Utility of Laryngeal High-speed Videoendoscopy in Clinical Voice Assessment

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Summary: Objective. This study aimed to assess the utility of laryngeal high-speed videoendoscopy (HSV) as a clinical tool.

Design. This is a prospective study of 151 patients.

Methods. A total of 151 adult patients (52 male, 99 female) underwent both videoendoscopy with stroboscopy (videostroboscopy) and HSV examination as part of a routine clinical voice assessment. At the time of the examination, ratings for videostroboscopy were reported in the clinical report. Next, the clinicians reviewed the HSV examination and indicated the changes in ratings of HSV relative to videostroboscopy. Finally, the clinical reports were reviewed by a clinician not involved in data collection or clinical care of the patients and noted differences between videostroboscopy and HSV clinical ratings, and resulting diagnoses were identified and grouped.

Results. Ratings of all vibratory features showed change between videostroboscopy and HSV. Mucosal wave and amplitude of vibration showed the largest percentage change, respectively, in 74% and 53% of the reports. They were followed by the features of glottal closure (36%), phase closure (32%), glottal edge (25%), and phase symmetry (21%). Ratings of supraglottic compression and vocal fold vertical level showed the least change between videostroboscopy and HSV. Changes in initial diagnosis owing to the inclusion of HSV were indicated in 7% of the cases.

Conclusions. HSV may be an important laryngeal imaging technique for functional assessment of the pathophysiology of certain voice disorders. HSV could enable important refinements in the diagnosis and management of vocal fold pathology.

Key Words: Voice disorders–High-speed videoendoscopy–Videostroboscopy–Vocal-fold vibration–Voice assessment.

INTRODUCTION

The value of direct visualization of laryngeal structures and vocal fold vibratory patterns to assess dysphonia is essential in the clinical realm. Currently, videoendoscopy with stroboscopy (videostroboscopy) is the most important clinical tool for instrumental voice assessment, allowing for the examination of vocal fold anatomy and physiology in individuals with voice disorders.[1] Videostroboscopy has improved overall assessment and diagnosis in individuals with voice disorders, yet videostroboscopy allows observation of periodic vocal fold vibration only. In individuals with voice disorders who present with aperiodic vocal fold vibration or intra-cycle irregularities, the stroboscopic light is unable to synchronize, and visualization and interpretation of the vibratory features of the vocal folds is lost.[2–8] The importance of assessing vibratory behaviors of the vocal folds in refinement of therapeutic and surgical interventions has been reported.[9,10] Therefore, laryngeal imaging techniques are essential for the assessment of vocal fold vibration and for the enhancement of the therapeutic and surgical voice outcomes in the clinical setting.

High-speed videoendoscopy (HSV) is a potential valuable component of clinical protocols for voice assessment and laryngeal evaluation. With significantly higher frame rates compared with videostroboscopy, HSV is able to provide true intra-cycle visualization within the vibratory cycle. On the contrary, videostroboscopy relies on a composite vibratory image sequence consisting of phases taken across many cycles.[11] Therefore, it can be expected that introducing high temporal resolution would lead to refinement of the assessment of disordered vocal fold vibration, because laryngeal imaging is not dependent on the assumption of periodicity. Other studies report such evidence.[3,7] Additionally, clinicians report equal to higher levels of confidence when rating vibratory features using simulated stroboscopy from HSV compared with videostroboscopy, further demonstrating the efficacy of HSV-based imaging.[12] The advancement of clinical protocols and the development of commercial HSV systems highly depend on providing clinical evidence for the utility and efficacy of HSV. In a research setting, videostroboscopy and HSV have been compared in both normal patients and patients with dysphonia, suggesting differences in ratings of vocal fold vibratory features.[5,13–15] However, few reports systematically document the clinical value of HSV examinations, resulting in a lack of research in realistic settings on rating the differences of vibratory features seen on videostroboscopy and HSV, and how it may affect diagnosis and treatment decision making.

The purpose of this study was to provide initial clinical evidence of the utility of HSV for voice assessment in an adult

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clinical setting. The study was designed to evaluate the added value of HSV in the evaluation of adult patients with a voice disorder. It was hypothesized that the inclusion of HSV in the clinical protocol would result in changes of the ratings of vocal fold vibratory characteristics and the initial diagnoses. The clinical adoption of HSV could provide refinements in the assessment of vocal fold vibratory characteristics that may lead to a more accurate functional assessment and diagnosis of voice disorders.

