Aerodynamic Outcomes of Four Common Voice Disorders: Moving Toward Disorder-Specific Assessment

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Summary: Objectives. The two goals of the present study were to (1) determine the ability of commonly used aerodynamic voice measures to capture change as a function of known interventions and (2) determine if certain aerodynamic measures demonstrate better responsiveness to change in specific disorder types than others.

Study Design. This is a retrospective, longitudinal, single-blinded, cross-sectional study.

Methods. Patients (n = 70) with a single voice disorder diagnosis of benign vocal fold lesions (lesions), unilateral vocal fold paralysis (UVFP), primary muscle tension dysphonia (MTD-1), or vocal fold atrophy (atrophy) underwent baseline testing, a single intervention (phonosurgery or voice therapy), and follow-up testing. Common aerodynamic measurements were completed in repeated syllables and an all-voiced sentence.

Results. Statistically significant improvements were observed for two outcome measures, average airflow in syllables, and average airflow in the all-voiced sentence. Patients with lesions, UVFP, and MTD-1 improved in average airflow in the all-voiced sentence. Patients with UVFP also improved in airflow in syllables.

Conclusions. Average airflow in the all-voiced sentence changed as a function of treatment for the lesion, MTD-1, and UVFP groups, demonstrating a disorder-specific pattern. Laryngeal airway resistance, and estimates of average subglottal pressure did not show significant change. Average airflow in the all-voiced sentence measurements is recommended as a routine voice measure, and further investigation of other aerodynamic measures' sensitivity to change is warranted.

Key Words: Aerodynamic–Voice assessment–Airflow–Vocal fold paralysis–Muscle tension dysphonia–Atrophy–Benign vocal fold lesions–Voice lab–Instrumentation–Outcomes.

INTRODUCTION

Quantification of treatment outcomes is essential to validating and improving treatment techniques, as well as capturing patient response to intervention. Researchers and voice clinicians alike are faced with a unique challenge in selecting treatment outcome measures because of the heterogeneity of voice disorder characteristics[1–3] and treatments.[4–6] Despite this heterogeneity, many voice centers use one standard voice laboratory protocol for all disorders.[7] Because voice characteristics are widely variable even within one disorder type, a single standard approach to treatment evaluation may not be appropriate. This article is part of a series intended to identify the most robust disorder-specific voice laboratory measures that best capture treatment change.

Previous work by this author group sought to determine if certain voice laboratory measurements correlated to changes in the Voice Handicap Index-10 (VHI-10).[8] This initial investigation, which included evaluation of commonly used aerodynamic analyses, examined changes in voice laboratory measures across two time-points representing the largest change in VHI-10 scores, independent of treatment in that time frame.[9] Results indicated that the only voice laboratory measure to correlate with a change in VHI-10 between two time-points was average airflow (mL/s) in connected speech for patients with unilateral vocal fold paralysis (UVFP). Although most voice lab measures failed to correlate to a change in VHI-10, the study did not assess correlation of change in VHI-10 as a function of a known intervention. The present study investigates the ability of aerodynamic measures to capture change before and after a known treatment in patients with four common voice problems: benign vocal fold lesions (lesions), UVFP, primary muscle tension dysphonia (MTD-1), and bilateral vocal fold atrophy (atrophy).

The ability of aerodynamic measures to distinguish pathologic from normal voice is well documented.[10,11] Similarly, aerodynamic patterns have delineated subcategories of MTD.[12] However, the ability to consistently capture salient changes after treatment has yet to be shown. Furthermore, some aerodynamic measures have demonstrated the ability to differentiate disorders at time of diagnosis.[13] Hillman et al[13] determined that organic hyperfunctional voice disorders (benign midmembranous vocal fold lesions, contact ulcers) demonstrated abnormally high alternating current (AC) flow and maximum flow declination rate (MFDR); alternatively, nonorganic vocal fold hyperfunction (similar to MTD-1 in the present population) demonstrated abnormally high levels of

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unmodulated direct current flow without high values for MFDR and AC flow. It is unknown if other disorder-specific aerodynamic patterns exist.

