Acoustic analysis of voice in patients treated by reconstructive subtotal laryngectomy. Evaluation and critical review

Analisi acustica della voce in soggetti sottoposti a laringectomia parziale sopraccricoidea. Valutazione e revisione critica

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Key words
Laryngeal tumours • Reconstructive subtotal laryngectomy • Functional results • Acoustic analysis of voice

Summary
Aim of this investigation was to analyse the voice in a group of 20 patients submitted to supracricoid partial laryngectomy (cricohyoidopexy, sparing two arytenoids) by the Multi Dimensional Voice Programme acoustic analysis system. Results revealed the following sound characteristics: high rate of noise, lack of periodic component of the signal, high rate of segments with no sound signal, vocal segments with marked air-turbulent flow, variation amplitude and frequency coefficients doubled compared to normal values, average fundamental frequency, if present, extremely variable and unsteady. These results show that the phonatory ability of the residual larynx, due to the altered anatomo-physiology of the structure after surgery, has to be completely re-estimated. In fact, the residual larynx determines a definitely reduced periodic acoustic signal, rich in noise and which cannot be modulated. Good phonatory results of this treatment are basically due to preservation of a still understandable (but not perfect!) speech which, by ensuring the subjects’ speech ability, overcomes and has little influence on the really poor quality of the vocal signal in these patients. However, the patient obtains a “new voice” as far as concerns acoustic features and this is very important for communication and social life. Moreover, the possibility of objectively estimating acoustic vocal function ability allows monitoring of the trend and results of possible speech therapy and/or phonosurgical rehabilitation treatment which should start from new anatomical and physiological bases, as well as from the new physical acoustic mechanism of signal production.
Introduction

Supracricoid partial laryngectomy (SCPL) with crico-hyoido-pexy (CHP) or with crico-hyoido-epiglottopexy (CHEP) is the only remaining surgical treatment feasible prior to total laryngectomy, in order to avoid a permanent tracheostoma. The almost total resection of the laryngeal structure usually requires functional rehabilitation which is aimed, primarily, during the post-operative period, at recovery of good sphincteric activity to determine good swallowing. Only once this has been achieved, is normal respiratory function through the natural airway (decannulation) taken into consideration. Recovery of the phonatory function is considered, first of all, a step during the rehabilitation programme and, thereafter, the last goal following decannulation. Clinical evaluation of the results of vocal function following SCPL is generally based on perceptive criteria. In clinical practice, instrumental analysis of the physical acoustic parameters of the voice are rarely carried out when conventional evaluations are performed. The instrumental methods currently used to investigate the acoustic features of the voice provide, above all, descriptive information, as in the case of spectrography and Yanagihara’s classification which, although useful for “common dysphonia” do not provide objective, quantitative and qualitative parameters to evaluate the sound signal in these cases. In fact, it should not be forgotten that the ELS (European Laryngological Society) protocol defined as “substitution voices” when the vocal signal does not originate from “two vocal cords”. This consideration is important, suggesting the need to investigate and implement “new” specific protocols in voice study, first of all, acoustic, which is obviously different from those (acoustic, perceptive, etc.) usually adopted in “common dysphonia” and evaluation of phono-surgery results. In fact, after SCPL, the anatomic, functional and acoustic situation is totally different from those in “common dysphonia” and conventional phono-surgery results.

We, therefore, decided to first submit the voice of subjects treated by SCPL to acoustic digital analysis by MDVP (Multi-Dimensional Voice Programme), a parametric, sophisticated software, in order to obtain reliable indications about the acoustic characteristics of vocal quality in these cases. This would also provide data which would be useful for detecting good indexes of acoustic evaluation for these patients, to be used together with traditional endoscopic and perceptive analysis. These considerations are important, because the patient acquires a “new” voice sound, which is very different from his/her own, and this aspect is not always taken into consideration for its social implications. It should not be forgotten that we recognize a person by his/her face or the sound of his/her voice!!

