

ADVANCED VOICE ASSESSMENT.

A prospective case-control study of jitter%, shimmer% and Qx%, glottis closure cohesion factor (Spead by Laryngograph Ltd.) and Long Time Average Spectra

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1. Introduction

It was suggested at the European Oto-Rhino-Laryngology conference 2007 in Vienna that voice analysis is empiric and that clinical voice treatment is not evidence based!! In the Cochrane Handbook [1] advice for evaluation of quality of research was made: Groups are made of the quality in 3 levels: **Level A (randomized controlled trial/meta-analysis):** High-quality randomized controlled trial (RCT) that considers all important outcomes. High-quality meta-analysis (quantitative systematic review) using comprehensive search strategies. **Level B (other evidence):** A well-designed, non randomized clinical trial. A non quantitative systematic review with appropriate search strategies and well-substantiated conclusions, includes lower quality RCTs, clinical cohort studies and case-controlled studies with non biased selection of study participants and consistent findings. Other evidence, such as high-quality, historical, uncontrolled studies, or well-designed epidemiological studies with compelling findings, is also included. **Level C (consensus / expert opinion):** Consensus viewpoint or expert opinion. The purpose of this categorization is that good studies can be structured in meta-analysis to affirm the results as it is done in e.g. cancer and cardiology research. In our two Cochrane reviews on vocal nodules [2] and laryngo-pharyngeal reflux [3] no clinical evidence based studies were found neither for the treatment of vocal nodules nor laryngo-pharyngeal reflux. In the review of vocal nodules 659 papers were evaluated, and in the review of laryngo-pharyngeal reflux 302 papers. The problem most commonly found, was lack of a clear baseline for inclusion in the studies, and, lack of unanimous objective visual and acoustic criteria. Therefore we have in a **part one** of this prospective case-control study [4] first, tried to make a defined baseline of a complaint of a non-functioning larynx, second, to standardize simple object visual demands for larynx mucosa including the vocal cords but based on oedema of the arytenoids, third, to evaluate the measures of jitter percent, shimmer percent in relation to the closed phase percent of the vocal cords. Evidence of pathological parameters were defined for sustained tones as well as the reading of a standard text, Table 1, difference was also found from before to after treatment, Table 2, treatment as earlier discribed [5] As **part two** we used the same patients material, for all with sufficient data, in the same prospective controlled case-

controlled setup, for two still more advanced objective throat function analysis: the Cohesion Factor of irregularity as defined in the Spead program by Laryngograph Ltd. illustrating kymographic aspects and Long Time Averaging Spectrum (LTAS).

Method

I. Inclusion criteria were a. subjective complaints of a non-functioning larynx combined with b. a professional assessment and visual score grouping the patients by swelling in the arytenoids +/- pathological vocal cords. Patients without swelling of the arytenoids and with normal vocal cords were rated normal, score 1 by visual inspection. Patients with swelling rated from 2 to 5 were abnormal. There are individual variations but a normal video-stroboscopy includes a normal surface of the arytenoids without oedema and a normal shape, as well as normal colour and movement at stroboscopy of the vocal cords and all the rest of the mucosa of the larynx. Fig. 1A, normal, score 1, and Fig. 1B and C, abnormal scores (score 3 and 5 presented).

II. The parameter: the closed phase of the vocal cords defines the exact point where the vocal cords meet in the synchronized glottography with stroboscopy [6]. This is difficult to see, if there is oedema of the arytenoids or of the whole larynx mucosa. The closure of the vocal cords (Qx%) and the fundamental frequency (Fx%) can under those circumstances be compromised even if the vocal cords themselves have movement. The whole larynx can be affected due to infections, allergy, reflux and misuse etc. [5]. Testing binary equal movements of the vocal cords related to the total amount of movements gives a Cohesion Factor of irregularity (Spead by Laryngograph Ltd.) for Qx% and Fx% analyzed for a sustained tone for 4 seconds and reading of a standard text ("the north win and the sun"). Fig. 2. The abnormality degrees of the arytenoids with visual scores of 4 is shown before and after treatment.