A review of voice outcome measurements by Carding et al[14] raised awareness of the paucity of research regarding the sensitivity to change, reliability, and validity of aerodynamic measurements. Those authors reviewed the psychometric literature for acoustic, perceptual, and patient self-report measures for voice analysis but were unable to assess aerodynamic tools because of the lack of research in this area. The authors encouraged additional research in aerodynamic voice analysis.[14] In addition, a recent study demonstrated null results in aerodynamic measures, despite improvements in quality of life and auditory-perceptual analyses with treatment.[15] A study of vocal changes before and after phonomicrosurgery in patients with vocal fold polyps yielded no change in multiple aerodynamic measures, including mean airflow rate (MFR) and estimates of mean subglottic pressure (P_{sub}).[15] Similarly, no differences were detected with MFR or laryngeal airway resistance (R_{law}) before and after thyroidectomy.[16] In contrast, measures of MFR and P_{sub} have demonstrated significant changes after thyroplasty in UVFP patients.[17,18] Aerodynamic measures (MFR and R_{law}) also decreased after thyroplasty in two iatrogenic UVFP patients.[19] Because of this contrasting evidence in aerodynamic responsiveness to change, formal evaluation of disorder-specific aerodynamic measures before and after treatment is imperative to specify which aerodynamic measures best reflect treatment change in each voice disorder.

The present study follows a line of research[9,20] that aims to provide evidenced-based voice laboratory measures with which to more accurately and appropriately evaluate treatment outcomes for voice disorders. The goals of this study were (1) to determine the ability of commonly used aerodynamic voice measures to capture change before and after known interventions and (2) to determine if certain aerodynamic measures demonstrate better responsiveness to change in specific disorder types than others.

MATERIALS AND METHODS

All study procedures were approved by the University of Pittsburgh Institutional Review Board (IRB # PRO13030372).

Participants

Participants were identified retrospectively from patients who presented to the University of Pittsburgh Voice Center (UPVC). Informed consent was obtained from all patients before data entry into a clinical research database. The database was then queried for patients meeting the inclusion/exclusion criteria by a research coordinator blinded to experimental hypotheses. Methods are similar to those in a companion article[20] on acoustic outcomes after treatment for voice problems and are restated here. A total of 3,555 patients received treatment at the UPVC from July 2011 to August 2013. Patient records from July 2011 to August 2013 were included if records indicated the following inclusion criteria: age >18 years; primary diagnosis of lesions, UVFP, MTD-1, or atrophy. Only patients with single category diagnoses were included (ie, atrophy alone, not atrophy, and UVFP). Diagnoses were determined during clinical diagnostic evaluations via a fellowship-trained laryngologist and voice-specialized speech-language pathologist (SLP) team. Cases were included if both pretreatment and posttreatment data were available; cases with invalid or insufficient data sets were excluded. The records of patients with lesions, UVFP, MTD-1, and atrophy who underwent the study interventions were reviewed, and all viable cases were used for analysis (Figure 1). To assess aerodynamic response to voice treatment, the interventions and follow-up time-points for each member of each group were comparable and were similar to the cohort of patients studied for the companion article on acoustic analyses. After exclusion based on the previously mentioned criteria, a total of 70 patients were included in the study.

Research in clinical outcomes

Research in clinical outcomes is traditionally difficult because of varying time frames after treatment, as well as varying treatments. Great care was taken in choosing the same treatments in each disorder group. Postintervention time-points were determined by recommended follow-up time frames used in routine patient care. The interventions and follow-up time-points for the lesion group were baseline and approximately 12 months after phonomicrosurgery, all other groups (MTD-1, atrophy, and UVFP) were baseline and approximately 6 months after treatment. Patients in the lesion group did not undergo preoperative direct voice therapy[21] because of the expectation that substantial improvement from direct voice therapy was unlikely, determined via stimulability for benefit from direct voice therapy by an SLP at the time of evaluation; these patients had large midmembranous lesions and were enrolled in postoperative voice therapy only. Patients with MTD-1 underwent, on average, five sessions of physiologically based voice therapy, which consisted of combinations of resonant voice,[22] flow phonation,[23] articulatory precision, and intonation training, as determined by the treating SLP. Patients with atrophy underwent injection augmentation with calcium hydroxyapatite (CAHa) or lipoinjection. Finally, patients with UVFP were treated with type I thyroplasty[24] medialization with Gore-Tex (W. L. Gore & Associates, Inc., Newark, DE).

Procedures

The following information was gathered as part of routine clinical examinations; however, all aerodynamic data were reanalyzed for the current investigation to ensure data quality. All aerodynamic data were collected before and after treatment using the Phonatory Aerodynamic System 6600 (PAS 6600) (KayPENTAX, Montvale, NJ). The system consists of a face mask coupled to a pneumotachometer with a pressure-sensor tube inside the face mask. The patients were seated and held the mask snugly over his/her nose and mouth. The pressure tube rested inside the oral cavity above the tongue. Aerodynamic data were collected during two separate tasks. For the first, average airflow (mL/s) and estimates of average subglottal pressure (P_{sub} in cm H_2O) were collected during the production