

Accuracy of Acoustic Analysis Measurements in the Evaluation of Patients With Different Laryngeal Diagnoses

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Summary: Objective. This study aims to investigate the accuracy of acoustic measures in discriminating between patients with different laryngeal diagnoses.

Study Design. The study design is descriptive, cross-sectional, and retrospective.

Methods. A total of 279 female patients participated in the research. Acoustic measures of the mean and standard deviation (SD) values of the fundamental frequency (F_0), jitter, shimmer, and glottal to noise excitation (GNE) were extracted from the emission of the vowel /e/.

Results. Isolated acoustic measures do not demonstrate adequate performance in discriminating patients with and without laryngeal alteration. The combination of GNE, SD of the F_0 , jitter, and shimmer improved the ability to classify patients with and without laryngeal alteration. In isolation, the SD of the F_0 , shimmer, and GNE presented acceptable performance in discriminating individuals with different laryngeal diagnoses. The combination of acoustic measurements caused discrete improvement in performance of the classifier to discriminate healthy larynx vs vocal polyp (SD of the F_0 , shimmer, and GNE), healthy larynx vs unilateral vocal fold paralysis (SD of the F_0 and jitter), healthy larynx vs vocal nodules (SD of the F_0 and jitter), healthy larynx vs *sulcus vocalis* (SD of the F_0 and shimmer), and healthy larynx vs voice disorder due to gastroesophageal reflux (F_0 mean, jitter, and shimmer).

Conclusions. Isolated acoustic measures do not demonstrate adequate performance in discriminating patients with and without laryngeal alteration, although they present acceptable performance in classifying different laryngeal diagnoses. Combined acoustic measures present an acceptable capacity to discriminate between the presence and the absence of laryngeal alteration and to differentiate several laryngeal diagnoses.

Key Words: Voice–Voice disorder–Accuracy–Larynx–Acoustic analysis.

INTRODUCTION

Voice disorder can be characterized as a pathologic process caused by anatomical or functional factors that may affect vocal production and/or laryngeal operation.¹

Vocal production involves physiological, auditory-perceptual, aerodynamic, acoustic, and emotional aspects, implying the need for a multi- and interdisciplinary approach in the evaluation, diagnosis, and treatment of voice disorders. Hence, vocal evaluations should combine information from different domains, including data from auditory-perceptual analysis, self-assessment, visual examination of the larynx, and aerodynamic and acoustic assessment,^{2,3} enabling a comprehensive view of the voice problem.

Laryngeal visual examination aims to obtain images of the structures and functioning of the larynx. It provides a physio-

logical characterization of the existing vocal deviation.^{4,5} In general, this exam is considered the main standard reference for diagnosing a voice disorder.^{6,7}

Acoustic analysis of the voice aims to quantify and characterize a sound signal in a noninvasive manner.⁸ This type of analysis is conducted from different models of analysis: linear models, based on the source-filter model,⁹ and nonlinear models, based on voice production as a chaotic system.¹⁰

Among the traditional acoustic measures are the parameters of fundamental frequency (F_0), which correspond to the number of full cyclic vibrations of the vocal folds per second; perturbation measurements, which concern the variability in glottal cycles in the short term, with regard to both frequency (jitter) and amplitude (shimmer); and noise measures, which assess the presence of additive noise in vocal emission.^{11,12} Jitter and shimmer are part of the basic and universal acoustic assessments and are found in most publications on the acoustic analysis of the voice.¹¹

In general, the goal of every evaluation method is information on a specific health condition, predicting or detecting this condition, which may refer to a specific disorder or a stage of the disorder.¹³ This information provided by tests should favor the correct decision making of clinicians, both in terms of intervention or referral to carry out a more detailed assessment.

Vocal evaluation can be used for different purposes, whether for screening, diagnostic classification, and monitoring the effectiveness of treatment offered to dysphonic patients.⁷

In the context of voice disorders, physical examination and analysis of voice quality (through perceptual evaluation and

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acoustic analysis) are among the first methods of evaluation used by clinicians with patients who have any complaints related to vocal production.^{3,14}

Thus, the vocal assessment process is based on the definition of the criteria for categorization of patients, according to the objectives of the evaluation procedure. In turn, the definition of these criteria is related to the reference standard used. In the voice area, visual examination of the larynx is the most common standard reference used for diagnostic classification to determine the presence or the absence of a voice disorder.⁷

In this context, diagnostic accuracy studies with noninvasive and inexpensive technique of the acoustic analysis are important for the determination of conduct and referral of patients with vocal complaints criteria.

