High-Speed Video or Video Stroboscopy in Adolescents: Which Sheds More Light?

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

Abstract

Objective. The primary objective of this study was to compare the utility of high-speed video (HSV) to videostroboscopy (VS) in the assessment of adolescents with normal and abnormal larynges. A secondary objective was to evaluate the ease of assessment of adolescents with HSV.

Study Design. Case series with chart review.

Setting. Tertiary academic health care center.

Subjects and Methods. This study involved a retrospective review of recordings of 7 adolescents assessed with both HSV and VS. The 14 recordings were randomized and presented to 4 groups of blinded evaluators: 2 fellowship-trained laryngologists, 2 speech language pathologists (SLP) with multiyear experience working in a voice clinic, 2 pediatric otolaryngologists, and 2 otolaryngology residents. Raters were asked to evaluate the videos using a standardized scoring tool. Raters also completed a questionnaire assessing their opinion of the HSV and VS recordings.

Results. Evaluators required more time to complete their assessment of VS recordings (2.95 min ± 2.41 min) than HSV recordings (2.31 min ± 1.92 min) (P = .004). There was no difference in ease of evaluation (P = .878) or diagnostic accuracy within evaluator groups by recording modality (P = .5).

The overall agreement between VS and HSV was moderate (kappa [SE] = 0.446 [0.029]). The debrief questionnaire revealed that 5 of 8 (62.5%) preferred VS to HSV.

Conclusion. This is the first comparative study between HSV and VS in patients under 18 years of age. HSV permitted faster evaluation than VS, but there was no difference in diagnostic accuracy between the 2 modalities. The evaluators preferred VS to HSV.

Keywords

High-speed video, stroboscopy, pediatric, children, videostroboscopy, HSV, digital imaging

Received March 7, 2014; revised July 18, 2014; accepted August 26, 2014.

Introduction

Since the 1960s, videostroboscopy (VS) has remained the primary method of evaluating vocal fold vibration and is the clinical standard for laryngeal imaging. The “slow-motion” imaging observed with VS represents a composite of images averaged over several vibratory cycles rather than real-time imaging. VS relies on periodic movement of the vocal folds and stable phonation in order to synchronize the strobe light and provide a composite image. It is only effective if the vocal folds have a single and stable fundamental frequency.¹,² High-speed video (HSV), on the other hand, creates a real-time frequency independent image with high temporal resolution. HSV was initially described in the 1940s but has remained impractical due to its high cost, illumination problems, limited recording time capacity, time-consuming analysis, and cumbersome equipment.³⁻⁵ However, due to the development of smaller, more affordable cameras, HSV can now be used in a clinical setting. It is available in color and has the ability to synchronize and compare VF vibration to acoustic data.⁴ Improved recording quality, enhanced digital storage capabilities, and semi-automatic analysis options have made this technique enticing. Some clinicians believe that enhanced visualization from HSV will allow for better evaluation of the cause of vocal fold disorders.⁴ The

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extraction, quantification, and presentation of diagnostic information derived from HSV into a clinically interpretable form, however, remain problematic.¹

Very little has been written about HSV and VS in adults, and to date, nothing has been written comparing these modalities in children. In 1 case report, HSV was shown to be superior to VS for diagnosing vocal fold paresis.⁶ In another study, good agreement between VS and HSV assessments was demonstrated in the evaluation of healthy subjects.⁷ However, when the 2 technologies were applied to patients with voice abnormalities, VS was not capable of interpreting vocal fold dysfunction in 63% of patients due to the severity of the voice disorder whereas HSV was capable of providing a diagnosis in 100% of patients.⁸ HSV can evaluate the vocal folds during phonation even for an aperiodic or highly irregular voice. Videostroboscopy cannot, by its very nature, demonstrate vocal fold vibration for that same range of pathology.

The studies mentioned in the previous paragraph were performed in adult subjects. To date, no published report has compared HSV to VS in the pediatric population. Hence, the primary objective of this study was to compare the utility of HSV to VS in the assessment of adolescents with normal and abnormal larynges. A secondary objective was to evaluate the ease of assessment of adolescents with HSV from the perspective of the laryngologist.

