

# Research Paper: Improving Voice Outcomes After Injury to the Recurrent Laryngeal Nerve



CrossMark

Lejla Junuzovic Zunic<sup>1\*</sup>, Amela Ibrahimagic<sup>1</sup>, Selma Altumbabic<sup>2</sup>, Sekib Umihanic<sup>1,3</sup>, Belkisa Izic<sup>4</sup>

1. Department of Speech Therapy and Rehabilitative Audiology, Faculty for Special Education and Rehabilitation, University of Tuzla, Tuzla, Bosnia and Herzegovina.

2. Department of Audiology and Phoniatrics, University Clinical Center Tuzla, Tuzla, Bosnia and Herzegovina.

3. Department of Otorhinolaryngology, Faculty of Medicine, University Clinical Center Tuzla, Tuzla, Bosnia and Herzegovina.

4. Clinic for Radiology and Nuclear Medicine, University Clinical Center Tuzla, Bosnia and Herzegovina.



**Citation:** Junuzovic Zunic L, Ibrahimagic A, Altumbabic S, Umihanic S, Izic B. Improving Voice Outcomes After Injury to the Recurrent Laryngeal Nerve. Iranian Rehabilitation Journal. 2017; 15(4):399-406. <https://doi.org/10.29252/NRIP.IRJ.15.4.399>

**doi:** <https://doi.org/10.29252/NRIP.IRJ.15.4.399>

## Article info:

Received: 22 Jul. 2017

Accepted: 20 Oct. 2017

## ABSTRACT

**Objectives:** The present study aimed to determine the voice outcomes before and after the administration of voice therapy in patients who suffered an injury to the recurrent laryngeal nerve after undergoing thyroidectomy.

**Methods:** The sample consisted of 26 patients (2 males and 24 females) aged between 18 and 80 years ( $m=55\pm 12$ ) who experienced injury to the recurrent laryngeal nerve following thyroidectomy that was used to treat a thyroid gland disease. Subjective and objective parameters of the voice of the patients as well as its aerodynamic aspects were assessed upon the completion of the surgical procedure and before and after the implementation of voice therapy. Objective voice analysis was performed with the help of computer software viz. "Speech Training for Windows, Version 4.00 - Dr. Speech "and" EZ Voice Plus (TM) v. 2.0;" while GRBAS scale was used for subjective voice assessment. The subjects were followed for two years. The data so collected during this period was analyzed by implementing descriptive statistical parameters, Chi-square test, t-test and Wilcoxon test.

**Results:** Patients with an injury to the recurrent laryngeal nerve were found to have voice alterations in all vocal parameters of subjective voice assessment conducted using the GRBAS Scale. These alterations ranged from moderate to severe degree, which provided a high degree of roughness in the voice. Objective voice assessment parameter analysis showed a decrease in voice pitch, increase in shimmer, decrease in noise-to-harmonics ratio, decrease in maximum phonation time and a decrease in voiceless percentage. Overall, it was observed that there were significant differences in all parameters of subjective and objective voice assessment, before and after vocal therapy, except for variables regarding the noise-to-harmonics ratio and aerodynamic variable of the S/Z ratio, although, the results on these vocal parameters were better after voice therapy.

**Discussion:** Laryngeal symptoms are known to often accompany thyroidectomy procedures. In the present study, it was observed that administration of vocal therapy and teamwork between the doctors and speech therapist significantly affected the patient's recovery and improvement in the quality of voice after thyroidectomy.

## Keywords:

Thyroidectomy, Recurrent laryngeal nerve, Voice symptoms, Voice therapy

## \* Corresponding Author:

Lejla Junuzovic-Zunic, PhD

Address: Department of Speech Therapy and Rehabilitative Audiology, Faculty for Special Education and Rehabilitation, University of Tuzla, Tuzla, Bosnia and Herzegovina.

Tel: +387 (35) 320 664

E-mail: [j.lejla@gmail.com](mailto:j.lejla@gmail.com)

## 1. Introduction

After diabetes, thyroid gland disorders are the second most common cause of occurrence of endocrine diseases [1]. Among these diseases, the most common ones that often require surgical intervention includes struma simplex, multinodular goiter, toxic adenoma, thyroid cancer and Graves' disease [2]. Thyroidectomy is suggested in clinical indications of malignancy, benign nodules or cysts, suspicious biopsy results, dysphagia due to cervical esophageal compression or dyspnea caused due to airway compression. Other patho-physiological conditions that may necessitate thyroidectomy are endemic goiter, Hashimoto's disease and other types of thyroiditis [3].

