Comparative assessment of the voice in patients treated for early glottis cancer by laser cordectomy or radiotherapy

Ocena porównawcza głosu u pacjentów z wczesnym rakiem głośni po chordektomii laserowej lub radioterapii

Eugeniusz Czecior\(^1\), Bogusława Orecka\(^1\), Piotr Pawlas\(^1\), Katarzyna Mrówka-Kata\(^1\), Grzegorz Namysłowski\(^1\), Krzysztof Składowski\(^2\), Paweł Sowa\(^1,\)*

\(^1\)Katedra i Oddział Kliniczny Laryngologii w Zabrzu Śląskiego Uniwersytetu Medycznego w Katowicach, Ordynator: dr hab. n. med. Grzegorz Namysłowski, Zabrze, Poland
\(^2\)I Klinika Radioterapii, Centrum Onkologii – Instytut im. Marii Skłodowskiej-Curie Oddział w Gliwicach, Kierownik: dr hab. n. med. Krzysztof Składowski, Gliwice, Poland

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**Abstract**

Introduction: Adaptation of laser surgery in laryngeal cancer treatment in 1970s led to great successes and common acceptance of this treatment method in cancer treatment. The results of cancer treatment with CO\(_2\) laser are the same as after radiotherapy or external access method. Material and methods: The study included 63 patients treated for glottis cancer T1. 33 persons were treated by cordectomy type III with transmuscular cordectomy using CO\(_2\) laser. The remaining 30 persons are patients treated using radiotherapy with so-called "small spots". The tested material consisted of 100% squamous carcinoma. The patients qualified for the examination received a card of voice self-examination. The perceptive examination of the voice was performed according to the GRBAS scale where each of parameters is defined in a four degree scale of the particular disturbance degree. The mobility and vibrations of the vocal folds were accessed using videolaryngoscopy while the acoustic analysis was performed on the basis of the acoustic analysis module. Results: On the basis of the patients' voice quality self-assessment and the perceptive assessment of the voice quality based on the GRBAS scale, no significant differences between the groups were found. Furthermore no statistically significant differences were found for the phonation closure and maximal phonation time in both groups.

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Introduction

Introduction of laser surgery in laryngeal cancer treatment in 1970s led to great successes and common acceptation of this treatment method in cancer treatment \[1, 2\]. The results of cancer treatment with CO\textsubscript{2} laser are the same as after radiotherapy or external access method. Radiotherapy often results in dryness and inflammation of the mucosa and this method cannot be re-applied in the case of recurrence. In comparison to radiotherapy, the cost of CO\textsubscript{2} laser treatment is lower, hospital stay is shorter, no dryness and mucosa is found and a normal swallowing and respiration is preserved. Laser therapy can be re-applied in the case of recurrence. A very important criterion after a glottis cancer is the voice quality. Phonosurgery of Tis–T1 glottic cancer requires the knowledge of the exact structure of the vocal folds and the cancer size using TK NMR, stroboscope examination, intravital staining or saline infusion into the Reinki space \[2, 3\]. The European Laryngological Society divided cordectomy into several types: subepithelial, subligamentous, transmuscular, total cordectomy, extended cordectomy including neighbouring tissues (second vocal fold, triquetro cartilage, ventricular fold or sublottis area) \[2–4\]. The voice quality depends on the type of performed cordectomy.

Material and Methods

The study included 63 patients treated for glottis cancer T1. 33 persons were treated by surgery from 06.1995 to 01.2006 w II Department and Clinics of Laryngology of the Silesian Medical University in Katowice. The patients were subjected to cordectomy type III + transmuscular cordectomy using microscope Zeiss equipped in CO\textsubscript{2} laser from the same company and with a special set of endings for throat and larynx surgery from Sharplan. The microscope was connected with a laser with Flashscanner Surgi Otuch projected by Sharplan for laryngological surgery with a 230 mm focus, with the spot diameter 1.0 mm in the cutting mode to 3.0 mm in the evaporisation mode. The continuous laser mode was used and the power between 3 and 7 W. The surgeries were performed under general intratracheal anaesthesia using Kleinsasser’s set.