III. The clinical use of harmonics including formants was empiric in pathology till now. This patient material analysed for the cohesion factor was also analysed for Long Time Average spectrograms (LTAS), for a sustained tone /a/ for 4 seconds and a standard text ("the north win and the sun"). The problem was to point out the maximal intensities in pathology especially related to formants, and the change related to treatment. Fig. 3a shows the normal LTAS during reading the north win and the sun, of 35 persons with normal larynx, score 1,

including normal arytenoids, the measurement taken from Spead by Laryngograph Ltd. and placed in an Excel sheet. The curves were extracted from individual sheets, harmonics were measured individually on Multi Dimensional Voice Profile system by Key Elemetrics and compared up to 12.000Hz.

The statistics were based on SAS JMP (survival analysis) of the huge amounts of data. 3b shows the curves of 301 patients with a visual score of deviant arytenoids form of 2-5.

Results

Table 3 shows the cohesion factor of Qx%, statistical analyses: Cohesion factor % for 35 normals and 301 abnormal as defined by oedema of the arytenoids and related pathological mucosa.

Among others a significant difference was found for Qx% and standard deviations between normal and abnormal measures, Welch ANOVA $p < 0,0001$ for sustained tone.

Analysis of Long Time Average Spectrograms (LTAS) showed no overall difference between the pathological video - stroboscopies Overlay Plot and the normals, but for the area between 2500 and 4000 Hz Table 4.

Discussion

It has been shown that jitter% and the closed phase % Qx of the vocal cords are better and evidence based, in a prospective case-control study and in a prospective cohort study, related to medical treatment of pathological changes of the larynx including the arytenoid regions, - not only of the vocal cords.

A differentiation can be made of whether the primary tone generator (including the arytenoids, the mucosa and the vocal cords) or the more coordination related factors of sound making should be focused upon in medical treatment. The cohesion % is significantly better in tone and text after treatment. In the LTAS the area of 2500 to 4000 Hz has a significantly higher value in dB after treatment when reading a standard text.

It was earlier shown that phonetograms are better after medical treatment [5]. So now we have evidence based measurements for the future treatment of voice disorders.

Conclusion

The new parameter, the Irregularity % or cohesion factor between all measured signals -and pairs of successive vocal cycles that fall into the same analysis bin in the histogram, has been presented as evidence based in a clinical setting in a prospective case – control study, and a cohort study before and after treatment. Normal values and values after treatment are given. On the same material the LTAS in the area of 2500-4000 Hz has been shown to be of evidence based value in a clinical setting in the case – control study as well as the cohort study before and after treatment, - with higher intensity values in normals and after treatment

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<http://www.cochrane.dk/cochrane/handbook/hbook.htm>
- [2].Pedersen M, McGlashan J Surgical versus non-surgical interventions for vocal cord nodules, *the Cochrane library, Oxford*. 2000 Protocol, 2001 review
- [3].Hopkins C, Yousaf U, Pedersen M Acid Reflux Treatment for Hoarseness [Review] print: 25th January 2006 in *The Cochrane Library Issue 1*. 2006
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- [5].Pedersen M, Beranova A, Møller S. Dysphonia: Medical treatment versus a medical voice hygiene advice approach. *European Archives of Otorhinolaryngology* 2004 261; 6:312-315
- [6].Pedersen M (Fog) Electroglottography compared with synchronized stroboscopy in normal persons. *Folia phoniatr* 1977 29:191-200



A:

arytenoids shape	mean jitter%	Std Dev	mean shimmer%	Std Dev	mean Qx%	Std Dev	N	Comments
shape 1	1	1	9,2	6,5	47,1	6,5	35	
shape 2-5	4	10,5	8,2	6,6	45,3	12,7	338	
statistics	-	-	-	-	significant difference for Qx% and standard deviations between normal and abnormal measures, Welch ANOVA p<0,0001			

B:

arytenoids shape	frequency variation%	Std Dev	loudness variation%	Std Dev	Qx%	Std Dev	N	normals SD
shape 1	9	6,9	15,4	5,1	48,7	6,5	35	for frequency variation <6,9 abnormal> 11,1
shape 2-5	12,3	11,1	16,4	5,6	46,0	11,4	338	normals SD for Qx% <6,5 abnormal> >11.4
statistics	p 0,03 *		-		p 0,011 *		*p as given (Wilcoxon test)	

Table 1

Groups of consecutive digitized videostroboscopies evaluated by 2-3 observers on the spot, and voice analysis at the same time of normal controls: arytenoids shape grade 1, without laryngeal complaints versus: abnormal clients with laryngeal complaints, arytenoids shape grade 2-5, measured with SPEAD by the firm Laryngograph Ltd.