**Methods**

This study was approved by the Hospital for Sick Children Research Ethics Board. A retrospective review of laryngeal images obtained at a tertiary pediatric voice clinic was performed. Subjects were included if they were under 18 years of age, had both VS and HSV images recorded during the same clinic visit, and had given consent to store the recordings for future analysis.

Recordings were obtained while the subjects performed standardized vocal tasks. VS was performed using a KayPENTAX 9100B (KayPENTAX, Montvale, New Jersey) stroboscopy system and a 3 CCD chip camera. Each child performed the following tasks: sustained “eeee,” “hee” // “hee” // “hee,” low to high and high to low glide. HSV was performed using a KayPENTAX Colour High Speed Video System Model 9710 (KayPENTAX) with each child performing a sustained “eee.” Images were acquired at 2000 frames per second for 2 seconds. The diameter of the rigid endoscope used was 9 mm with a 70 degree viewing angle.

VS and HSV recordings from the eligible subjects were anonymized and a randomized order was generated. They were presented in this same randomized order to 4 different groups of evaluators blinded to the clinical diagnosis (formulated by the senior author PC using the history, examination, and both VS and HSV images): 2 fellowship-trained laryngologists, 2 speech language pathologists (SLP) with multiyear experience working in a voice clinic, 2 pediatric otolaryngologists, and 2 senior otolaryngology residents. Evaluators were permitted to review the recordings as many times as necessary. Evaluators were asked to score the videos using a standardized scoring tool. The scoring tool, developed and validated by Rosen,⁹ measures the following stroboscopic parameters: symmetry, amplitude, periodicity, nonvibratory segments, duration of closure, and closure patterns. Evaluators were also asked to record the amount of time required, the ease of evaluation using the recording (easy/moderate/difficult), and their diagnosis. A debrief questionnaire (Supplemental Appendix 1, available at www.otojournal.org) assessing their experience with laryngeal imaging and their opinion of VS and HSV was also completed.

**Statistical Methods**

Descriptive statistics are reported as means and standard deviations or counts. Comparison of continuous variables between the 2 techniques (VS and HSV) was made using a paired sample t test. Statistical significance was defined as P < .05. The accuracy of the 2 modalities was compared using Fisher’s exact test with a 2-tailed P value reported.

Kappa statistics were calculated to compare agreement within a reviewer using VS and HSV for each parameter on the assessment tool and also for the overall result. Kappa is intended to give a quantitative measure of the magnitude of agreement between observers. Similar statistics were used to compare agreement within a reviewer on the final diagnosis comparing their results for VS and HSV. Standard interpretation of kappa values were used; <0.2 is slight, 0.2 to 0.4 is fair, 0.4 to 0.6 is moderate, 0.6 to 0.8 is substantial, and 0.8 to 1.0 is almost perfect.¹⁰ All analyses were performed using SPSS statistical software (IBM SPSS Inc, version 21, Chicago, Illinois).

**Results**

Seven patients (2 male, 5 female) with a mean age 15.7 years (range, 10-17 years) met the inclusion criteria. The clinical diagnoses included normal (n = 3), bilateral membranous vocal fold lesions (BVFL) (n = 1), laryngeal papillomatosis (LPR) (n = 2), and recurrent respiratory papillomatosis (RPP) (n = 1).

Evaluators required more time to complete their assessment of VS recordings (2.95 min ± 2.41 min) than HSV recordings (2.31 min ± 1.92 min) (P = .004) (Figure 1). However, there was no difference in ease of evaluation (P = .878) (Figure 2) or diagnostic accuracy within evaluator groups by recording modality (P = .5) (Figure 3).

