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Voice analysis before and after vocal rehabilitation in patients following open surgery on vocal cords

Analiza glasa pre i posle vokalne rehabilitacije kod bolesnika posle otvorene operacije glasnica

Mila Bunijevac*†, Mirjana Petrović-Lazić†‡, Nadica Jovanović-Simić†, Mile Vuković†

***Public Health Hospital "St Vračevi", Bijeljina, Bosnia and Herzegovina; †Faculty for Special Education and Rehabilitation, University of Belgrade, Belgrade, Serbia; ‡ENT Clinic, Clinical Hospital Center "Zvezdara", Belgrade, Serbia**

Abstract

Background/Aim. The major role of larynx in speech, respiration and swallowing makes carcinomas of this region and their treatment very influential for patients' life quality. The aim of this study was to assess the importance of voice therapy in patients after open surgery on vocal cords. **Methods.** This study included 21 male patients and the control group of 19 subjects. The vowel (A) was recorded and analyzed for each examinee. All the patients were recorded twice: firstly, when they contacted the clinic and secondly, after a three-month vocal therapy, which was held twice *per* week on an outpatient basis. The voice analysis was carried out in the Ear, Nose and Throat (ENT) Clinic, Clinical Hospital Center "Zvezdara" in Belgrade. **Results.** The values of the acoustic parameters in the patients submitted to open surgery on the vocal cords before vocal rehabilitation and the control group subjects were significantly different in all specified parameters. These results suggest that the voice of the patients was damaged before vocal rehabilitation. The results of the acoustic parameters of the vowel (A) before and after vocal rehabilitation of the patients with open surgery on vocal cords were statistically significantly different. Among the parameters – Jitter (%), Shimmer (%) – the observed difference was highly statistically significant ($p < 0.01$). The voice turbulence index and the noise/harmonic ratio were also notably improved, and the observed difference was statistically significant ($p < 0.05$). The analysis of the tremor intensity index showed no significant improvement and the observed difference was not statistically significant ($p > 0.05$). **Conclusion.** There was a significant improvement of the acoustic parameters of the vowel (A) in the study subjects three months following vocal therapy. Only one out of five representative parameters showed no significant improvement.

Key words:
otorhinolaryngologic surgical procedures; laryngeal neoplasms; treatment outcome; voice quality; rehabilitation; speech production measurement.

Apstrakt

Uvod/Cilj. Glavna uloga larinksa – govor, disanje i žvakanje – čine da karcinomi tog regiona i njihovo lečenje veoma utiču na kvalitet života tih bolesnika. Cilj ove studije bio je da se proceni značaj vokalne terapije kod bolesnika posle otvorene operacije na glasnicama. **Metode.** Ovo ispitivanje obuhvatilo je 21 bolesnika muškog pola i kontrolnu grupu koju je činilo 19 ispitanika. Kod svih bolesnika, sniman je i analiziran intenzitet vokala (A). Svi bolesnici snimani su dva puta, prvi put kad su se javili u ambulantu i drugi put posle tromesečne vokalne terapije. Vokalna terapija sprovodila se ambulantno, dva puta sedmično. Analiza glasa izvršena je u ORL klinici Kliničko-bolničkog centra „Zvezdara" u Beogradu. **Rezultati.** Vrednosti akustičkih parametara kod bolesnika nakon otvorene operacije glasnica pre vokalne terapije i ispitanika kontrolne grupe značajno su se razlikovali u svim navedenim parametrima. Ovi rezultati ukazuju na to da je glas ispitanika pre vokalne terapije bio oštećen. Rezultati akustičkih parametara samoglasnika (A) pre i posle vokalne terapije kod bolesnika posle otvorene operacije na glasnicama statistički su se značajno razlikovali. Među parametrima Jitter (%) i Shimmer (%) razlika je bila visoko statistički značajna ($p < 0,01$). Indeks turbulencije glasa i odnos šum/harmonik takođe su se značajno poboljšali, a razlika je bila statistički značajna ($p < 0,05$). Analizom tremora kroz indeks intenziteta, nije došlo do značajnog poboljšanja, a posmatrana razlika nije bila statistički značajna ($p > 0,05$). **Zaključak.** Nakon tromesečne vokalne terapije došlo je do značajnog napretka akustičkih parametara intenziteta vokala (A) analiziranih ispitanika. Od pet analiziranih reprezentativnih parametara samo jedan nije imao značajan napredak.

