocal fold vibrations: High-speed imaging, kymography, and acoustic analysis: A preliminary report. *Laryngoscope* 110, 2117-2122.
5. Gall, V., Hanson, J., 1973. Bestimmung physikalischer parameter der Stimmlippschwingungen mit hilfe der Laryngxphotokymographie. *Folia Phoniatr. (Basel)* 25, 450-459.
6. Qiu, Q., Schutte, H., Gu, L., Yu, Q., 2003. An automatic method to quantify the vibration properties of human vocal folds via videokymography. *Folia Phoniatr. Logop.* 55, 128-136.
7. Qiu, Q., Schutte, H., 2006. A new generation videokymography for routine clinical vocal-fold examination. *Laryngoscope* 116, 1824-1828.

8. Švec, J., Schutte, H., 1996. Videokymography: High-speed line scanning of vocal fold vibration. *J. Voice* 10, 201-205.
9. Sung, M., et al., 1999. Videostrobokymography: A new method for the quantitative analysis of vocal fold vibration. *Laryngoscope* 109, 1859-1863.
10. Krausert, C., et al., 2011. Mucosal wave measurement and visualization techniques. *J. Voice* 25, 395-405.
11. Lee, J., et al., 2001. A method for assessing the regional vibratory pattern of vocal folds by analysing the video recording of stroboscopy. *Med. Biol. Eng. Comput.* 39, 273–278.
12. Izdebski, K., 2012. Clinical voice assessment: The role and value of the phonatory function studies, in: Lalwani, A. (Ed.), *Current Diagnosis & Treatment Otolaryngology—Head and Neck Surgery*. Lange Publications, New York, pp. 416-429.
13. Mendelsohn, A., Sung, M., Berke, G., Chhetri, D., 2007. Strobokymographic and videostroboscopic analysis of vocal fold motion in unilateral superior laryngeal nerve paralysis. *Ann. Otol. Rhinol. Laryngol.* 116, 85-91.
14. Piazza, C., et al., 2012. Quantitative analysis of videokymography in normal and pathological vocal folds: A preliminary study. *Eur. Arch. Otorhinolaryngol.* 269, 207-212.