However, there appeared to be a trend of increasing accuracy according to the level of training and experience with VS. The chi-square trend P value for VS (looking at the trend from fellowship-trained laryngologist to speech language pathologist with voice clinic experience to pediatric otolaryngologist to resident) was .54. The highest diagnostic accuracy was observed in fellowship-trained laryngologists, followed by speech language pathologists with voice clinic experience, which supports the validity of the evaluation methodology. Hence, there appeared to be a trend toward better interpretation with more training; however, this was not statistically significant (P = .54) due to
the small sample size. This trend of improving accuracy was not evident with the HSV recordings. Chi-square trend P value for HSV (looking at the trend from fellowship-trained laryngologist to speech language pathologist with voice clinic experience to pediatric otolaryngologist to resident) was .96.

The agreement between observers (interobserver agreement) was reported using the kappa statistic (Table 1). The overall agreement between VS and HSV for the 6 stroboscopic parameters assessed was moderate (kappa [SE] = 0.446 [0.029]). Specifically, there was fair agreement for symmetry, amplitude, nonvibratory segments, as well as duration of closure. There was moderate agreement for periodicity as well as closure patterns.

The debrief questionnaire revealed that 5 of the 8 evaluators (62.5%) preferred VS over HSV. Four (50%) evaluators stated that HSV provided more information. Only 2 (25%) evaluators stated that they would use HSV routinely (1 SLP and 1 senior resident)

One subject in the current study developed temporary tongue blisters following HSV examination due to thermal injury. There were no other adverse events encountered.

**Discussion**

VS is the most widely used laryngeal imaging modality in pediatric and adult laryngology. VS allows examination with both rigid and flexible laryngoscopes. However, VS assessments are limited when used to assess aperiodic vocal fold vibration and in children who cannot tolerate rigid laryngoscopy for longer than a few seconds. HSV may represent a solution to these limitations.

Unfortunately, HSV also has inherent limitations. For example, evaluation of abduction and adduction may not be feasible due to the length of time recorded and the burden of data generated. A typical 2-second HSV recording obtained at 2000 frames per second requires 1.5 gigabytes of data. The HSV system requires a dedicated computer to support the software and process the image data. In some instances, motion abnormalities are subtle and may need to be evaluated for longer periods of time than can be captured by HSV. However, the utility of HSV in children and
adolescents and a thorough comparison to VS has not been adequately investigated.

Previous studies based on adult subjects have demonstrated that HSV is useful in detecting abnormalities in patients with abnormal vocal folds but does not add to the evaluation of normal subjects. Kendall and colleagues retrospectively studied 50 healthy adults imaged with HSV and VS and found a difference only in the evaluation of periodicity, with aperiodic vibratory characteristics noted in 30% of VS recordings (n = 15) and in only 4% of HSV recordings (n = 2) (P = .001).

Patel et al compared HSV and VS in 126 adults with epithelial, subepithelial, or neurologic disorders and found that 62% of VS recordings were non-interpretable because of the severity of the voice disorder, whereas 100% of HSV recordings were interpretable. The authors concluded that HSV provides additional important information in patients with severe dysphonia, particularly when they exhibit values exceeding 0.87% jitter, 4.4% shimmer, and a signal to noise ratio less than 15.4 on acoustic analysis.

Olthoff et al used a standardized protocol to classify vocal fold vibratory movement in 162 subjects with 324 recordings obtained with HSV and VS. The rating “not assessable” was attributed more often to VS recordings than HSV recordings (P < .001). Moreover, methodologic failures were less frequent with HSV, and the length of investigation was shorter. The investigators concluded that HSV required less time, caused fewer methodologic errors, and is more reliable for detecting functional deficits.

In the present study, evaluators were able to assess HSV recordings faster than VS recordings (2.31 min vs 2.95 min), confirming the findings of Olthoff et al. However, evaluators in our study did not find a difference in ease of evaluation and diagnostic accuracy between the 2 imaging modalities. Interestingly, there was a trend of increasing diagnostic accuracy with VS according to the level of training and experience of the evaluators. A similar trend was not detected with HSV. This likely resulted from greater variability in diagnostic accuracy in HSV evaluations. The debrief questionnaire demonstrated a clear preference for VS among the evaluators, with only 2 of the 8 evaluators suggesting that they would use HSV routinely. Only 1 of our evaluators (a fellowship-trained laryngologist) had previous experience with HSV. The lack of experience and exposure to HSV could explain why most of the evaluators preferred VS to HSV.

