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Short Report

Can Phonovibrograms be Used in Clinical Voice Pathology?

M. Pedersen[1*] MD, M. Eeg Can. Stat, B. Akram, A. Alexius Agersted, A. Jønsson, Medical students

*Corresponding author: : Dr. Pedersen M, The Medical Center, The Voice Unit, Østergade 18, 3, 1100 Copenhagen, Denmark,

Tel: +45 33 15 96 00; Fax: +45 33 13 77 05; Email: m.f.pedersen@dadlnet.dk

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Abstract

High-speed film has shown to give more advanced diagnoses in laryngology than video stroboscopy, specially combined with kymography and electroglottography. Documentations in pathology from randomized controlled trials are necessary. The setup by Wolf Ltd. for the high-speed measurements also includes a large amount of acoustical analysis and others. In this presentation we show some of the measures that we believe contain possibilities for randomized controlled trials in the future.

Keywords: High-speed film; Phonovibrogram, Vocal folds; Glottal Trajectories; Glottal Area Waveform; Pathology; Dysphonia; Acute laryngitis

Introduction

High-speed film has been shown to provide other results of diagnosis and treatment than video stroboscopy in randomized controlled trials [1, 2]. This is a new aspect which gives perspective for further randomized trials also for high-speed film combined with electroglottography and kymography. We earlier tried to identify the difference between electroglottography of singers and non-singers [3]. The phases of closing and opening are different; the closing phases are longer in singers because the amplitude of the vocal folds is larger. In kymography we have not been able to find quantitative parameters in pathology [4]. A vocal fold is assumed to move with vibrations according to the "two-mass model" (as a system of two coupled oscillators) [5]. Stiffness of the vocal fold is discussed and investigated from many perspectives in literature [6-10].

The software program developed in Erlangen in Germany [11] is usable with the high-speed program from Wolf Ltd. [12]. Stiffness of the vocal folds was focused upon and measurements of mean stiffness of the Glottal Area Waveform (GAW), right and left vocal folds as well as Trajectory 50% of the left and right vocal fold were focused upon. Data has only given hints of deviations in pathology, useable in randomized control trials.

Material and Methods

The examination is based on two patients, one female contest winning singer (20 years) and one male with severe acute laryngitis (59 years). They are both included with details in a comparison of 12 patients with varies disorders.

Data were acquired with a high-speed camera recording in real-time during phonation of the vowel /a/. Into the oropharynx was placed a rigid endoscope (90^0 optic, 9-mm diameter) coupled to a high-speed camera (Wolf, Germany). The high-speed open quotient is routinely measured in front, middle and rare part of the vocal fold with 4000 pictures per second. The high-speed film including the arytenoid oedema was also recorded with the standard equipment from Wolf Ltd (11, 12). With the high-speed film we use an average of 4000 pictures of the vocal folds for two seconds and store.

With the Glottis Analysis Tools Program phonovibrograms are made to compare the patient's voice functions. Furthermore the symmetry measures are calculated for the vocal folds for the following signals, Glottal Area Waveform (GAW) and Glottal Trajectories for the two patients. A comparison of data differences between the two high-speed film is calculated and compared with an earlier group with various diagnosis of pathology.

Results

The results from the Glottis Analysis Tools Program are presented, measuring high-speed film for vocal fold dynamics for each vocal fold with the phonovibrograms.