Ključne reči:
hirurgija, otorinolaringološka, procedure; larinks, neoplazme; lečenje, ishod; glas, kvalitet; rehabilitacija; govor, produkcija, merenje.

Correspondence to: Mila Bunijevac, Public Health Hospital "St. Vračevi", Srpske Vojske 53, 76 300 Bijeljina, Republika Srpska, Bosnia and Herzegovina. E-mail: bunijevacmila@yahoo.com

Introduction

Partial laringectomy was introduced in order to alleviate a handicap associated with total laryngectomy. Partial laringectomy surgery removes only affected laryngeal parts preserving intact airway and providing notably less damage to vocal generator.

Cordectomy *via* thyrotomy is the oldest surgical procedure for the treatment of early glottic carcinoma [1].

Cordectomy can be performed by the following two methods depending on the indication: endoscopic laser cordectomy, and laryngofissure with cordectomy.

The major role of larynx in speech, respiration and swallowing makes carcinomas of this region and their treatment very influential for patients' life quality. Laryngeal carcinomas are second in frequency among all primary epithelial malignant tumors of head and neck and they make 2% of all human carcinomas.

Treatment of early stage glottic carcinoma, in the most cases, is successful for two reasons. Firstly, carcinoma of the true vocal cord gives an early symptom – hoarseness – that is relatively easy to be diagnosed. Secondly, the glottic region is insufficient in lymph drainage which provides spreading to regional lymph nodes extremely rare, less than 1% within stadium T1. All these factors enables high curability of glottic carcinomas in early stage [2].

The aim of this study was to assess the importance of voice therapy in patients after open surgery on vocal cords.

Methods

This research involved 21 male examinees and the control group of 19 subjects. The average age of the subjects was 48.9 ± 4.55 years. All the patients were recorded twice: firstly, when they contacted the Clinic and secondly, after a three-month vocal therapy, which was held twice *per* week on an outpatient basis. The examinees vocalized a vowel (A) in the most adequate height for them individually, afterwards the mean produced values were analyzed. Acoustic parameters of the vowel (A) of each examinee were analyzed in real time. Acoustic interpretation was performed in the ENT Clinic, Clinical Center "Zvezdara" in Belgrade. The success of vocal therapy was followed by a computerized laboratory for vocal analysis, model 4300, "Kay Elemetrics" company. This computerized laboratory provides unbiased voice analysis records and concurrently serves as a support for subjective assessment of voice. This study was conducted among the patients who had undergone open surgery. Five parameters of multidimensional voice analysis were studied: parametric signal (jitter percent %), noise parameters [noise/harmonic ratio (NHR)], voice turbulence index (VTI), tremor parameter [the frequency tremor (Fo) intensity index (FTRI %)].

In the paper the descriptive statistics methods were applied: measures of variability and tabulation. The analytical statistics methods were as follows: Student's *t*-test for parametric and Wilcoxon test of equivalent W-pairs for nonparametric data. Since the sample size was 21, the significance of differences in Wilcoxon test was determined by Zed-Z test, because the data were in normal distribution.

Results

This research involved 21 male examinees and the control group of 19 subjects. The average age of the subjects was 48.9 ± 4.55 years. The distribution of factors associated with glotis carcinoma is shown in Table 1. Most often the patients had all of the factors we tested, we labeled these factors as associated ones (87.8%). Analyzing them separtely smoking was the most common factor (76.20%), then work in air polluted enviroment (66.5%), and inflammatory processes (47.0%).