It has been observed that the adept methods of thyroid and parathyroid surgery have extremely less morbidity and mortality rates. In addition, they are so designed that the chances of successful achievement of therapeutic goal is significantly increased [4]. Over the years it has already been established that surgical treatment of diseases related to the thyroid gland are fairly safe. They are well researched and standardized on the basis of the results obtained from multidisciplinary research studies [5].

However, one of the most significant complications of administration of thyroid gland surgery is injury to the recurrent laryngeal nerve [6, 7]. Damage to the laryngeal nerves or muscle lesions located on the anterior side of the neck along with impaired laryngeal and tracheal motion, can lead to vocal dysfunction. Furthermore, injury to the external branch of the superior laryngeal nerve is comparatively difficult to recognize, especially because it is less noticeable. However, if left undetected and thus untreated, it can lead to significant problems [7, 8]. This can be understood by considering the fact that the external branch of the superior laryngeal nerve is the only motor supplier to the cricothyroid muscle and also plays an important role during high-frequency phonation.

Iatrogenic injuries to this nerve, which are the most common forms of injuries that occur during thyroid gland surgery, are also known to be associated with varying levels of phonation. Compromising phonation abilities can affect the patient's life in an adverse manner, especially if the patient's career depends on having a full vocal range [9]. When it comes to cases of unilateral paralysis of the superior laryngeal nerve, coughing, irritation in the larynx and/or pharynx, vocal fatigue, decrease in range frequency and range in-

tensity are some of the possibilities that may occur. In cases of injury to the internal branch of the superior laryngeal nerve, the patient may complain of feeling as if something is stuck in the throat [10]. Thyroidectomy is usually followed by various vocal and laryngeal symptoms [11]. It is also said that dysphonia is inevitable after the surgery [12]. Therefore, it is important to consider voice preservation as the subsequent step of thyroid gland surgery, especially in patients whose profession depends on their voice [11].

After an overview of 27 articles and 25,000 cases of patients who underwent thyroidectomy procedure, it was found that the average rate of incidence of temporary recurrent laryngeal nerve palsy is around 9.8% and that of complete paralysis is 2.3%. However, the authors stated that the range may vary from 2.3% to as much as 26%, depending upon the screening method used to test the larynx [13]. It has also been observed that 1 out of 10 patients experience a temporary laryngeal nerve injury after thyroidectomy surgery, which is then followed by voice problems that persist for a considerable amount of time in at least one out of 25 such patients.

Conventionally, reduced quality of life after thyroid gland surgery involves many factors and may include needing medications, thyroid suppression, radioactive screening/treatment; occurrence of temporary and permanent hypoparathyroidism, temporary or permanent dysphonia and dysphagia [3]. Voice disorders caused by thyroidectomy can occur in patients with thyroid pathology, even before they have had surgical intervention. The study shows that these voice-related symptoms in this particular population have a frequency ranging from 9% to 38%. Symptoms include roughness, shortness of breath, vocal fatigue and lack of confidence in communication [14].

Hence, it is recommended that the doctors should inform the patients about the temporary outcomes of thyroidectomy, such as voice disorders and difficulties in swallowing [15]. In patients who are already experiencing post thyroidectomy voice disorders they should be made aware of the fact that hoarseness, vocal fatigue, breathing problems while speaking or difficulties in adjusting volume or voice pitch are the possible side effects of the surgery. In addition, it should also be considered that there may be other possible side effects of the surgery, such as loud breathing, shortness of breath, fatigue during speech, permanent cough or problems in swallowing.

These are all indicators of vocal cord weakness. These side effects can, but not necessarily improve on their

own. Such voice problems can be stabilized in a matter of few months.

However, the laryngeal nerves may take over a year to fully heal, but in some cases it may happen that they never fully recover. Even in such circumstances, there still exist options for improving the voice parameters [3]. One of the options is the administration of voice disorder therapy. Voice disorder therapy can be defined as an effort to restore the voice to the level of adequacy that can be realistically expected and satisfy the patient's emotional and social needs as well as other needs related to the patient's profession [16]. The aim of this study is to determine the voice outcomes before and after voice therapy in patients who suffered an injury to the recurrent laryngeal nerve after thyroidectomy.