The remaining 30 persons are patients treated using radiotherapy in the Marie Skłodowska-Curie Oncology Institute in Gliwice from 03.1995 to 10.2003 by radiation with so called “small spots” within the area from the incisure thyroidea superior to the inferior cricoid cartilage and the anterior border of the posterior throat wall at 6MV or Gamma Co-60 with a fractional dose of 3 Gy/tumour up to a total dose of 51–54 Gy/tumour in 16-17 fractions.

The operated group consisted of 91% men and 9% women. The patients radiated are in 90% men and in 10% women. The men were aged from 50 to 83 years (mean age 66 years). The age of women was within the range of 35 to 87 years (mean age 61 years). The mean age in the operated group was 63 years, and in the radiated group – 69 years. The tested material consisted of 100% squamous carcinoma with the following advance stages: G1 – 69%, G2 – 26%, G3 – 5%.

The patients were subjected to a thorough laryngological examination and the history was completed. The patients with additional disorders of the vocal cords, which can influence the voice quality were not included into the examination.

The patients qualified for the examination received a card of voice self-examination to choose one of three options:

- a) voice is the same as before the surgery,
- b) voice slightly worsened,
- c) voice much worsened.

The perceptive examination of the voice was performed by a three-person group (laryngologist, phoniatrist, laryngologist). The final result consisted the mean of three assessments.

The perceptive examination of the voice was performed according to the GRBAS scale where each of parameters is defined in a four degree scale of the particular disturbance degree: 0 – normal or no particular voice disturbances, 1 – small disturbance, 2 – medium disturbance, 3 – disturbance of a high degree. The voice setup was assessed on the basis of a three degree scale: 1 – soft, 2 – hard, 3 – blowing.

The mobility and vibrations of the vocal folds were accessed using videolaryngoscopy – the Storz: laryngostrobe-8020 and the telecom SL pal 20212020 camera from the same company. The image was registered in PC computer as the film files “avi”. The images were registered in the licence software (system for phoniatry: “Iris” Professional 2.2.11.0) with a video registration module. The examination was performed using a local oral anaesthesia by 10% lignocaine. The images were registered twice. The first image consisted of a six-fold magnification of the vocal folds in the laryngostroboscope, the second – the video stroboscopic examination during phonation a vowel “a”. The videostroboscopic examination accessed:

- “N” – symmetry and regularity of the vocal folds vibrations (phase and amplitude),
- “A” – vibration amplitude, “P” – mucosal wave, “Z” – phonation closure. MPT (Maximal Phonation Time) was assessed.

The acoustic analysis was performed on the basis of the acoustic analysis module, consisting of a PC computer and the Iris software. The acoustic recording in the form of „wave” files was subjected to acoustic analysis. The voice registration was performed in a special room, using a computer equipped in a microphone at approx. 20 cm from a patient’s mouth. To analyse the laryngeal tone, „a” vowel was registered, as the most recognizable. The following parameters were examined:

A – parameters determining the relative frequency change (Jitt%, RAP%, PPQ%,Fo)

<table>
<thead>
<tr>
<th>Examined parameter</th>
<th>group I</th>
<th>group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-assessment of the voice quality</td>
<td>the same</td>
<td>21.21%</td>
</tr>
<tr>
<td></td>
<td>slightly worsened</td>
<td>63.64%</td>
</tr>
<tr>
<td></td>
<td>significantly worsened</td>
<td>15.15%</td>
</tr>
</tbody>
</table>
B – parameters determining the relative amplitude change (Shim%, APQ%)
C – parameters determining the relative noise measurements (N/S)

Statistical analysis used Statistica 8.0 StatSoft Inc (2007) software. After data distribution was determined in Kolmogorov-Smirnow’s test, the data with the normal distribution were analysed using Student’s t-test and other data using U-Mann-Whitney’s test. The numbers in the tested group were compared using $\chi^2$ test. The statistical significance was defined at $p = 0.05$

Results

On the basis of the patients’ voice quality self-assessment, no significant differences between the groups were found (Tab. I).