Table 1

Representation of factors associated with glotis carcinoma

Factors	Yes (%)	No (%)
Work in an area with air pollution	66.50	33.50
Smoking	76.20	23.80
Inflammatory processes	47.00	53.00
Associated factors	87.80	12.20

Analyzing the results, we firstly compared the values of acoustic parameters in the examinees before vocal rehabilitation and of the control group before vocal rehabilitation, too.

The obtained results are shown in Table 2. We noticed that values of all processed parameters were highly statistically different. This indicated that the patients' voice was damaged significantly. The obtained values of the parameters were

Table 2

Values of vocal parameters of the patients before vocal rehabilitation and the control group examinees

Vocal parameters	Patients with open surgery on vocal cords (n = 21)		Control group (n = 19)		Difference		*p*
	Mean value	SD	Mean value	SD	Absolute	%	
Jitter (%)	2.005	1.475	0.497	0.222	1.510	7.37	< 0.01
Shimmer (%)	5.646	2.520	1.844	0.437	3.810	67.32	< 0.01
NHR (db)	0.162	0.051	0.112	0.013	0.115	71.72	< 0.01
VTI	0.072	0.026	0.043	0.016	0.020	32.30	< 0.01
FTRI (%)	1.190	0.849	0.318	0.137	0.871	73.21	< 0.01

Jitter – variability of the fundamental frequency; Shimmer - variations in the amplitude of primary laryngeal tone; VTI – voice turbulence index; FTRI – frequency tremor intensity parameter; NHR – relationship of intraharmonic noise and harmonics; *p* – statistical significance.

following: Jitter(%): W = 480, Z = -4.360, $p < 0.01$; Shimmer (%): W = 466, Z = -4.153, $p < 0.01$; NHR (db): W = 458, Z = -4.262, $p < 0.01$; VTI: W = 460, Z = -4.498, $p < 0.01$; FTRI (%): W = 472, Z = -4.519, $p < 0.01$.

Table 3 shows the values of acoustic parameters before and after vocal rehabilitation. The results of acoustic parameters of the vowel (A) before and after vocal rehabilitation were significantly different. The observed difference for the parameter of short-term and long-term frequency disturbances- Jitter percent (%) and Shimmer percent (%) was statistically significant (W = 485, Z = -4.882, $p < 0.01$; and respectively) W = 452, Z = -4.756, $p < 0.01$, and respectively). VTI also notably improved, the observed difference was highly statistically significant (W = 129.1, Z = -2.154, $p < 0.05$). Analyzing the tremor through FTRI, no significant improvement was noticed. The observed difference was not statistically significant (W = 164, Z = -1.259, $p > 0.05$). The presence of noise in the analyzed signal – NHR, significantly changed after therapy. The observed difference was statistically significant (W = 129.1, Z =- 2.154, $p < 0.05$).

Table 4 shows the values of acoustic parameters in the examinees after vocal rehabilitation and in the control group subjects. The results showed that the values of the acoustic parameters in the patients after vocal rehabilitation and the value of acoustic parameters in the control group, except for FTRI (%) were not significantly different. The obtained values of parameters were as follows: Jitter (%) – W = 147, Z = -1.360, $p > 0.05$; Shimmer – W = 166, Z = -1.153, $p > 0.05$; NHR (db) – W = 158, Z = -1.262, $p > 0.05$.

Discussion

In this research the success of vocal therapy in the examinees was followed by multidimensional analysis of the vowel (A) vocal parameters. Many studies documented effects of vocal therapy in improving the acoustic parameters of voice [3–6]. Our results on distribution of predisposing factors for glotis carcinoma are congruent with the other authors' data [4, 7].

Numerous researches confirmed that normal and pathological voice differ in many parameters. Pathological voice is characterized by high values of frequency disturbances and amplitude disturbances. Our study affirms the same.

The differences between the values of the acoustic parameters before vocal rehabilitation and of the control group with all specified parameters were highly statistically significant. These results suggest that the voice of the examinees was considerably damaged before the beginning of vocal rehabilitation.