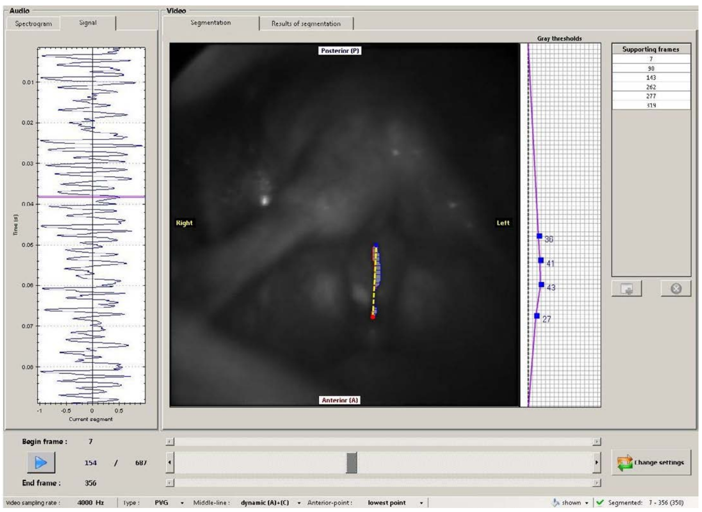


Figure 1 shows the method for segmentation of single movements of the vocal folds defining points of interest. The left vocal fold edge is marked with a blue line; the red vocal fold edge is marked with a red line, while the glottal axis is marked with a yellow line.

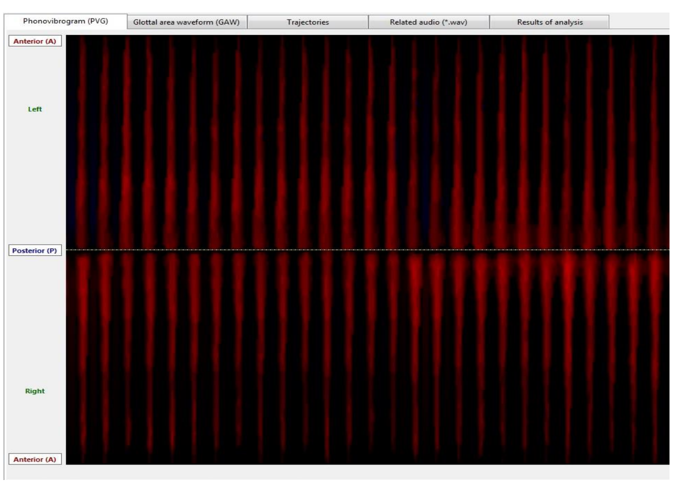


Figure 2 shows the phonovibrogram of the price winning female singer of 20 years of age. The single movements of the vocal folds (right and left) are extremely regular.