METHOD

Research design

The research design of this study was intended to replicate real-life clinical settings. Instead of implementing an experimental design with controlled independent variables, a comparative study design was carried out. This allowed the participating clinicians to implement HSV as it best complements clinical voice assessment in an active voice center, The Voice and Swallowing Center at the Charlotte Eye Ear Nose and Throat Associates (CEENTA), in Charlotte, North Carolina.

For this study, a custom-designed HSV system was implemented at the Center in 2007. An initial full-year period allowed the clinicians to be trained and become accustomed to using HSV in their daily clinical practice. In the following 4 years, HSV was used as part of the clinical voice evaluations, subsequent to perceptual assessment, acoustic analysis, and videostroboscopy.

Three voice-specialized speech-language pathologists (voice clinicians) performed initial voice assessment of incoming patients. The clinicians were instructed to use HSV following the standard clinical protocol and consent. Clinicians were also instructed to write the voice reports based on the standard clinical protocol with the addition of noting the changes in functional ratings between videostroboscopy and HSV.

Human data

Following voice-related quality of life self-assessment, medical history, self-reporting perceptual evaluation of voice quality, and acoustic analysis, each patient was examined by a voice clinician, using a 70-degree 10-mm Rigid Laryngoscope, Model 49–4072 (JEDMED Instrument Co, St. Louis, MO), via videostroboscopy with subsequent HSV examination. In both examinations, participants were instructed to produce multiple sustained phonations of the vowel /i/ at comfortable pitch and loudness. Comfortable pitch and loudness were elicited by carrying a conversation, followed by producing the sustained phonations at the same pitch and loudness. The digital videostroboscopy system used was KayPENTAX RLS 9100B (PENTAX Medical, Montvale, NJ) coupled with a 120-W xenon light source. The full videoendoscopy with stroboscopy examination recordings were several minutes in length; however, the sustained-vowel videostroboscopic portions used for evaluating the studied vibratory features were 3–5 seconds in length. The custom HSV system consisted of a Phantom v7.3 high-speed camera by Vision Research Inc (Wayne, NJ), coupled with a 300-W constant xenon light source (Model 7152A, PENTAX Medical Company). HSV examinations were recorded in color at the speed of 5512.5 frames per second (fps) (N = 122), or in monochrome at the speed of 11,025 fps (N = 29). Examination recording length for the color HSV was 4.2 seconds and for the monochrome was 3.5 seconds.

TABLE 1.
Demographics and Clinical Characteristics of the 151 Study Patients

Variable	Value	Percent, %
Sample characteristics:		
Age—median	51	
Age range	22–84	
Sample size	151	100.0
Female	99	65.6
Male	52	34.4
Primary diagnosis:		
Lesions* (total)	38	25.2
Bilateral	18	11.9
Unilateral with a reactive lesion	13	8.6
Unilateral	7	4.6
Edema	28	18.5
Dysphonia or voice disturbance	27	17.9
Laryngeal spasm	14	9.3
Paresis (bilateral)	11	7.3
Paresis (unilateral)	11	7.3
Paralysis (unilateral)	7	4.6
Reflux	5	3.3
Vocal fold weakness or bowing	4	2.7
Chronic laryngitis	2	1.3

* Lesions = nodules, cysts, polyps, leukoplakia, granuloma.

Voice assessment reports of 151 voice patients, 22–84 years of age (52 male, 99 female), were used in this study. Those data were collected in the CEENTA Voice and Swallowing Center from July 2008 to January 2012. Patients were diagnosed with a variety of voice disorders (Table 1). At CEENTA, voice clinicians complete all videostroboscopy and HSV evaluations. They have been trained to rate both the anatomical and the vibratory characteristics (physiology) of vocal fold phonation. These ratings of vocal fold phonation were then described and reported in the clinical report. All clinical videos and reports were subsequently reviewed by an otolaryngologist in consultation with the voice clinicians. This study was approved by the institutional review board of the University of South Carolina.

Measurement

As part of the established clinical protocol, eight vocal fold vibratory features were judged for differences between videostroboscopy and HSV: mucosal wave, amplitude of vibration, glottal closure pattern, phase closure, glottal edge, phase symmetry, supraglottic compression, and level of vocal fold approximation. Periodicity was not included owing to the inherent inability of videostroboscopy to evaluate this feature.[5,14] Voice clinicians were instructed to review steady-state phonation in both the videostroboscopy and the HSV samples. For the videostroboscopy examinations, the video playback software was set at 30 fps by default, whereas for the HSV examinations, the defaults were set at 30 and 60 fps for color and monochrome,