Material and methods

Studies have been carried out on a selected group of 20 patients (mean age 58.8 years, range 48-70), all male, affected by laryngeal carcinoma, treated by SCPL, with crico-hyoido-pexy (CHP), with preservation of both arytenoids. The vocal signal was recorded at least 3 months after decannulation (min 3 months, max 5 months). All subjects were submitted to the usual rehabilitation programme following surgery. The vocal signal was recorded and analysed using the KAY Computer Speech Lab model 4300B (Kay Elemetrics Corp., Lincoln Park, NJ, USA), assisted by a personal computer with CSL 5.0 basic software. The software used in the analysis was the MDVP, with a microphone at a distance of 20 cm from the lips, at an angle of 45°, in a quiet room (< 30 dB background noise). Vocal samples were all digitally recorded at a sampling rate of 50 kHz. All subjects were trained to voice a vocal sample of a sustained /a/, at a conversational voice intensity, always within 55 dB and 65 dB, on average (not including recordings, the average intensity of which was out of range), as constant as possible, with no intensity or frequency variation, for the Maximum Phonation Time (MPT). In order to refer to only one constant method of study, the input microphone saturation was constantly fixed, in all cases, at (6/9) (six ninths) of CH1. This adjustment produced a fair saturation of dynamic range with no “overload”. Investigations related to the central portion of vocalization, each sample of at least 3 seconds, after calculating MPT and observed with an average value of 5.554 and range between 4.496 and 6.711 sec. Normal reference values were obtained from a randomised sample of 20 normal male speakers (mean age 60.4 years, range 50-70) (Table I).

It is well known that the MDVP system provides 33 measures of vocal signal, of which 3 only methodological and 30 related to acoustic features. In the present study, only 11 out of the 30 parameters implemented by the software, have been considered. These parameters are the more representative and significant in describing restored vocal functional in these cases: Fo, vFo, vAm, Jitt, Shim, NHR, VTI, SPI, DVB, DSH, DUV. Fo (Hz). Average Fundamental Frequency for all extracted pitch periods. vFo (%). Fundamental Frequency Variation represents the relative standard deviation (SD) of the period-to-period calculated fundamental frequency. It reflects the very long-term variations of Fo for all the analysed voice sample.
vAm (%). Peak Amplitude Variation represents the relative SD of the period-to-period calculated peak-to-peak amplitude. It reflects the very long-term amplitude variations within the analysed voice sample.

Jitt (%). Jitter Percent provides an evaluation of the variability of the pitch period within the analysed voice sample. It represents the relative period-to-period (very short-term) variability.

Shim (%). Shimmer Percent provides an evaluation of the variability of the peak-to-peak amplitude within the analysed voice sample. It represents the relative period-to-period (very short-term) variability of the peak-to-peak amplitude.

NHR. Noise-to-Harmonic Ratio is an average ratio of energy of the inharmonic components in the range 1500-4500 Hz to the harmonic components energy in the range 70-4500 Hz. It is a general evaluation of the noise presence in the analysed signal (such as amplitude and frequency variations, turbulence noise, sub-harmonic components and/or voice breaks).

VTI. Voice Turbulence Index is an average ratio of the spectral inharmonic high frequency energy in the range 2800-5800 Hz to the spectral harmonic energy in the range 70-4500 Hz in areas of the signal where the influence of the frequency and amplitude variations, voice breaks and sub-harmonic components are minimal. VTI measures the relative energy level of high frequency noise. It correlates primarily with the turbulence caused by incomplete or loose adduction of the vocal folds.

SPI. This parameter is not a measurement of noise, but rather the harmonic structure of the spectrum. Soft Phonation Index is an average ratio of the lower frequency harmonic energy (70-1600 Hz) to the higher frequency (1600-4500 Hz) harmonic energy (compare to NHR and VTI). An increased value of SPI may be an indication of incomplete or loosely adducted vocal folds during phonation. SPI is very sensitive to the vowel formant structure, because vowels with lower high frequency energy will result in higher SPI. Only values computed for the same vowel can be compared. The vowel /a/ is recommended.

DVB (%). Degree of Voice Breaks shows, in percent, the ratio of the total length of areas representing voice breaks to the time of the complete voice sample.

DSH (%). Degree of Sub-Harmonics is an estimated relative evaluation of sub-harmonic to Fo components in the voice sample.