A: sustained tone /ah/.
B: reading of a standard text: the North wind and the sun.

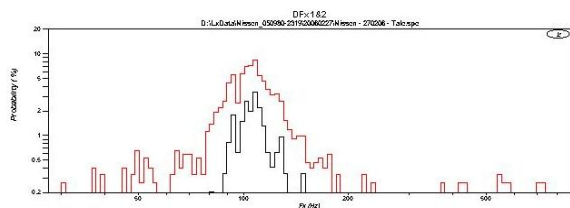
A: 77 patients with examinations before and after treatment, intonation of a sustained tone /ah/.

arytenoids abnormality	(shape 5 1 pt.)	(shape 5 3 ppt.)
shape 4	1. examination	2. examination
mean jitter%	5,7	1,1
mean shimmer%	7,4	6,8
mean Qx%	43,7	48,1
	Std Dev 17,9	Std Dev 1,1
	N 1 st 32/ 2nd25	N 1 st 32/ 2nd25
shape 3	1. examination	2. examination
mean jitter%	3,8	1,6
mean shimmer%	7,4	7,3
mean Qx%	42,3	48,1
	Std Dev 8,7	Std Dev 3,0
	N 1 st 26/ 2nd30	N 1 st 26/ 2nd30
shape 2	1. examination	2. examination
mean jitter%	4,9	2,2
mean shimmer%	4,9	1,6
mean Qx%	45,4	50,3
	Std Dev 11,1	Std Dev 3,3
	(shape 1 2 ppt.)	(shape 1 1 pt.)
	N 1 st 16/ 2nd18	N 1 st 16/ 2nd18

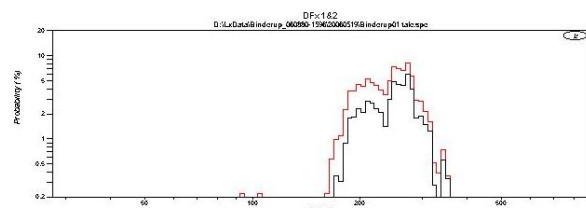
Table 2. statistics

For Tone, no significant change was found of jitter% and shimmer% with paired t-test. For Qx% there was a significant better closure of the glottis of 4,6% (43,8% to 48,4%) with a significance of 0,0008 with paired t-test. For the reading of a standard text the regularity frequency% was reduced with 1,98% (p= 0,053), the regularity of loudness% with 1,7% (p=0,004) and the Qx% was better with a change of 2,56% (p=0.044) analysed with paired t-tests.

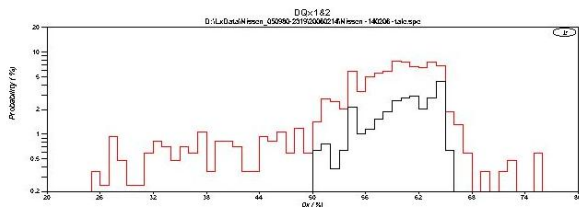
Arytenoids score 4, Fx % cohesion factor before treatment