The results of the perceptive assessment of the voice quality on the basis of the GRBAS scale showed no significant differences between the groups (Tab. II).

Assessing the voice setup no significant statistical differences between these parameters were found. Assessment of mobility and vibration of the vocal folds using videolaryngoscope in these two groups was possible only for the Z parameter, which characterises closure of the vocal folds. No statistically significant differences were found for the phonation closure.

Maximal phonation time in both groups showed no significant statistical differences and it was 13.36 seconds for the I group and 14.33 seconds for the II group (Tab. III).

Assessment of the parameters defining relative change in the frequency of the vocal folds vibration showed no statistically significant differences for the Jitt% $1.05 \pm 0.68$ vs $0.60 \pm 0.60$ between the surgery patients and the patient treated by chemotherapy. Similarly, for the following parameters: RAP% $0.84 \pm 0.27$ vs $0.42 \pm 0.46$ (Table IV) and PPQ% $1.04 \pm 1.70$ vs $0.53 \pm 0.61$.

However, statistically significant basic frequency (F0) was found in the patients from group I in relation to the group II ($205.81 \pm 60.86$ vs $155.60 \pm 68.81$).

A statistically significant difference in both groups was found for the noise content in the voice signal – it was $9.21 \pm 6.76$ for the I group vs $7.33 \pm 9.56$ in II group.

No statistically significant differences in the amplitude of the vocal folds vibration was found – parameter Shim% $10.89 \pm 8.01$ vs $7.76 \pm 6.78$, parameter APQ% $10.65 \pm 9.35$ vs $7.23 \pm 6.26$.

Discussion

Modern medicine is aimed not only at removal of laryngeal tumours but also for restoration or improvement of the phonation function of the organ, and restoration of the patient’s life comfort [5–8]. At the beginning of the 20th century, there was 10% of the occupations requiring efficient information exchange and 90% of those requiring manual efficiency. At the moment, this ratio is completely changed and as much as 90% of the occupations require efficient information exchange with the use of voice [9–11]. Therefore, assessment of the voice quality also screens for the treatment efficiency.

The complex assessment of the phonation activity should be supplemented by the subjective scale of self-assessment since it shows how much the voice disturbance can influence the quality of life [9, 12, 13]. The presented paper used the simplified self-assessment test and showed no statistically significant differences between the patients treated with laser cordectomy and radiotherapy. It corresponds with the results

### Table II – Voice quality in the GRBAS scale in the I and II group of patients

<table>
<thead>
<tr>
<th>disturbances</th>
<th>G</th>
<th>R</th>
<th>B</th>
<th>A</th>
<th>S</th>
<th>Group (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (0)</td>
<td>33.33</td>
<td>57.58</td>
<td>90.91</td>
<td>93.94</td>
<td>18.18</td>
<td>Group I (%)</td>
</tr>
<tr>
<td></td>
<td>50.00</td>
<td>60.00</td>
<td>96.67</td>
<td>96.67</td>
<td>23.33</td>
<td>Group II (%)</td>
</tr>
<tr>
<td>Small (1)</td>
<td>21.21</td>
<td>21.21</td>
<td>6.06</td>
<td>6.06</td>
<td>39.39</td>
<td>Group I (%)</td>
</tr>
<tr>
<td></td>
<td>30.00</td>
<td>30.00</td>
<td>0</td>
<td>3.33</td>
<td>60.00</td>
<td>Group II (%)</td>
</tr>
<tr>
<td>Medium (2)</td>
<td>30.30</td>
<td>15.15</td>
<td>3.03</td>
<td>0</td>
<td>42.42</td>
<td>Group I (%)</td>
</tr>
<tr>
<td></td>
<td>10.00</td>
<td>6.67</td>
<td>0</td>
<td>0</td>
<td>16.67</td>
<td>Group II (%)</td>
</tr>
<tr>
<td>Large (3)</td>
<td>15.15</td>
<td>6.06</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Group I (%)</td>
</tr>
<tr>
<td></td>
<td>10.10</td>
<td>3.33</td>
<td>3.33</td>
<td>0</td>
<td>0</td>
<td>Group II (%)</td>
</tr>
</tbody>
</table>