DUV (%). Degree of Voiceless is an estimated relative evaluation of non-harmonic areas (where Fo cannot be detected) in the voice sample. In the case of non-sustained phonation from the beginning to the end of the data acquisition, DUV will evaluate also the pauses before, after and/or between the voice sample(s).

The MDVP does not provide results when the analysed signal is totally formed by non-harmonic areas.

The results were submitted to statistical evaluation by comparing mean values of each parameter in the normal and “surgery” group, using Student’s t test, at p = 0.05 significance level.

### Results

Standard reference values, in normal subjects (normative), are shown in Table I.

Results in subjects submitted to SCPL are shown in Table II. A variable amount of harmonic areas was found in all cases. In fact, MDVP does not provide results when the signal is totally formed by non-harmonic areas. The results are recorded as average, min, max, range values and SD.

<table>
<thead>
<tr>
<th>Table I. Standard reference values.</th>
<th>Parameter</th>
<th>Range</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fo Average Fundamental Frequency (Hz)</td>
<td>85.055-164.823</td>
<td>117.515</td>
<td>20.630</td>
<td></td>
</tr>
<tr>
<td>vFo Fundamental Frequency Variation (%)</td>
<td>0.419-2.332</td>
<td>0.895</td>
<td>0.375</td>
<td></td>
</tr>
<tr>
<td>vAm Peak-Amplitude Variation (%)</td>
<td>4.332-22.091</td>
<td>8.897</td>
<td>2.897</td>
<td></td>
</tr>
<tr>
<td>Jitt Jitter percent (%)</td>
<td>0.134-1.939</td>
<td>0.538</td>
<td>0.371</td>
<td></td>
</tr>
<tr>
<td>Shim Shimmer percent (%)</td>
<td>1.656-6.727</td>
<td>2.900</td>
<td>1.010</td>
<td></td>
</tr>
<tr>
<td>NHR Noise to Harmonic Ratio</td>
<td>0.089-0.201</td>
<td>0.125</td>
<td>0.019</td>
<td></td>
</tr>
<tr>
<td>VTI Voice Turbulence Index</td>
<td>0.004-0.124</td>
<td>0.057</td>
<td>0.020</td>
<td></td>
</tr>
<tr>
<td>SPI Soft Phonation index</td>
<td>1.793-14.141</td>
<td>5.822</td>
<td>3.473</td>
<td></td>
</tr>
<tr>
<td>DVB Degree of Voice Breaks (%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>DSH Degree of Sub-harmonics (%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>DUV Degree of Unvoiced Voice (%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Results were then submitted to statistical evaluation by comparing mean values of each parameter with normal reference values. Using Student’s t test with $p = 0.05$ significance level after evaluating the t value in each parameter, all variations between standard parameters and those in patients who underwent surgery, except for DSH (Table III), were statistically significant.

### Discussion

The clinical evidence of a change in residual laryngeal anatomo-physiology, following SCPL, causes reasonable doubt that most parameters and traditional methods used in vocal evaluation, cannot, from a physiological, physical and acoustic standpoint, be taken into consideration after this type of surgery. Cabrera Trigo $^{24}$ pointed out that such treatment causes an alteration in the endolaryngeal tract characterised by an irregular air passage and a new vocal production mechanism which appears very different from that of the normal larynx. Namely, non-adductive and muscular fascicular movements, subglottic expiratory air vector with very low subglottic pressure $^{25}$, turbulent air flow along irregular laryngeal margins.

In fact, Dejonkere et al. $^{13}$, adopting the ELS protocol in “common dysphonia”, refers to “substitution voices” when the signal does not originate from two vocal chords, and suggests the use of specific protocols $^{26}$ $^{27}$. As far as concerns that same protocol, the technical nature of the equipment and software, for voice analysis, needs to be taken into further consideration, since most of them, except for those like MDVP, if not highly sophisticated and carefully handled, can