after treatment



Arytenoids score 4, Qx % cohesion factor before treatment



after treatment

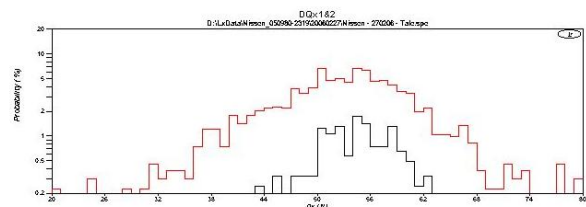
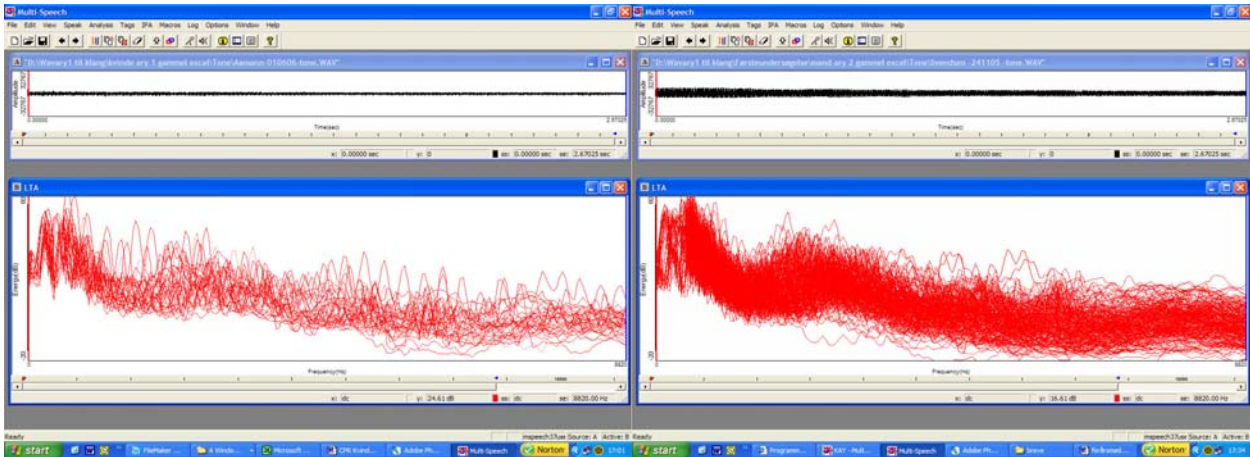


Fig. 2

Fig. 3a shows the normals visual score 1 related to LTAS and 3b the abnormal arytenoids visual score 2-5 related to LTAS



Sustained tone Qx%		Reading of a text Qx%	
Qx%			
Arytenoid 1	19 (12-26) range	35 (30-40) *p 0,042	←
Arytenoids 2-5	18 (15-20) range	41 (39-42) difference	
Sustained tone Fx%		Reading of a text Fx%	
Arytenoids 1	1,9 (1-6) range	13 (8-19) *p ,03	←
Arytenoids 2-5	5,3 (3,7-5,8) range	19(18-21) difference	

Sustained tone Qx%		Reading of a text Qx%	
before	17 (12-22) range	44 (40-48) p*0,015	
after	14 (9-19) range	37 (33-41) difference	←
Sustained tone Fx%		Reading of a text Fx%	
before	4.5 (1.8-7.2)	22 (19-26)	
after	3 (0.3-5.7)	17 (14-22)	

Cohesion factor before and after treatment arytenoids score 2-4

Table 3. Cohesion factors for Qx% and Fx%

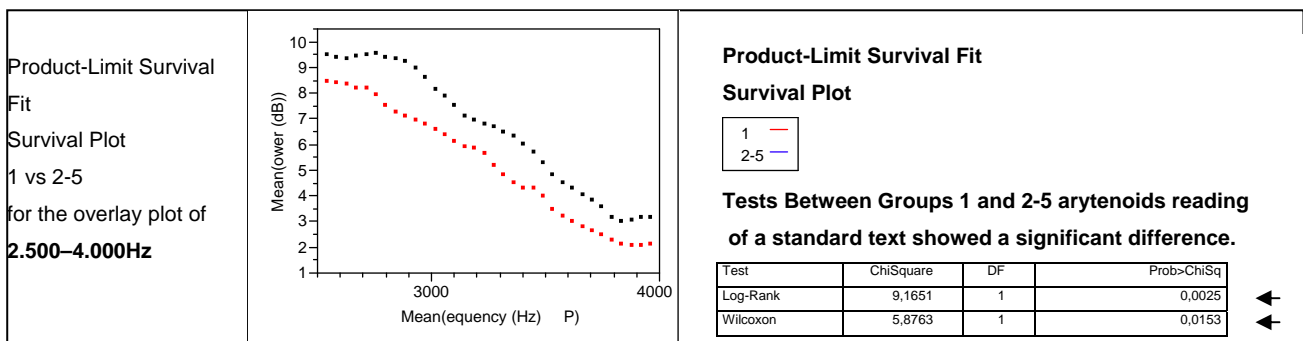


Table 4. LTAS in normals with arytenoids score 1 vs abnormal with arytenoids score 2-5

Table 5. LTAS Product-Limit Survival Fit Survival Plot group 2-4 before and after treatment showed a significant difference