### Table III – Parameters of phonation in patients from group I and II

<table>
<thead>
<tr>
<th>Examined parameter</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice setup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>soft</td>
<td>15.15%</td>
<td>23.33%</td>
</tr>
<tr>
<td>hard</td>
<td>75.76%</td>
<td>73.33%</td>
</tr>
<tr>
<td>blowing</td>
<td>9.09%</td>
<td>3.33%</td>
</tr>
<tr>
<td>Phonation closure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>complete</td>
<td>75.76%</td>
<td>90.00%</td>
</tr>
<tr>
<td>incomplete</td>
<td>24.24%</td>
<td>10.00%</td>
</tr>
<tr>
<td>Maximal phonation time</td>
<td>13.36 seconds</td>
<td>14.33 seconds</td>
</tr>
</tbody>
</table>

### Table IV – Obtained parameters of vocal folds vibration in patients from group I and II

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jitt%</td>
<td>$1.05 \pm 0.86$</td>
<td>$0.68 \pm 0.60$</td>
</tr>
<tr>
<td>RAP%</td>
<td>$0.84 \pm 1.27$</td>
<td>$0.42 \pm 0.46$</td>
</tr>
<tr>
<td>PPQ%</td>
<td>$1.04 \pm 1.70$</td>
<td>$0.53 \pm 0.61$</td>
</tr>
<tr>
<td>F0 (Hz)</td>
<td>$205.81 \pm 60.86$</td>
<td>$155.60 \pm 68.81$*</td>
</tr>
<tr>
<td>Shim%</td>
<td>$10.89 \pm 8.01$</td>
<td>$7.76 \pm 6.78$</td>
</tr>
<tr>
<td>APQ%</td>
<td>$10.65 \pm 9.35$</td>
<td>$7.23 \pm 6.26$</td>
</tr>
<tr>
<td>N/S</td>
<td>$9.21 \pm 6.76$</td>
<td>$7.33 \pm 9.56$</td>
</tr>
</tbody>
</table>
of Hirano, who first performed such comparison. However, 50% of the patients treated with laser in this study were previously subjected to radiotherapy [14]. Delsupehe [15], Mc Guirt [6, 16], Brandenburg [2], also obtained similar results. Rydel [17], Krengli [18], Elner [19], Epstein [20] described better results in the radiotherapy group. The GRBAS scale was used for the perceptive assessment of the voice. This method is by many authors considered as a method, which in a reliable and simply manner describes the voice characteristics [21–26].

This work presents much more patients, in comparison to the so far published papers but no statistically significant changes in the whole GRBAS scale were found, which corresponds with the results of other authors [5, 6, 16]. Peretti considers that cordectomy type I and II leads to a significant improvement of G parameter, and of RBAS to a lesser degree, as well as of other parameters of the objective analysis [7]. When assessing the voice in the GRBAS scale some authors presents better results for the patients after radiotherapy [8, 21–23, 27].

Assessment of the voice setup defines how the vocal folds change from the breathing to phonation. In the natural conditions, the voice should be generated freely, without effort, with a soft (physiological) setup. In both groups we found a hard setup dominated but no statistical significant differences were noted. Krengel’s study [18] confirmed our results.

Videolaryngostroboscopy is a valuable clinical examination in diagnostics and assessment of the voice disturbance treatment [4, 22, 24, 28–30]. By examining mobility and vibration of the vocal folds, phonation closure was analysed, as an indicator of glottis efficiency [14, 18, 28]. Lack of the total phonation closure consists one of the factors playing a crucial role in development of voice hoarseness and it depends on the volume of the removed vocal fold [7, 16, 31]. Peretti considers that only cordectomy type I (subepithelial) and type II (subligamentous) allows to restore the complete closure in 89% of the operated as a result of the vocal fold regeneration. The results of the analysis of the group I show that cordectomy type III (transmuscular) allows to obtain similar results. Complete closure was found in 75.76% of the patients from group I and in 90% from group II [7]. Krengli [18] also confirms in his research that cordectomy type III allows to obtain the complete closure between the healthy fold and the scar developed after cordectomy.