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### Table II. Values of treated patients.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fo  Average Fundamental Frequency (Hz)</td>
<td>70.085-526.13</td>
<td>179.825</td>
<td>154.113</td>
</tr>
<tr>
<td>vFo Fundamental Frequency Variation (%)</td>
<td>2.976-45.313</td>
<td>17.379</td>
<td>12.088</td>
</tr>
<tr>
<td>vAm Peak-Amplitude Variation (%)</td>
<td>14.278-48.451</td>
<td>27.469</td>
<td>11.004</td>
</tr>
<tr>
<td>Jitt Jitter percent (%)</td>
<td>3.479-23.627</td>
<td>11.157</td>
<td>6.707</td>
</tr>
<tr>
<td>Shim Shimmer percent (%)</td>
<td>7.254-41.835</td>
<td>20.009</td>
<td>9.183</td>
</tr>
<tr>
<td>NHR Noise to Harmonic Ratio</td>
<td>0.185-0.702</td>
<td>0.635</td>
<td>0.357</td>
</tr>
<tr>
<td>VTI Voice Turbulence Index</td>
<td>0.141-1.535</td>
<td>0.499</td>
<td>0.470</td>
</tr>
<tr>
<td>SPI Soft Phonation Index</td>
<td>0.722-7.609</td>
<td>3.561</td>
<td>2.609</td>
</tr>
<tr>
<td>DVB Degree of Voice Breaks (%)</td>
<td>0-97.244</td>
<td>27.657</td>
<td>36.673</td>
</tr>
<tr>
<td>DSH Degree of Sub-harmonics (%)</td>
<td>0-9.756</td>
<td>0.696</td>
<td>2.607</td>
</tr>
<tr>
<td>DUV Degree of Unvoiced Voice (%)</td>
<td>0-98.148</td>
<td>69.271</td>
<td>39.673</td>
</tr>
</tbody>
</table>

### Table III. Statistical results.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal speakers Mean values</th>
<th>Treated pts. Mean values</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fo  Average fundamental frequency</td>
<td>117.515</td>
<td>179.825</td>
<td>2.054</td>
<td>0.047</td>
</tr>
<tr>
<td>vFo Fundamental Frequency Variation</td>
<td>0.895</td>
<td>17.379</td>
<td>6.096</td>
<td>0.000</td>
</tr>
<tr>
<td>vAm Peak-Amplitude Variation</td>
<td>8.897</td>
<td>27.469</td>
<td>7.299</td>
<td>0.000</td>
</tr>
<tr>
<td>Jitt Jitter percent (%)</td>
<td>0.538</td>
<td>11.157</td>
<td>7.070</td>
<td>0.000</td>
</tr>
<tr>
<td>Shim Shimmer percent (%)</td>
<td>2.900</td>
<td>20.009</td>
<td>8.282</td>
<td>0.000</td>
</tr>
<tr>
<td>NHR Noise to Harmonic Ratio</td>
<td>0.125</td>
<td>0.635</td>
<td>6.380</td>
<td>0.000</td>
</tr>
<tr>
<td>VTI Voice Turbulence Index</td>
<td>0.057</td>
<td>0.499</td>
<td>4.202</td>
<td>0.000</td>
</tr>
<tr>
<td>SPI Soft Phonation Index</td>
<td>5.822</td>
<td>3.561</td>
<td>2.458</td>
<td>0.019</td>
</tr>
<tr>
<td>DVB Degree of Voice Breaks (%)</td>
<td>0</td>
<td>27.657</td>
<td>3.407</td>
<td>0.002</td>
</tr>
<tr>
<td>DSH Degree of Sub-harmonics (%)</td>
<td>0</td>
<td>0.696</td>
<td>1.194</td>
<td>0.240</td>
</tr>
<tr>
<td>DUV Degree of Unvoiced Voice (%)</td>
<td>0</td>
<td>69.271</td>
<td>7.809</td>
<td>0.000</td>
</tr>
</tbody>
</table>

With significance level at 0.05, values exceeding 1.684 (established-t), obtained by means of Student t test (calculated), should be statistically significant.
easily produce unreliable results when measuring a fundamental frequency or other parameters in a sound signal, the periodicity of which is no longer regular\textsuperscript{15,23}.