According to the senior author (PC), who performed all rigid laryngoscopies with VS and HSV, there were several limitations experienced with the HSV equipment: (1) Recordings were technically more challenging to obtain; (2) the product software was relatively more complex; (3) acquisition of recordings was more challenging and time-consuming, which was problematic in the younger subjects; (4) adequate lighting required the use of a larger rigid endoscope and was very dependent on accurate positioning; and (5) there were significant temperature increases at the tip of the telescope generated by the HSV light source. This increase in temperature was very rapid with endoscopes with a diameter less than 9 mm, which prevented their use in this cohort of subjects. Caution is also recommended with adult size endoscopes.

One subject in the current study developed temporary tongue blisters following HSV examination due to thermal injury while using a 9 mm endoscope. The injury was not immediately appreciated due to the use of local anesthetic applied to the oral cavity. Given that examination of children is more difficult and time-consuming, the risk of thermal injury is increased. The risk of thermal injury can be decreased by selecting patients who tolerate rigid endoscopy well, manually decreasing light intensity on the light source, using larger endoscopes, and allowing the equipment to cool between endoscopy attempts. HSV should not be used in children who require endoscopes with a diameter smaller than 9 mm.

Table 1. The Overall Agreement between Videostroboscopy (VS) and High-speed Video (HSV) Using the Kappa Statistic for the 6 Stroboscopic Parameters Assessed Was Moderate (Kappa [SE] = 0.446 [0.029]).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Kappa Statistic (SE) for Agreement between VS and HSV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetry</td>
<td>.384 (.087)</td>
</tr>
<tr>
<td>Amplitude</td>
<td>.297 (.064)</td>
</tr>
<tr>
<td>Periodicity</td>
<td>.463 (.069)</td>
</tr>
<tr>
<td>Nonvibratory segments</td>
<td>.381 (.066)</td>
</tr>
<tr>
<td>Duration of closure</td>
<td>.344 (.095)</td>
</tr>
<tr>
<td>Closure pattern</td>
<td>.588 (.081)</td>
</tr>
<tr>
<td>Overall</td>
<td>.446 (.029)</td>
</tr>
</tbody>
</table>

Conclusion

In summary, this is the first comparative study between HSV and VS in subjects under 18 years of age. The evaluators in this study preferred VS over HSV, which is possibly due to past experience with VS. Obtaining images with HSV was more technically challenging in younger patients, required a dedicated computer, and presented a risk of thermal injury. The findings of this study do not support the routine use of HSV in children and adolescents. Further technical and software improvements are required before HSV replaces VS for routine laryngeal imaging. This is a preliminary study. Studies with larger patient populations and a larger variety of vocal fold abnormalities are required to further investigate the utility of HSV in the pediatric population.

Acknowledgments

The authors acknowledge the contributions of Drs A. Wong, M. Shah, V. Forte, M. Merdad, and A. Grewal for reviewing and scoring the laryngeal recordings.
Author Contributions

Tulika Shinghal, study design, collection of data, statistical analysis, and the drafting and revisions of the manuscript; Aaron Low, evaluation of videos and revision of manuscript; Laurie Russell, evaluation of videos and revision of manuscript; Evan J. Propst, evaluation of videos and review of manuscript; Antoine Eskander, statistical analysis and review of manuscript; Paolo Campisi, study design, collection of data, statistical analysis, and the drafting and revisions of the manuscript.

Disclosures

Competing interests: Paolo Campisi, OtoSim Corp. Stocks owned. No relationship to this study.
Sponsorships: None.
Funding source: None.

Supplemental Material

Additional supporting information may be found at http://otojournal.org/supplemental.

References