## 2. Methods

### Participants

The sample consisted of 26 patients (2 males and 24 females), who were recommended surgery due to a thyroid gland disease, following which they experienced recurrent laryngeal nerve injury. The average chronological age of patients was 55 years; however, 18 of the selected patients were over 60 years of age. The study was conducted at the Ear, Nose and Throat Clinic of the University Clinical Center in Tuzla. After the medical diagnosis of thyroid gland disease was made by a specialist (in nuclear medicine), the patients were subjected to further medical examination by the ENT specialist so as to exclude the existence of other causes of voice changes. Only after getting unilateral paresis confirmation from the ENT specialist, the patients were subjected to speech assessment that was followed by voice therapy so that voice quality of the patients is improved. Patient voice assessment was conducted after the surgical procedure (initially) and after the implementation of voice therapy (finally).

### Measures

The parameters of objective and subjective voice assessment were evaluated, as well as aerodynamic measurements (maximum phonation time of vowel sound "a" (MPT) and S/Z ratio). To record the patient's voice, the AKG 190HS microphone was placed at a distance of 30 cm. Objective voice analysis was performed using computer software "Speech Training for Windows, Version 4.00 - Dr. Speech "and" EZ Voice Plus (TM) v.2.0." The vocal parameters that were assessed in the study were the average fundamental frequency (F0), mini-

um fundamental voice frequency (MINF0), maximum fundamental voice frequency (MAXF0), frequency perturbations (jitter), amplitude perturbations (shimmer), noise-to-harmonics ratio (NHR), percentage of voiced speech (% VOICED), percentage of voiceless speech (% VOICELESS).

Subjective voice assessment was conducted using the GRBAS scale [17]. The scale is intended for a perceptual assessment of voice quality. It also helps in estimating the total Grade of abnormality, Roughness, Breathiness, Asthenia and Strain. Each of these parameters is measured by a four-step scale: 0-normal voice, 1-mild deviation, 2-moderate deviation and 3-severe deviation. Voice therapy was conducted two times a week for two months. Out of the total number of patients, 17 patients attended voice therapy for voice improvement and were rehabilitated. In the rest 9 patients, a subjective and objective analysis of the voice was performed, but they did not attend voice therapy for unknown reasons. The study lasted two years, from 2014 to 2016. The present study was approved by the Ethics Committee of University Clinical Center Tuzla. The participants signed a consent form and were made aware to their right to withdraw at any stage of the study.

### Data analysis

Statistical analysis was performed using the software package SPSS 24.0 (Armonk, NY:IBM Corp.). Descriptive statistics parameters, Chi-square test, t-test and Wilcoxon test were also conducted for data analysis. Statistical significance level of 95% ( $P < 0.05$ ) was considered to be the significance limit for all statistical tests.

## 3. Results

Although the acoustic parameters of male and female voices differ, this study included only two male patients, which was not considered to affect the results of objective voice assessment. Chi-square test showed a statistically significant difference in the proportion of women and men ( $\chi^2 = 18.615$ ;  $df = 1$ ;  $P = 0.000$ ). Table 1 shows a comparison of the objective vocal parameters of patients who underwent surgery after being diagnosed with thyroid disease, before and after the voice therapy. It is evident that these patients experienced a decrease in voice pitch, increase in shimmer and decrease in NHR ratio and MPT as well as a lower percentage of voiced speech.

It was also evident that significant differences were found in all objective vocal parameters i.e. the values

**Table 1.** Testing the significance of differences in objective vocal parameters in patients who were surgically treated, before and after voice therapy

Variable	Mean	Standard Deviation	P
F01	146.91	39.83	0.001*
F02	181.71	32.97	
MINF01	139.41	40.61	0.001*
MINF02	176.17	32.36	
MAXF01	155.57	38.11	0.002*
MAXF02	189.61	33.03	
F0MED1	146.72	39.90	0.001*
F0MED2	181.46	33.39	
SHIMMER1	0.83	0.71	0.011*
SHIMMER2	0.31	0.37	
JITTER1	0.45	0.33	0.006*
JITTER2	0.19	0.12	
NHR1	8.03	5.88	0.112
NHR2	10.84	4.71	
% VOICED1	76.16	33.65	0.010*
% VOICED2	100.00	-	
% VOICELESS1	11.58	19.26	0.025*
% VOICELESS 2	-	-	
MPT1	12.24	5.30	<0.001*
MPT2	17.41	5.77	
S/Z1	1.23	0.52	0.099
S/Z2	0.95	0.30	

Iranian Rehabilitation Journal

of all observed vocal parameters were within normal limits only after the patients underwent voice therapy. Significant differences were not found in variables that described the Noise-to-Harmonics Ratio (NHR) and aerodynamic variables in the S/Z voice ratio, although the results of the final measurements show a

significant improvement in these vocal parameters after voice therapy.