Acoustic analysis has gained prominence in vocal evaluation because it integrates the physiological and auditory levels. It allows one to quantify vocal deviation and to infer the functioning of the larynx, given that the voice is a physical phenomenon influenced by the effects of neurophysiological mechanisms.¹⁵ The presence of laryngeal alteration may cause deviation in vocal quality and in the acoustic characteristics of the vocal signal;¹⁶ therefore, these measures may also be used for screening laryngeal alterations.⁸

Some studies^{17–19} have shown an association between acoustic measures and laryngeal functioning. Differences are observed when comparing calculated short-term perturbation and noise in patients with structural and functional changes in the larynx with that in vocally healthy individuals.

Thus, considering the existence of associations between acoustic measures and laryngeal functioning and the need to comprehend the acoustic set of measures that may provide greater discriminatory power in relation to different laryngeal diagnoses, the present study seeks to investigate the accuracy of acoustic analyses, both isolated and combined, in discriminating between patients with different laryngeal disorders.

Therefore, it is assumed that the combination of the measures of F_0 , perturbation, and noise may improve the classification of vocal signals stemming from different laryngeal disorders, thus contributing to the clinical evaluation of the voice and patient monitoring during treatment.

We did the methodological choice to include only female in our study, considering relationship between the gender variable and the F_0 mean measure, which is associated with the anatomical features of the vocal folds, which are dissimilar between adult males and females.^{11,20} In addition, the methodological choice of including only female patients is justified by the higher prevalence of voice disorders in this population, as demonstrated in previous studies.^{21–23}

METHOD

Study design

This research is a descriptive, cross-sectional, and retrospective study. It was evaluated and approved by the Research Ethics Committee of the institution of origin, pinion number 52492/12. All participants received an explanation of the research and signed an informed consent form.

Sample

The present study included patients according to the following eligibility criteria:

- female patients;
- subjects aged 18 years and below 65 years, considering that individuals younger than 18 years may be under the influence of vocal changes related to age;
- patients who have undergone laryngological evaluation in the two previous weeks during the data collection session of this research, to confirm the diagnosis of voice disorder; and
- patients who presented with vocal complaint, with a positive answer to the question “Do you consider that you have a voice problem now?”

Patients with cognitive or neurologic alterations that prevented the realization of the recording procedures were excluded.

Thus, of the total of 530 patients evaluated in this laboratory screening service between April 2012 and February 2015, 96 were male, 75 were older than 18 years or over 65 years, and 80 showed no conclusive result of laryngeal examination. All patients presented vocal complaints, as set out in the eligibility criteria. No patient had neurologic or cognitive impairment that prevented the collection of voice. Thus, they excluded 251 subjects not fit the eligibility criteria, with a final sample of 279 patients, as shown in [Figure 1](#).

These 279 patients had an average age of 38.10 ± 11.08 years and the following laryngeal diagnoses: vocal nodules, 93 (33.33%); no functional or structural larynx disorder, 64 (22.93%); vocal cyst, 34 (12.18%); voice disorders secondary to a gastroesophageal reflux disorder, 27 (9.67%); vocal polyps, 17 (6.14%); middle-posterior triangular gap, 18 (6.45%); unilateral vocal fold paralysis, 10 (3.58%); *sulcus vocalis*, 8 (2.86%); and Reinke’s edema, 8 (2.86%). All patients were seen in the initial evaluation before the voice therapy.

Procedures

The data collection session occurred at the time of the initial assessment of the patient in the above-mentioned voice laboratory before the vocal treatment, with an average duration of 60 minutes. In the section of data collection, the following procedures were performed: a brief anamnesis with personal and voice data and voice recording.

Initially, we applied a brief anamnesis with patients, containing personal and vocal information. Personal information refers to the gender, age, and profession of the patients. Voice information was related to the presence of vocal complaint and a brief history of the vocal problem. Although the presence of vocal complaint was one of the eligibility criteria for participation in the present study, patients who responded positively to the question “Do you consider that you have a voice problem now?” were considered as vocal complaints patients.

For the voice collection, *FonoView* software version 4.5 (CTS Informatics, Pato Branco, Paraná, Brazil), a Dell all-in-one desktop (Eldorado do Sul, Rio Grande do Sul, Brazil), and a unidirectional cardioid microphone (model-835; Sennheiser, Hannover,

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