Maximal Phonation Time (MPT) is the most commonly assessed aerodynamic parameter and it is a sensitive indicator if the voice disturbance. Literature underlines that the phonation time can be influenced by many factors, such as gender, age, type of the used vowel, tone height and intensity [10, 12, 25]. In the present work MPT in both groups was shortened and showed no statistically significant differences, which corresponds with the results presented by other authors [4, 7, 16, 27, 29, 32].

The more perfect technique for the voice quality assessment is the objective acoustic analysis, a relatively new and non-invasive method [21, 22, 33].

The acoustic analysis of the frequency, amplitude and relative noise measurements are the most representative and gradually replace the perceptive assessment in the opinion of many authors [22–24]. The maximally objective voice assessment can be obtained by combining the subjective perceptive assessment, videostroboscopy with the objective acoustic analysis [3, 30].

The parameters showing the relative frequency change: Jitt’s, RAP%, PPQ%, showed no statistically significant differences between the groups, which is consistent with the results of Mc Guirt [6, 16], Rosier [34], observed better results in the group after radiotherapy. Rydell [17], observed the higher voice quality after radiotherapy, especially in the group of parameters of the relative frequency changes. Krengli [18] describes in his paper better results for all parameters of the acoustic analysis in the radiotherapy group, with a particular involvement of the parameters of the relative frequency change.

In this work, among the parameters characterising the relative frequency change, only the basic frequency Fo was statistically significant in group I. In the literature, authors underline that the Fo value depends on the mass and stiffness of the vibrating vocal folds [26, 30, 31, 35]. Cordectomy decreases mass of the vocal fold and a stiff scar appears after the surgery, resulting in the frequency increase of the basic glottis tone. Additionally, subglottic pressure decreases at the incomplete glottis closure, which many authors considers as having influence upon the Fo value [26, 30, 36, 37]. Radiotherapy also causes the Fo increase due to the stiffness of the vocal folds [3, 5, 6, 32, 38]. Fo changes also with the age, voice ageing starts usually around 60 years of age and its tone decreases in women and increases in men [11]. According to Hirano [25, 39] Fo is the main parameter describing the individual voice features. Mc Guirt [6] observed the Fo increase without differences between the groups, which was confirmed by Delsupehe [15]. Comparing Fo parameter between the groups, Rydell [17], Krengli [18] showed much better results for the radiated group. Honocodeevar-Baltezar [14], Lehman [5] did not observed any changes in the basic frequency after radiation, while Stoicheff [8] described a decrease in the Fo value.

The group describing the relative amplitude change – Shimm % and APQ% showed no statistically significant differences between the groups, which was also confirmed by Brandenburg, Delsupehe, Mc Guirt and Rydell, the latter shows also better results of the parameters defining the relative frequency change [2, 6, 15–17]. Similar results were shown by Elner and Fex [19].

The last of the parameters of the objective acoustic analysis is the noise to signal ration – N/S, which defines the noise content in the voice signal. Some authors consider that this parameter is influenced by the irregular voice folds shape, and insufficient glottis closure during phonation [9, 40]. This work shows no statistically significant differences between the groups, which corresponds with the results of Brandenburg [2], Rydell [17] Elner and Fex [19]. Krengli [18], presented better results in the radiated group.

**Conclusion**

In conclusion patients after laser surgery and radiotherapy achieved satisfactory quality of voice. Moreover type III laser cordectomy reveals similar voice quality as radiotherapy alone.
Authors’ contributions/Wkład autorów

Eugeniusz Czeceor – study design, data collection, acceptance of final manuscript version, literature search; Bogusława Orecka – data collection, data interpretation, acceptance of final manuscript version; Piotr Pawlas – study design, data collection, statistical analysis; Katarzyna Mrówka-Katańczyk – literature search; Grzegorz Namysławski – acceptance of final manuscript version; Krzysztof Śliwiński – data interpretation; Paweł Sowa – statistical analysis, data interpretation, acceptance of final manuscript version, literature search.

Conflict of interest/Konflikt interesu

None declared.

References/Piśmiennictwo