Clearly, the acoustic evaluation of this voice requires objective and quantitative acoustic parameters and methods of the vocal product to investigate results and upgrade phonatory aspects in surgery. To this end, the modern acoustic digital analysis of the vocal sound (noise, harmonics, frequency and intensity short-term variations, etc.) can still be used. This application is of considerable clinical interest on account of the possibility of obtaining various measures of the vocal sample as well as information on the “neoglottic” functional results. These methods then allow easier and less subjective comparison of acoustic functional results in surveys\textsuperscript{28}.

Acoustic features of the voice in patients submitted to SCPL are related to anatomical structures and functional abilities of the residual restored phonatory system. Hence, the “neoglottis” vibrational pattern appears rather “unstable” and not-always-periodic, because of the anatomical characteristics of vibrating structures\textsuperscript{29,30}:

1. arytenoid mucosa with no structure “which can be modulated” lying below;
2. tongue base/pharynx/epiglottis;
3. T-shaped neoglottis (with 2 arytenoids);
4. upside-down L-shaped (with 1 arytenoid);
5. closure modes (sagittal, front, mixed);
6. incomplete closure.

This obviously entails completely “new” functional and acoustic consequences. Many Authors have compared vocal characteristics after SCPL with CHP or CHEP, from both a quantitative and qualitative point of view. Now, we first analysed studies in which qualitative evaluation of phonatory results, after this type of surgery, consisted in assigning, following simple subjective criteria, a more or less positive judgement of evaluation of phonatory and vocal function, in general (Table IV).

In 103 patients submitted to CHP, Labayle and Da-\textsuperscript{31}han observed improvements occurring over months. This was often related to the decision of the patient to undertake rehabilitation, aiming at good results. These improvements, following rehabilitation, were really surprising.

Piquet et al.\textsuperscript{32} studied a group of 117 patients, of whom 71 submitted to CHP and 46 to CHEP. Vocal quality was good in 80\% of cases, better and with a sound production intensity higher than that prior to treatment and with a low-pitched timbre. In 20\% of cases, the restored voice kept on being unvoiced even after vocal rehabilitation.

Prades and Martin\textsuperscript{33} observed 19 patients submitted to CHP and referred to the quality of the voice as always being good. As far as concerns this result, an essential role was played by the mobility of the arytenoids and by the fact that, despite a reduced antero-posterior diameter, the width and height of the laryngeal canal are preserved, thus allowing better vibration of the structures when the air column passes.

Ferri and Bottazzi\textsuperscript{34}, in 21 patients with SCPL, observed: good recovery of phonatory quality in 5 (23\%); sufficient in 10 (47\%); poor in 6 (30\%).

Pech et al.\textsuperscript{35} evaluating phonatory function in a group of 49 patients, 17 of whom following CHEP and 32 following CHP, observed good recovery of the voice in all CHEP-treated patients, while in the 32 CHP-treated patients voice quality was poor. Albeit, as the Authors stressed, the worst voice, in these patients, is always better than the oesophageal voice, certainly in function of the absence of a tracheostoma.

Guerrier et al.\textsuperscript{36} studied functional ability in 58 patients, all affected by laryngeal glottic carcinoma, submitted to CHEP. After a minimum observation of at least 4 months, results demonstrated good phona-
tory recovery in all patients. Factors influencing voice quality, besides preservation of the arytenoids, are motivation, but above all, patient’s educational ability allowing him/her gain the greatest profit from the various orthoepical rehabilitation manoeuvres.

Marandas et al. 37 in a survey of 57 patients submitted to CHP, at the Institute Gustave Roussy, observed poor phonatory results in 16 patients (28%) and good in 41 (72%).

Prades et al. 38 analysed 2 patients who underwent CHEP, concluding, from the results, that phonation is basically a source of complaint among the patients, as well as a strain due to closure of the glottis. These two functions of the neolarynx are, as a rule, of poor quality. Moreover, there is little difference between the results of the various surgical techniques, and even these are very difficult to define.