In the second part of the analysis, the subjective parameters of the voice of patients before and after voice therapy were compared, and as shown in Table 2, all vocal parameters in this assessment showed significant

**Table 2.** Testing the significance of differences in objective vocal parameters in patients who were surgically treated, before and after voice therapy

Variable	Percentiles			P
	25 <sup>th</sup>	Median	75 <sup>th</sup>	
Grade 1	1	2	3	<0.001
Grade 2	0	0	0	
Roughness 1	1	3	3	<0.001
Roughness 2	0	0	0	
Breathiness 1	0	2	3	0.001
Breathiness 2	0	0	0	
Asthenia 1	1	2	3	0.001
Asthenia 2	0	0	0	
Strain 1	2	3	3	0.001
Strain 2	0	0	1	

Iranian Rehabilitation Journal

differences. After voice therapy, there were no reported cases of alterations in patients in any of the subjective variables of the assessment.

#### 4. Discussion

The number of patients with indications for thyroid gland surgery, is increasing, and, although it is performed on both sexes, the number of women patients is considerably high [3, 18], which was also confirmed by the results of this study. A surgical procedure can improve or worsen the voice quality regardless of the state of the voice prior to surgery [19]. The results of this study show that the subjective parameters of voice assessment viz. Roughness, breathiness, asthenia and strain in the voice of patients, post-surgery but prior to voice therapy, were moderate to severe. Early vocal symptoms after thyroidectomy are frequent and are present in 14% of all patients [11].

Some of the most common symptoms in patients after thyroidectomy are roughness, shortness of breath, vocal fatigue and lack of confidence in communication [14]. The voice quality of 350 patients who underwent total thyroidectomy was evaluated by speech therapists, showed that all patients had changes in vocal cord strain and muscular activity of the larynx thereby resulting in a low voice, while patients who did not suffer from such nerve damage showed no changes in voice quality [12]. Furthermore, the results of this study showed a decrease in pitch, increase in shimmer, a decrease in HNR ratio,

MPT and voice percentage were the parameters that were most affected after thyroidectomy.

In one of the previous studies that was based on post-surgery testing of the acoustic parameters in females and males, it was found that there are significant changes in some of the acoustic parameters, but only in female patients. The highest fundamental frequency, the standard deviation of the average fundamental frequency, the average phonetic range of the semitones in fundamental frequency, the absolute jitter, the relative average perturbation, the perturbation height coefficient, the shimmer measured in decibels, the percentage of shimmer, the amplitude perturbation coefficient, the noise-signal ratio and the degree of subharmonic values are reported to be lower in female patients after thyroidectomy [20].

The acoustic or aerodynamic profile of the recurrent laryngeal nerve or the external branch of the superior laryngeal nerve cannot be defined separately. However, the nerve injuries cause a different degree of glottal incompetence and at the very least unilateral limitation of the mass or regularity in the strain. It has also been known that unilaterality results in an unequal mass of vocal cords, length and strain, which then implicates higher perturbation values in pitch, intensity and HNR ratio [11]. Furthermore, changes in the voice may be affected by surgical trauma and laryngotracheal fixation of the anterior laryngeal musculature.

On the other hand, Cricothyroid muscles are known to play a primary role in controlling the fundamental fre-

quency of the voice. Injuries to the superior laryngeal nerve can lead to a significant decrease in the vocal range, asymmetry of the vibratory phase of the vocal cords and acoustic aperiodicity, which generally leads to reduced voice quality [21]. However, many patients complain about voice disorders after thyroid gland surgery despite showing normal laryngeal neuromuscular functioning. Some reports state that the external laryngeal nerve participates directly or indirectly in vocal functions, hence, demonstrating activity while decreasing and increasing voice levels [8, 21].

Dysfunction of the recurrent laryngeal nerve often causes vocal disruptions, which presents a disability that can diminish the quality of life. This can be understood from the fact that such vocal constraints affect communication skills and cause social and psychological problems along with other problems that may be related to the patient's profession [22]. Laryngeal videostroboscopy and spectrographic analysis are very useful tools used in assessing the existence of vocal problems in patients after thyroidectomy. The results obtained from such analytical methods can help in addressing early speech rehabilitation, especially in patients who use their voice professionally [8].

