TSHA Practice Brief: Performing an Economical Acoustic and Aerodynamic Voice Assessment—Can It Be Done

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The diagnostic voice evaluation serves multiple purposes: to identify a voice disorder; to identify the extent and nature of the disorder and the etiology, physiology, and/or behavioral factors underlying the disorder; and to develop a treatment plan (Roy et al., 2013; Stemple, Roy, & Klaben, 2014). In order to provide a complete picture of the disorder, a comprehensive voice assessment should include a thorough case history, an examination of the oral peripheral mechanism, and completion of the five domains of assessment: an auditory-perceptual evaluation, acoustic assessment, aerodynamic assessment, vocal fold imaging, and patient self-assessment (Roy et al., 2013).

Over the past decade, the American Speech-Language-Hearing Association (ASHA) ASHA Special Interest Group for Voice and Voice Disorders (SIG 3; previously Special Interest Division 3) has been working to create standard guidelines for voice assessment and, as a part of this process, developed the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) (Kempster, Gerratt, Verdolini Abbott, Barkmeier-Kraemer, & Hillman, 2009), performed a systematic review on evidence-based clinical voice assessment, and recently published a tutorial on performing instrumental assessment of voice (Patel et al., 2018). While the tutorial identifies technical specifications, stimuli, and assessment measures, many clinicians are often intimidated by the cost of equipment required for the instrumental portion of the assessment and therefore miss out on this critical piece of information.

Instrumental Assessment

Multiple instruments are available for assessment of the voice and vocal folds. These include software and equipment for acoustic and aerodynamic recording, laryngeal imaging, inverse filtering, electroglottography (EGG), and laryngeal electromyography (LEMG). The latter three instruments are not used in routine clinical assessment and hence will not be included in the discussion here. Laryngeal imaging studies, specifically videostroboscopic exams, should be obtained from the otolaryngologist if the clinician does not have the equipment or training to perform them. The focus of this article will be on acoustic and aerodynamic assessment, and the aim of this article will be to identify economical, low-cost tools when available.

Acoustic Assessment

Acoustic measures are objective, noninvasive measures aimed at identifying vocal abnormality, corroborating auditory-perceptual judgment, and providing a better understanding of the underlying physiology (Patel et al., 2018; Stemple et al., 2014). There are innumerable software and web-based applications (apps) that perform acoustic measures primarily on frequency (mean, standard deviation, range), intensity (mean, standard deviation, range), and quality i.e., perturbation measures (jitter, shimmer) and signal/harmonic-to-noise ratio using a time-based algorithm. More recently, researchers and clinicians are moving away from time-based measures and utilizing frequency-based cepstral measures for acoustic analyses. Cepstral peak prominence measures for vowel and speech (CPP) are more robust and allow for measurement even in significantly aperiodic voice signals while using sustained vowels and continuous speech. Perturbation and noise measures require a periodic signal and are limited to a vowel phonation in patients with mild to moderately severe hoarseness. Clinicians unfamiliar with cepstral measures are referred to more detailed articles for a thorough understanding (Awan, Roy, & Dromey, 2009; Maryn, Roy, De Bodt, Van Cauwenberge, & Corthals, 2009; Watts, Awan, & Maryn, 2017a).

The value of acoustic measurement depends on the quality of the recordings and the analyses as well as its comparison to the appropriate normative measures. It is imperative that the clinician pays attention to the ambient noise (measured using a sound-level meter) and the equipment used (microphone, recorder, sound-level meter, computer processor, etc.). The readers are referred to the tutorial by Patel et al., 2018, on the ideal specifications for equipment and the stimuli. Some common acoustic software include the MultiDimensional Voice Program (MDVP) and the Analysis of Dysphonia in Speech and Voice (ADSV) by Pentax Medical, the freely downloadable Praat, or Dr. Speech by TigerDRS. Of these, only the ADSV and Praat currently measure CPP and have strong evidence demonstrating the reliability and validity of these software. VoiceSauce (Shue, Keating, Vicenik, & Yu, 2011), a Matlab-based program, and SpeechTool (Hillenbrand, 2008)are also freeware that perform CPP analyses. OperaVox (On Person Rapid Voice eXaminer, OperaVOX Ltd.), a smartphone application, has been found comparable to MDVP in terms for frequency, intensity, and perturbation measures. It, however, does not obtain noise measures and CPP but provides clinicians with flexibility of use with a smartphone or tablet device (Mat Baki et al., 2015). The advantage of paid software is the customer service and support that comes along with it, but for a clinician with minimal resources, Praat is a viable alternative (Watts, Awan, & Maryn, 2017b). Irrespective of the choice of software, all clinicians should obtain program-specific normative data for comparison with patient data.

Aerodynamic Assessment

This form of assessment is critical to informing the clinician about the laryngeal valving mechanism but is often left out of voice evaluations due to the instrumentation needs. Ideally, clinicians use a pneumotachograph to obtain measures of glottal airflow and subglottal pressure. However, if a pneumotachograph, an expensive piece of equipment, is not available to the clinician, an analog or digital spirometer can be used to obtain vital capacity (VC), and a stopwatch (MPT) can be used to measure maximum phonation time. The ratio of the largest VC to the longest MPT trial is called the phonation quotient (PQ) and provides an estimate of glottal airflow (Hirano, 1989; Iwata & von Leden, 1970; Joshi & Watts, 2016; Joshi & Watts, 2017). Studies have shown comparable results between certain pneumotachographs and spirometers for PQ. A pneumotachograph is required for the measurement of subglottal pressure; however, the “five for five” water submersion task can be utilized as a *screening tool*for subglottal pressure. The patient uses a straw that is 5cm deep in a glass of water and blows bubbles for five seconds. The inability to perform this task indicates difficulty building up subglottal pressure of $5cmH_20$, the amount required for speech (Awan, 2001; Duffy, 2013). The s/z ratio is another task that can be used as a screening tool for assessing adequate laryngeal valving. This task is a ratio of the duration for maximum sustained phonation of the /s/ to the maximum sustained phonation of the /z/ (Eckel & Boone, 1981). A value greater than 1.2 is indicative of a laryngeal pathology, but this value should not be used as a diagnostic cut-off score.

Summary

Acoustic and aerodynamic assessments are vital to a clinical voice assessment but can be intimidating to the beginning voice clinician. Inclusion of these assessments and performing them accurately is important for appropriate diagnosis, development of a treatment plan, assessing progress with treatment, and also for reimbursement of the services the clinician provides. While high-quality equipment can be expensive, there are alternatives that can provide similar information in the case of acoustic measurement and the basics of an aerodynamic assessment. Readers are urged to read the tutorial on instrumental assessment of voice (Patel et al., 2018) for a detailed protocol for both of these assessment domains.

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