High-speed films of pathological vocal folds and stiffness of the vocal folds

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Abstract
With the High-speed films we are able to capture the movements of a single vocal fold. In the High-speed Endocam system (WOLF Ltd.) there has been developed a software reproduction of the stiffness of single vocal fold movements with the Glottis Analysis Tools, based on the High-Speed.
Differences in stiffness of the vocal folds are seen between trained and non-trained voice users. The objective voice to evaluate this new method, based on software reproduction of the vocal fold movements.
Keywords: High speed films, video stroboscopy, voice, laryngeal mucosal function, genetics.

Introduction

The development of tissue understanding is ongoing [1]. In our clinical voice research two aspects have been important, the view of the vocal folds and larynx tissue regulators. It was a step forward when stroboscopy in the clinic was developed [2]. But shortly afterwards electroglottography (EGG) measures supported the averaged stroboscopy of a few pictures per second and after one generation online high speed films with several thousand pictures per second were made clinically feasible for voice measures as a continuation of EGG combined with stroboscopy [3, 4]. We soon discovered that the diagnoses made by high speed films were different from the video stroboscopy [5]. We noticed that the larynx including the arytenoid regions had new diagnostic aspects, as an introduction to the whole upper airway. The swallowing process and the lower airways were also better understood related to high speed films of the arytenoid region [6]. To document that the high speed films give different – supplementary understanding of the larynx – including the voice, respiration and swallowing processing, it was suggested by the statistician to randomize the patients in a way to show that diagnoses and treatment were different based on video stroboscopy and high speed films. Therefore a prospective and randomized study has been made. 12 patients were needed based on a power calculation of 95%, assessing arytenoid-region edema score 1-5, vocal fold abnormalities, front-, middle- and rear open quotients and suggested treatment after each examination on high speed films compared with video stroboscopy which did not include the referred on line measured parameters but visual evaluation of function: mucosal movement, regularity, amplitude, and closure of the vocal folds [7, 8].
When introducing new technology, the benefits have to be understood. In the clinic we strive to deliver the best clinical service basing treatment on evidence and expand the evidence where possible. With high speed films it is possible to see the vocal folds movement (4.000 frames per sec) in more details than the average pictures provided by the video stroboscopy (mostly 25 frames per sec). Vocal folds move in an adult man ~110 Hz (pictures per second) and in a woman ~220 Hz (pictures per second). The magic flute by Mozart, the high F is ~1300 Hz, looking at 25 pictures per second will not show the true motion of the vocal folds movement. It is unknown how often there is a treatment related difference and the relevance of the difference is not known.

Method

We included patients prospectively in the clinic, after a written consent, with hoarse voices for more than two weeks and assessed each patient with both high speed films and video stroboscopy *in a randomized sequence*. High speed films were assessed with visual arytenoids-region edema score 1-5, vocal fold abnormalities and front, middle and rear open quotients. Suggested treatments were based on the examination done, saved before proceeding. With video stroboscopy averaged movements of the vocal folds were possible with mucosal movement, regularity, amplitude, and closure of the vocal folds. Comparing diagnosis given for each patient based on the examinations (either video-stroboscopy or high speed film) and

ultimately, the corresponding treatment was also done, saved in this prospective randomized way.

Statistical consideration

Table 1

Evidence Hierarchy
Systematic Review
(Meta-Analysis)
Randomized Controlled Trial
Cohort Study
Case-Control Study
Cross-Sectional Survey
Case Report

Evidence based research has an evidence hierarchy, where systematic review is at the highest level.

Table 2

Examples of the evidence hierarchy

Type	**Examples**
Systematic Review	Summary of results of all relevant trials
Meta-Analysis	Summary of average results of trials.
Randomized Controlled Trial	Isolation of effect. All other differences are random and thus statistically controllable.
Cohort Study	For example number of cortisone inhaler prescriptions before and after high speed films could be introduced, or number of patients referred to speech therapy based on voice diagnosis.
Case-Control Study	Looking at patients with a certain disease and patients matching these patients except for the disease.
Cross-sectional Survey	Looking at a representative sample here and now: How many took medication A and did not have disease B.
Case report	Description of individuals: A patient took medication A and it cured disease B (but no proof what caused, disease B to be cured).

Analysis

How do we prove that one type of examination is better than another one? The question is what to measure, considering the SMART goal criteria: specific, measureable, achievable, relevant, timely and how do we compare the examinations, which design and analysis is best?

It is relevant but for whom, table 3 gives an example of that.

Table 3

Design and analysis

Patient Getting the best treatment with minimal personal risk Minimize the discomfort of the examination (Quality of Life)	Investigator Understand root cause for pathological voices (not only symptoms)
Society Minimize use of pharmacologist Minimize number of sick days Minimize cost for treatment and examination	Regulator (National State) Want the cheapest possible examination Safest possible examination Acceptable reliability of examination

Results

A total of 19 patients, 7 males and 10 females were included in the study. The patient's ages ranged from 18 to 72 years and were on an average 38 years old.
Table 4 shows the strikingly different aspects of treatments of patients for voice training or cortisone / formeterol inhaler for high speed films and video stroboscopy. Other treatments were not statistically different. Since the comparison was made on the same patients we have a study which includes 38 examinations in 19 patients.

	High speed films	Video stroboscopy
Voice training or Cortisone/formeterol inhaler	Of 19 (11%)	Of 19 (37%)

In the logistic regression model where the correlation between the two randomized assessments on the same patient is taken into account, the two sided p-value was 0.0190 when comparing video stroboscopy with high speed films, a statistically significant higher proportion of patients had treatment involving either voice training or pharmacological treatment with local cortisone/formeterol inhaler 11% versus 37%, respectively..

Discussion and Conclusion

The base line was hoarseness for two weeks or more without other earlier treatment - the outcome was normalized voice in this prospective randomized study comparing high speed films with video stroboscopy. The study showed a reduction in the need for either voice training or local cortisone inhaler with adrenalin from 37% to 11% when comparing diagnosed based on video stroboscopy and high speed films, respectively (p=0,0190) . It is interesting to look into new methods for mucosa studies which are made possible with high speed films, especially arytenoid regions in the larynx. The high speed films analysis, now much cheaper than before, showed that voice disorders were more related to other phenomena e.g. mucosa function and genetics and not behavior. The future aspects include optical coherence tomography (OCT) and genetics for further understanding of the mucosal function of the upper airways [9,10].

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