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--hino-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 RCT’s, 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 laryngopharyngeal reflux [3] no clinical evidence based studies were found neither for the treatment of vocal nodules nor laryngopharyngeal 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 tons 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 described [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. illucidating kymographic aspects and Long Time Averaging Spectrum (L-T AS).

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]. His 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]. Estimating 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. His patient material analysed for the cohesion factor was also analysed for Long Time Average spectrograms (L-T AS), 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 L-T AS during reading the north win and the sun, of 35 persons with normal larynx, score 1,
including normal arytenoids, the measurement taken from
Spear by Laryngograph Ltd. and placed in an Excel sheet.
The curves where extracted from individual sheets, harmonics
where measured individually on Multi Dimensional Voice
Profile system by Key Elemetrics and compared up to
12,000Hz.
The statistics where 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 abnormals 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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[3].Hopkins C, Yousaf U, Pedersen M Acid Reflux Treatment
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[4].Pedersen M, Yousaf U. Videostroboscopic expert
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110-113.
[5].Pedersen M, Beranova A, Møller S. Dysphonia: Medical
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315
[6].Pedersen M (Fog) Electroglottography compared with
synchronized stroboscopy in normal persons. Folia phoniatr
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### 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.

<table>
<thead>
<tr>
<th></th>
<th>Std Dev</th>
<th>Std Dev</th>
<th>N 1</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>shape 2-5</strong></td>
<td>10,5</td>
<td>8,2</td>
<td>6,6</td>
<td></td>
</tr>
<tr>
<td><strong>statistics</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>significant difference for Qx% and standard deviations between normal and abnormal measures, Welch ANOVA p&lt;0.0001</td>
</tr>
</tbody>
</table>

### Table 2.

**A**: sustained tone /ah/.

**B**: reading of a standard text: the North wind and the sun.

<table>
<thead>
<tr>
<th></th>
<th>Std Dev</th>
<th>Std Dev</th>
<th>Std Dev</th>
<th>N 1</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>shape 2-5</strong></td>
<td>12,3</td>
<td>11,1</td>
<td>16,4</td>
<td>5,6</td>
<td></td>
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<tr>
<td><strong>statistics</strong></td>
<td>p 0,03 *</td>
<td>-</td>
<td>p 0,011 *</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 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.

<table>
<thead>
<tr>
<th>Sustained tone Qx%</th>
<th>Reading of a text Qx%</th>
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<tbody>
<tr>
<td>Arytenoid 1 19 (12-26) range</td>
<td>35 (30-40) *p 0.042</td>
</tr>
<tr>
<td>Arytenoids 2-5 18 (15-20) range</td>
<td>41 (39-42) difference</td>
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</table>

<table>
<thead>
<tr>
<th>Sustained tone Fx%</th>
<th>Reading of a text Fx%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arytenoid 1 1.9 (1-6) range</td>
<td>13 (8-19) *p 0.03</td>
</tr>
<tr>
<td>Arytenoids 2-5 5.3 (3.7-5.8) range</td>
<td>19 (18-21) difference</td>
</tr>
</tbody>
</table>

Table 3. Cohesion factors for Qx% and Fx%

Tests Between Groups 1 and 2-5 arytenoids reading of a standard text showed a significant difference.

<table>
<thead>
<tr>
<th>Test</th>
<th>ChiSquare</th>
<th>DF</th>
<th>Prob&gt;ChiSq</th>
</tr>
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<tbody>
<tr>
<td>Log-Rank</td>
<td>9.1651</td>
<td>1</td>
<td>0.0025</td>
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<tr>
<td>Wilcoxon</td>
<td>5.8763</td>
<td>1</td>
<td>0.0153</td>
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</table>

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

Tests Between Groups of score 2-4 of the arytenoids

By reading of a standard text before and after treatment

<table>
<thead>
<tr>
<th>Test</th>
<th>ChiSquare</th>
<th>DF</th>
<th>Prob&gt;ChiSq</th>
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<tbody>
<tr>
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<td>0.2050</td>
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<tr>
<td>Wilcoxon</td>
<td>5.3489</td>
<td>1</td>
<td>0.0207</td>
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