Although the literature mentions that many cases of injury to recurrent nerve with paresis or paralysis may result in spontaneous recovery over time, this may take months. Early identification of the problem offers significant advantages for the patient in terms of returning to normal activities and thus improvement of the quality of life. There is evidence that early treatment of voice paralysis improves long-term prognosis for functional recovery, with minimal morbidity of voice. Furthermore, it has been proposed by experts that when it comes to vocal cord mobility problems, then the treatment should be directed towards vocal therapy [3]. It can play valuable roles in the management of paresis and paralysis of vocal cords [23].

In a study involving 74 patients with unilateral vocal cord paralysis, it is reported that 68.9% of patients had improved mobility of vocal cords after early aggressive vocal therapy. In addition, significant decrease in the fundamental frequency has been shown along with improvement in the MPT and the subjective assessment parameters [24]. Studies have also shown that vocal therapy can be useful regardless of when the voice paresis occurred [3]. Even in cases when surgical therapy had to be carried out, pre-surgical vocal therapy helps the patients by providing them with the training for op-

timal post-surgical phonation and preparing the patient psychologically for upcoming surgery.

The importance of vocal therapy is often overlooked in medicine. With good guidelines, vocal therapy can help in achieving astonishingly rapid improvement in voice quality. Typical vocal therapies involve a speech therapist, who provides the patient with the necessary information about phonation, specific abnormalities and vocal hygiene. If the pre-surgical vocal therapy was optimal and if the surgical procedure was successful, then, the post-surgical vocal therapy lasts very briefly. In the majority of patients who had a good pre-surgical therapy, the aim is achieved within one to three months after the surgical procedure [23], as was the case with this study.

## 5. Conclusion

Although today, thyroidectomy is considered a fairly safe method, there always exists the possibility of occurrence of complications during the surgical procedure, which includes injury to the recurrent laryngeal nerve. Patients suffering from this injury often show subjective and objective voice disorders. In such cases, it is recommended to include the subjective and objective voice assessment of the patients before and after thyroidectomy in the diagnostic protocol. This can help in monitoring the voice disorders and provide the patients with timely vocal therapy. Good co-operation between doctors, patients and speech therapists can support the patients with unilateral paresis or paralysis of vocal cords to have good chances of recovering and improving voice quality.

## Acknowledgments

This research was extracted from Altumbabic PhD thesis (2017) under the mentorship of Junuzovic-Zunic in the Department of Speech Therapy and Rehabilitative Audiology, Faculty for Special Education and Rehabilitation, University of Tuzla, Tuzla, Bosnia and Herzegovina.

## Conflict of Interest

The authors declared no conflicts of interest.

