# High-Speed Videokymography for Voice Disorders

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Kymographic imaging refers to a special way of displaying vibrations by putting together a great number of images recorded with a single line of a video camera. The method has been found particularly well suited for laryngoscopic imaging of the vibrations of the vocal folds, which are the ultimate source of human voice. Three different kymographic methods have currently been used for displaying the vocal fold vibrations– digital high-speed kymography, videokymography and strobokymography. Digital high-speed kymography uses high-speed digital cameras delivering 1000 – 8000 images/s of the whole vocal folds and extracts the kymograms afterwards from these video recordings. Videokymography is based on a special videokymographic camera which can record both video images of the whole vocal folds at standard TV rates (50 or 60 images/s) as well as kymographic images from a single line of the vocal folds at the high-speed rates of c. 8000 images/s. Strobokymography uses standard color digital video cameras delivering 50 or 60 images/s registering the stroboscopically slowed-down motion of the vocal folds and extracts the kymograms afterwards from these video recordings.

While kymographic imaging has been recognized as a convenient, novel way to display laryngeal behavior, little systematic research has been done to map the relevant features displayed in such images. Based on videokymographic images from the archive of more than 7,000 videokymographic examinations of subjects with a wide range of voice disorders we have currently specified 10 feature categories the can be visually identified in high-speed videokymographic images when diagnosing origins of voice problems. They include refined traditional features (eg, duration of closure, vibrations of supraglottal tissues, left-right asymmetry, mucosal waves), as well as additional features that are obscured in strobolaryngoscopy (eg, different types of irregularities, left-right frequency differences, shapes of lateral and medial peaks, cycle aberrations). The variations in the identified features reveal different behavioral origins of voice disorders. The findings open new possibilities for diagnosis, objective documentation and for monitoring vocal fold behavior in clinical practice through kymographic imaging.

One of the current challenges is to automatically detect and quantify the variations of the vocal fold vibrations within the 10 feature categories so that they correspond to the visually perceived properties in the kymograms. For this, new image processing algorithms need to be developed. The ultimate long-term goal of the research is to relate the displayed vibration characteristics to the tissue properties of the vocal folds and design strategies how undesirable tissue properties can be altered through conservative or surgical treatment.

Key Words: diagnostics, high-speed imaging, laryngoscopy, videokymography, vocal fold vibration, voice disorder