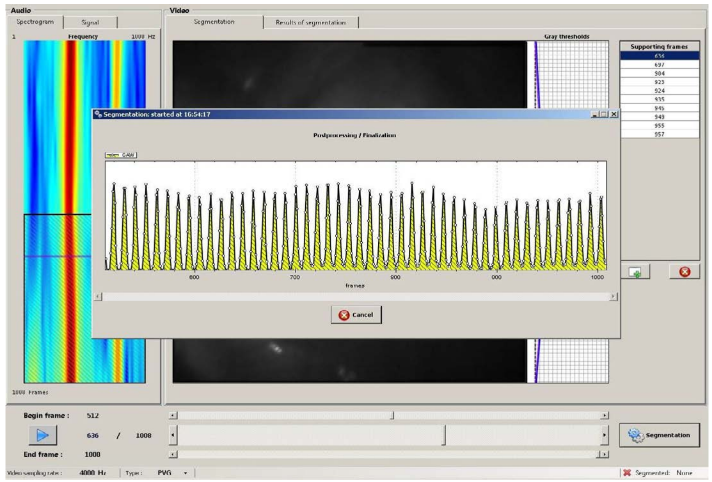
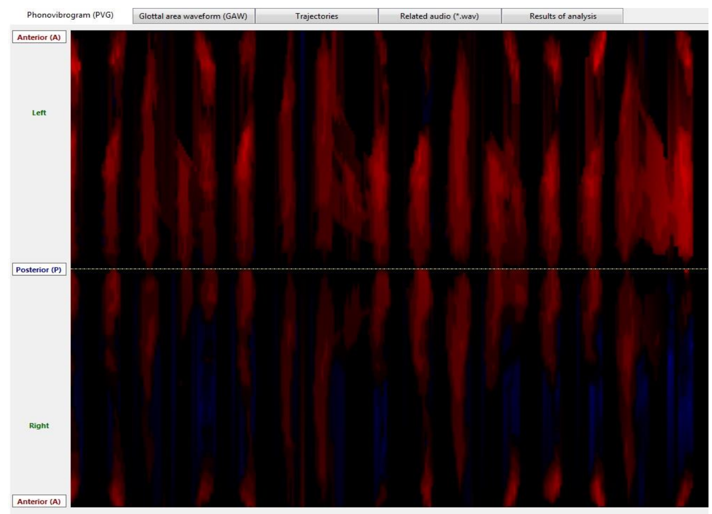
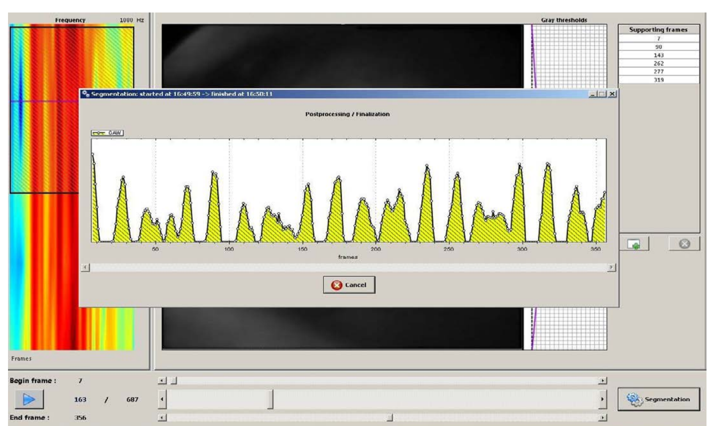


Figure 3 shows the regulation of the single movements presenting the area of the phonovibrogram showed in Figure 2. The regularity of the single movement is very big.



Based on the setup presented in Figure 1, Figure 4 shows the phonovibrogram of the 59 years old male with extreme dysphonia do to a heavy acute laryngitis. The phonovibrogram is highly irregular due to occasional diplophonia.



In Figure 5 the corresponding irregularity of Figure 4 of the single area measurements are seen.

Patient 1. _A002(SegFr_512-1008)

			[MEAN]	[STD]	[MIN]	[MAX]
Stiffness	[GAW]		0,38	0,02	0,333	0,413
Stiffness	[GAW]	[Left]	0,391	0,024	0,338	0,432
Stiffness	[GAW]	[Right]	0,395	0,024	0,352	0,451
Stiffness	[Traj-50%]	[Left]	0,483	0,043	0,371	0,625
Stiffness	[Traj-50%]	[Right]	0,486	0,029	0,392	0,513

Patient 2. _A001(SegFr_7-356)

			[MEAN]	[STD]	[MIN]	[MAX]
Stiffness	[GAW]		0,29	0,059	0,207	0,418
Stiffness	[GAW]	[Left]	0,313	0,056	0,232	0,444
Stiffness	[GAW]	[Right]	0,298	0,04	0,215	0,376
Stiffness	[Traj-50%]	[Left]	0,356	0,069	0,251	0,479
Stiffness	[Traj-50%]	[Right]	0,288	0,037	0,248	0,323

Table 1 is showing calculated measures for the signals of Glottal Area Waveform (GAW) and Glottal Trajectories in the left and right side for patient 1 and 2.

Mean values and standard deviation of 30 single movements of the vocal folds are presented, the minimum and maximum values as well. The same calculation procedure has been made for the Trajectories 50% [Traj-50%] of the right and left vocal folds.