Vigneau et al. 39 analysed functional results, in a survey of 64 patients submitted to SCPL from 1975 to 1985. 52 underwent CHEP and 8 CHP, with 4 patients who underwent total laryngectomy a few weeks after surgery on account of a resection considered oncologically insufficient. According to the rehabilitation protocol, the beginning of orthoepical retraining was programmed to begin 10 days after surgery, together with external massage. A good, perfectly understandable, and satisfactory voice was achieved in 69% of CHEP speakers and in 60% of CHP speakers. In 21% and 22%, respectively, of CHEP speakers and CHP speakers, the voice was slightly voiced, low intensity but understandable and considered satisfactory by the patients. The remaining 10% of the CHEP speakers and 11% of the CHP speakers had a residual voice which was hardly understandable and, in general, of poor quality.

Traissac et al. 40 analysed 122 cases, of which 97 following CHEP and 25 CHP. A good voice was achieved in 25% of patients treated with CHEP and in 17% of those treated with CHP. The voice was unvoiced in patients treated according to SCPL-CHEP and in 60% of those who underwent SCPL-CHP. Finally, in 17% and 23% of patients treated, respectively, with CHEP and CHP, an understandable voice was noted. No big differences between results, obtained shortly after surgery and those after a rehabilitation programme, were noted which is in contrast with other Authors’ experience. In fact, to this end, Minni et al. 41 reported that it is because of the continuous rehabilitation exercises that the intensity of vocal production becomes more and more dynamic, continuous and regular after surgery and, furthermore, in the opinion of these Authors, early treatment of speech defects, by guaranteeing fast recovery of laryngeal physiological function, allows a more rapid return to social life of patients submitted to SCPL.

Pastore et al. 42 submitted the recorded phrases of 14 patients, following reconstructive subtotal laryngec-
A different evaluation is made following a technical quantitative analysis of the sound signal quality, produced by the residual laryngeal structure, after SCPL. In fact, Dejonkere et al. 13, proposing the ELS protocol for the functional assessment of the voice in “common dysphonia”, define “substitution voices” those when the signal does not originate from the two vocal cords; they suggest to re-address the specific protocol, after acoustic analysis. In fact, the most important acoustic finding is the high variability of the fundamental frequency (when a nearly – periodic signal is generated!) caused by the radical anatomical change after SCPL. Except for pressure generated by pulmonary air flow, all that produces the voice physiologically is altered. The signal with all its periodic and aperiodic (noise) components is generated by mucosa vibration which may change from time to time in site and encounter mode. These vibrating structures (arytenoids, tongue base, pharyngeal walls), are visibly, structurally and functionally, very different from vocal cords. According to this viewpoint, the analytical protocol of this voice must be conceptually different from that for “common dysphonia”.

Moerman et al. 27 have suggested that “Substitution voicing” cannot be evaluated accurately by the GIR-BAS perceptual rating scale, and a valid alternative is needed.

According to Bron et al. 52, the restoration of laryngeal function after SCPL with CHEP is satisfactory. Although most of the patients seem to recover normal swallowing function, severe voice alterations appear to be inevitable.

Recently, Yuceturk 53 performed a multidimensional assessment of voice and speech after supracricoid laryngectomy with CHP: the study evaluated vocal function in patients with SCPL compared with that in normal subjects. The acoustic parameters were found to be significantly different from those of normal subjects. The values of perceptual scores were within approximately 50% of the normal range. The number of arytenoids spared did not affect either acoustic or perceptual measurements. A rough, breathy, unpleasant, but intelligible and acceptable, voice could be obtained after SCPL with CHP.

Analyses of our data, obtained using a special high-tech system, suitable for the analysis of small periodic vocal signals, showed a high DVB parameter which displays the rate of absence of both periodic and aperiodic sonority, averaging from one quarter to almost the entire duration of the sound signal. In the remaining sound portions, DVU, which represents a measure of non-harmonic sound portions, i.e., where no Fo could be measured, shows an irregular periodic phonation with a range between 0
and 98% of the samples examined, the mean value of which was about 70%. This percentage implies a sound signal production which, for over two thirds of its duration, is only noise. On the contrary, it was always possible to detect an almost periodic part of the signal (minimum value: 2%). Hence, it is obvious that Fo evaluations, when measured, are very irregular and unpredictable, as the Fo parameter shows, because of the very wide range of values and the high percentage of the Fundamental Frequency Variation (vFo).