## References

- [1] Tunbridge WMG, Evered DC, Hall R, Appleton D, Brewis M, Clark F, et al. The spectrum of thyroid disease in a community: The whickham survey. *Clinical Endocrinology*. 1977; 7(6):481-93. doi: 10.1111/j.1365-2265.1977.tb01340.x
- [2] Dodig K, Kusić Z. *Klinička nuklearna medicina*. Zagreb: Medicinska Naklada; 2012.
- [3] Chandrasekhar SS, Randolph GW, Seidman MD, Rosenfeld RM, Angelos P, Barkmeier Kraemar J, et al. Clinical practice guideline: Improving voice outcomes after thyroid surgery. *Otolaryngology-Head and Neck Surgery*. 2013; 148 (6S):1-37. doi: 10.1177/0194599813487301
- [4] Zábrodský M, Chovanec M, Fik Z, Bouček J, Betka J. Changes of VKG picture and objective voice analysis in the application of minimal invasive technologies and NM in thyroid gland surgery. *Otorhinolaryngology and Phoniatics*. 2012; 61(3): 148-161.
- [5] Souza SL, Crespo A, Alves de Medeiros JL. Laryngeal vocal and endoscopic alterations after thyroidectomy under local anesthesia and hypnosedation. *Brazilian Journal of Otorhinolaryngology*. 2009; 75(4):511-516. doi: 10.1016/S1808-8694(15)30489-4
- [6] Yeung P, Erskine C, Mathewes P, Crowe, PJ. Voice changes and thyroid surgery: Is pre-operative indirect laryngoscopy necessary. *The Australian and New Zealand Journal of Surgery*. 1999; 69(9):632-4. doi: 10.1046/j.1440-1622.1999.01653.x
- [7] Sanabria A, Silver CE, Suárez C, Shaha A, Khafif A, Owen RP et al. Neuromonitoring of the laryngeal nerves in thyroid surgery: A critical appraisal of the literature. *European Archives of Oto-Rhino-Laryngology*. 2013; 270(9):2383-95. doi: 10.1007/s00405-013-2558-1
- [8] Aluffi P, Policarpo M, Cherovac C, Olina M, Dosdegani R, Pia F. Post thyroidectomy superior laryngeal nerve injury. *European Archives of Oto-Rhino-Laryngology*. 2001; 258(9):451-4. doi: 10.1007/s004050100382
- [9] Sakorafas GH, Kokoropoulos P, Lappas C, Sampanis D, Smyrniotis V. External branch of the superior laryngeal nerve: Applied surgical anatomy and implications in thyroid surgery. *The American Surgeon*. 2012; 78(9):986-91. PMID: 22964209
- [10] Andrews ML. *Manual of Voice Treatment: Pediatrics through Geriatrics*. Canada: Thomson Delmar Learning ; 2006.
- [11] Stojadinovic A, Shaha AR, Orlikoff RF, Nissan A, Kornak MF, Singh B et al. Prospective functional voice assessment in patients undergoing thyroid surgery. *Annals of Surgery*. 2002; 236(6):823-32. PMID: PMC1422649
- [12] Neri G, Castiello F, Vitullo F, De Rosa M, Ciammetti G, Croce A. Post thyroidectomy dysphonia in patients with bilateral resection of the superior laryngeal nerve: A comparative spectrographic study. *Acta Otorhinolaryngol Italica*. 2011; 31(4):228-34. PMID: PMC3203714
- [13] Jeannon JP, Orabi AA, Bruch GA, Abdalsalam HA, Simo R. Diagnosis of recurrent laryngeal nerve palsy after thyroidectomy: A systematic review. *International Journal of Clinical Practice*. 2009; 63(4):624-9. doi: 10.1111/j.1742-1241.2008.01875.x
- [14] de Morais Costa EB, de Araujo Pernambuco L. Vocal self-assessment and auditory and auditory perceptual assessment of voice in women with thyroid disease. *Revista Cefac*. 2014; 16(3):967-72. doi: 10.1590/1982-021620145913
- [15] Lombardi CP, Raffaelli M, D'Alatri L, Marchese MR, Rigante M, Paludetti G et al. Voice and swallowing changes after thyroidectomy in patients without inferior laryngeal nerve injuries. *Surgery*. 2006; 140(6):1026-34. doi: 10.1016/j.surg.2006.08.008
- [16] Aronson AE. *Clinical voice disorders: An interdisciplinary Approach*. New York: Thieme Inc.; 1980.
- [17] Hirano M. Psycho acoustic evaluation of voice. In: Hirano M, editor. *Clinical examination of the voice*. New York: Springer; 1981.
- [18] Bhattacharyya N, Fried MP. Assessment of the morbidity and complications of total thyroidectomy. *Archives of Otolaryngology*. 2002; 128: 389-92. doi: 10.1001/archotol.128.4.389
- [19] McIvor NP, Flint DJ, Gillibrand J, Morton RP. Thyroid surgery and voice related outcomes. *The Australian and New Zealand Journal of Surgery*. 2000; 70(3):179-83. doi: 10.1046/j.1440-1622.2000.01781.x
- [20] Akyildiz S, Ogut F, Akyildiz M, Engin EZ. A multivariate analysis of objective voice changes after thyroidectomy without laryngeal nerve injury. *Archives of Otolaryngology*. 2008; 134(6):596-602. doi: 10.1001/archotol.134.6.596
- [21] Hong KH, Kim YK. Phonatory characteristics of patients undergoing thyroidectomy without laryngeal nerve injury. *Otolaryngology-Head and Neck Surgery*. 1997; 117(4):399-404. doi: 10.1016/S0194-5998(97)70133-5
- [22] Dralle H, Sekulla C, Lorenz K, Brauckhoff M, Machens A. Intraoperative monitoring of the recurrent laryngeal nerve in thyroid surgery. *World Journal of Surgery*. 2008; 32(7):1358-66. doi: 10.1007/s00268-008-9483-2
- [23] Rubin AD, Sataloff RT. Vocal fold paresis and paralysis. *Otolaryngologic Clinics of North America*. 2007; 40(5):1109-31. doi: 10.1016/j.otc.2007.05.012
- [24] Mattioli F, Bergamini G, Alicandri Ciufelli M, Molteni M, Luppi MP, Nizzoli F, et al. The role of early voice therapy in the incidence of motility recovery in unilateral vocal fold paralysis. *Logopedics, Phoniatics, Vocology*. 2011; 36(1):40-7. doi: 10.3109/14015439.2011.554433