The results of the acoustic parameters of the vowel (A) before and after vocal rehabilitation were significantly different. The observed difference of two parameters – Jitter (%)

Table 3

Values of vocal parameters before and after vocal rehabilitation

Vocal parameters	Before vocal rehabilitation (mean value ± SD)	After vocal rehabilitation (mean value ± SD)	Difference		*p*
			Absolute	%	
Jitter (%)	1.991± 1.388	0.561 ± 0.250	1.423	72.59	< 0.01
Shimmer (%)	5.522 ± 5.456	1.990 ± 0.642	3.663	65.10	< 0.01
NHR (db)	0.157 ± 0.041	0.111 ± 0.008	0.045	29.10	< 0.05
VTI	0.071 ± 0.026	0.048 ± 0.013	0.016	23.66	< 0.05
FTRI (%)	1.202 ± 0.849	0.321 ± 0.155	0.868	72.91	> 0.05

Jitter – variability of the fundamental frequency; Shimmer – variations in the amplitude of primary laryngeal tone; VTI – voice turbulence index; FTRI – frequency tremor intensity parameter; NHR – relationship of intraharmonic noise and harmonics; *p* – statistical significance.

Table 4

Vocal parameters of the patients after vocal rehabilitation and the control group examinees

Vocal parameters	Patients after vocal rehabilitation (mean value ± SD)	Control group (mean value ± SD)	Difference		*p*
			Absolute	%	
Jitter (%)	0.561 ± 0.250	0.508 ± 0.167	0.052	9.42	> 0.05
Shimmer (%)	1.982 ± 0.642	1.844 ± 0.438	0.137	6.95	> 0.05
NHR (db)	1.396 ± 0.391	1.101 ± 0.364	0.294	21.11	> 0.05
VTI	0.111 ± 0.008	0.110 ± 0.007	0.001	0.88	> 0.05
FTRI (%)	0.321 ± 0.145	0.318 ± 0.147	0.002	0.92	< 0.05

Jitter – variability of the fundamental frequency; Shimmer – variations in the amplitude of primary laryngeal tone; VTI – voice turbulence index; FTRI – frequency tremor intensity parameter; NHR – relationship of intraharmonic noise and harmonics; *p* – statistical significance.

and Shimmer (%) was highly statistically significant ($p < 0.01$). VTI and NHR were also significantly improved, the observed difference was statistically significant ($p < 0.05$). Similar results were obtained by other authors [5, 7–10]. Analyzing tremor through FTRI, no significant improvement was observed and the observed difference was not statistically significant ($p > 0.05$). Examining available literature we did not find information on this parameter. A possible explanation for unsatisfying improvement of FTRI is the short duration of vocal rehabilitation. We can ascertain that the three-month vocal rehabilitation yielded good results and that it gave a great improvement of acoustic voice parameters, considering that only one of the analyzed parameters did not have a statistically significant improvement.

The gained results also showed that the values of acoustic parameters in the examinees after vocal rehabilitation and the values of acoustic parameters in the control group were not significantly different, except for one parameter – FTRI (%). Only with FTRI (%) the difference was statistically significant ($p < 0.05$). This was expected due to the abscence of improvement after vocal therapy.

Conclusion

The results of this research show that patients after open surgery on the vocal cords could repair their voice qualities by vocal therapy.

On the basis of the obtained results it could be concluded that a three-month vocal rehabilitation improves acoustic parameters of the vowel (A). Only one, out of five analyzed parameters showed no significant improvement. The computerized laboratory for vocal analysis, which was used in this study, provides visual, acoustic and aerodynamic information. This computerized laboratory provides unbiased voice analysis records and concurrently serves as a support for subjective assessment of voice. It could be used to confirm comparability. Pre-treatment and post-treatment data could be documented with a patient submitted to the program of vocal therapy. These data are helpful for the process of establishing the final diagnosis, as well as for the process of therapy. In this way the computerized laboratory for vocal analysis is very valuable both for patients and therapists.

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