The signal has a high Noise to Harmonic Ratio (NHR), and the important turbulent air passage (incomplete closure) is described by the increased VTI value. Amplitude is not constant: tripled variation amplitude coefficient (vAm) and, finally, considerably increased amplitude and frequency perturbations, are fully confirmed.

All these features describe a very slight periodic, unstable, signal, and explain the large percentage of high grade dysphonia in perceptive evaluations 34.

Conclusions

In conclusion, the residual larynx produces a slight sonorous, almost completely aperiodic signal with a variable and inconstant Fo, when and if it is generated. These observations clearly show that the “post-reconstructive-surgery voice” is to be reconsidered, not only as a product of a different functional anatomical configuration of the residual larynx, but also from the resulting acoustic physical product standpoint. In other words, the new laryngeal physiology produces a “different” signal which can never be compared to the “normal” one. This consideration is the most important as the patient gets a “new” voice sound, which is very different from his/her own, and this aspect is not always considered for its social implications. We must remember that we recognize a person by his/her face or the sound of his/her voice!

These evaluations involve new parameters of study and of the real physical acoustic features. To this end, MDVP parameters are indicated for their accurate, direct and quantitative information on some acoustic aspects of functional ability and quality of vocal production, limiting the uncertain subjective, perceptive (GIRBAS scale) or spectrographic interpretations (Yanagihara classification), still improperly used in this situation. Our results, according to Marioni et al. 26, help us in defining guidelines to evaluate the functional results of SCPL and facilitate interstudy comparison. These studies will be integrated by investigations on speech intelligibility 9.

These evaluations, together with both direct and stroboscopic endoscopic visualisation, will likely provide useful suggestions to improve “vocal performance”, in these patients, by future phonosurgical and/or speech therapy rehabilitation programmes.

References

gating the efficacy of (phonosurgical) treatments and evaluating new assessment techniques. Guideline elaborated by the Committee on Phoniatrics of the European Laryngological Society (ELS). Eur Arch Otorhinolaryngol 2001;258:77-82.


Multi Dimensional Voice Program (MDVP). Operation Manual. Kay Elemetrics Corp. USA.


Prades JM, Martin C. Techniques and indications des laryngectomies reconstructives type crico-arytenoïdoplastie et laryngectomie frontale antérieure avec épiglotteoplastique (a propos de trente cas recents). J Franc d’ORL 1985;34:467-71.


47 Laccourreye H, Laccourreye O, Weinstein G, Menard M, Brasnu D. Supracricoid laryngectomy with cricohyo-
48 Laccourreye O, Crevier-Buchman C, Weinstein G, Biacabe B, Laccourreye H, Brasnu D. Duration and frequency char-
acteristics of speech and voice following supracricoid lar-
49 Vigili MG, Colacci AC, Magrini M, Cerro P, Marzetti A. Qual-
ity of life after conservative laryngeal surgery: a multi-
dimensional method of evaluation. Eur Arch Otorhinol-
aryngol 2002;259:11-6.
50 Marquez Moyano JA, Sanchez Gutierrez R, Roldan Nogueras J, Ostos Aumente P, Lopez Villarejo P. Assess-
ment of quality of life in patients treated by supracricoid partial laryngectomy with cricohyoidepiglottopexy
51 Luna-Ortiz K, Nunz-Valencia ER, Tamez-Velarde M, Granados-Garcia M. Quality of life and functional evalua-
tion after supracricoid partial laryngectomy with cricohy-
doepliglottopexy in Mexican patients. J Laryngol Otol
52 Bron L, Pasche P, Brossard E, Monnier P, Schweizer V. Functional analysis after supracricoid partial laryn-
ectomy with cricohyoidepiglottopexy. Laryngoscope
2002;112:1289-93.
53 Yuceturk AV, Gunhan K. Multidimensional assessment of voice and speech after supracricoid laryngectomy with
54 Makeiff M, Barbotte E, Giovanni A, Guerrier B. Acoustic and aerodynamic measurement of speech production after
supracricoid partial laryngectomy. Laryngoscope

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