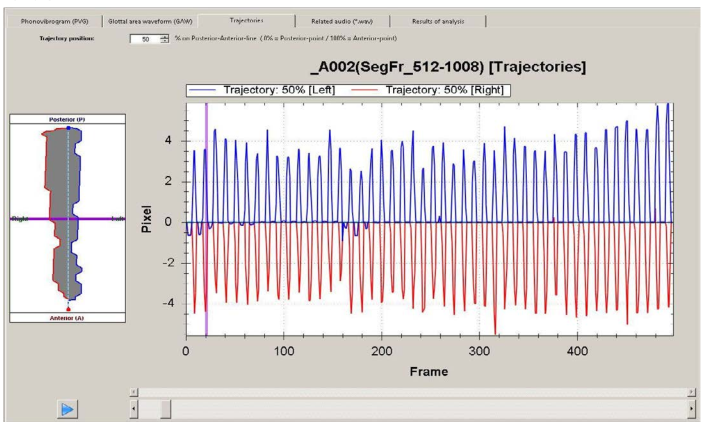


Figure 6. Figure 6 illustrate [Traj-50%]. The [Traj-50%] is calculated from two moving points. These two points is defined as a point on each vocal fold halfway between the anterior and posterior commissure. Halfway (or 50%) is marked on the figure as the purple line. The light blue line indicates the medial position for the left and right sides.

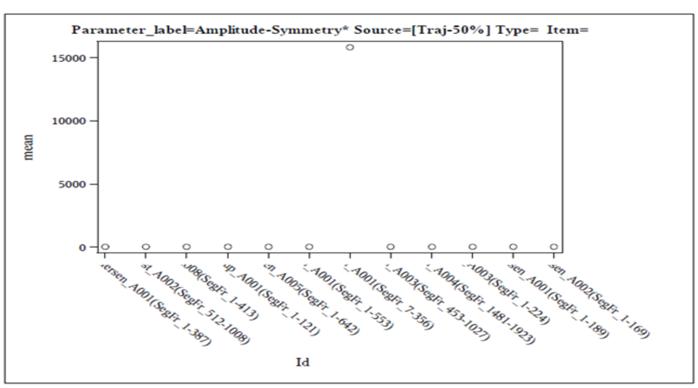


Figure 7 is a graph from the total data material witch shows the discrepancy between the male patient with dysphonia (_A001(SegFr_7-356)) compared with the whole group (consisting of 12 patients) including the female singer (_A002(SegFr_512-1008)). From the total data material the deviation from average is calculated to be more than 2 standard deviations.

Parameter	Source	Person	Observation	Group average	Singer observation
Amplitude-Symmetry	[Traj-50%]	_A001(SegFr_7-356)	15796.53	1317.43	0.95
Amplitude-Symmetry-Index	[Traj-50%]	_A001(SegFr_7-356)	0.30	0.71	0.86

Table 2. Our data analysis (Table 2) shows the female singer (_A002(SegFr_512-1008)) listed as "Singer observation", as well as an average of all patients from the overall data material listed as "Group average", hold up against the man with acute laryngitis (_A001(SegFr_7-356)) listed as "Observation". Table 2 shows an Amplitude-Symmetry deviation between the singer and the male with acute laryngitis probably due to dystonia and occasional diplophonia. At the purple line which indicates vocal fold edge points at medial position for the left and right sides.

Discussion and Conclusion

We have shown that the pictures of single movement of the vocal folds as well as regularity are extremely different from a female contest winning singer to an acute laryngitis patient with the software program of Glottal Area Waveform developed in Erlangen. The software include many methods for evaluation of voice function. We intend to make summary statistics to find patients for whom their values differ significantly from others regarding GAW and thereafter make hypotheses for testing in the future. The planned randomized trial will be based on patients complaining of dysphonia compared to their normalization of voice. The new tool of the phonovibrogram has wide perspectives also in the clinic for all kinds of laryngeal disorders.

The setup by Wolf Ltd. for the high-speed measurements also includes a large amount of acoustical analysis and others. In this presentation we have shown some of the measures that we believe contain possibilities for randomized controlled trials in the future.

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