

Medialization thyroplasty in glottis insufficiency due to unilateral vocal fold paralysis and after laser cordectomies – preliminary report

Anna Rzepakowska, Ewa Osuch-Wójcikiewicz, Ewelina Sielska-Badurek, Kazimierz Niemczyk

Katedra i Klinika Otolaryngologii, Warszawski Uniwersytet Medyczny, Kierownik: prof. dr hab. Kazimierz Niemczyk

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ABSTRACT:

Introduction: Medialization thyroplasty (type I) is surgical procedure performed on the thyroid cartilage. The major indication for this surgery is significant glottis insufficiency due to unilateral vocal fold paresis. However the procedure is also performed after vocal fold resections during cordectomy. The aim: The evaluation of voice results in patients after medialisation throplasty. Material and methods: In Otolaryngology Department of Medical University of Warsaw there were performed so far 8 thyroplasty procedures under local anaesthesia with implantation of medical silicon prothesis. 6 patients had unilateral vocal fold paresis and the rest two underwent in the past laser cordectomy due to T1a vocal carcinoma.

Results: There were no complications during and post the surgery. The follow up examination in 1st, 3rd, 6th i 12th months postoperatively revealed for all patients significant improvement of glottal closure in laryngowideostroboscopy. The voice quality improved both in perceptual evaluation (GRBAS scale) and acoustic analysis (Fo, jitter, shimmer, NHR) in both patients groups. However the rate of improvement was much more significant in group with unilateral vocal fold paresis. In all patients the maximum phonation time (MPT) increased. The self-evaluation of voice quality with Voice Handicap Index questionnaire confirmed also individual improvement.

Conclusions: The speech rehabilitations is not successful in each patient with glottis insufficiency. The medialisation thyroplasty remains the standard procedure for permanent improvement of voice quality in those cases.

KEYWORDS:

thyroplasty, unilateral vocal fold paralysis, cordectomy, glottis insufficiency, voice quality

INTRODUCTION

Glottic insufficiency is defined by lack of joining of vocal folds during phonation. It is accompanied by unwanted flow of air during creation of the fundamental tone. Voice created in this way is quieter, weaker, with air present, sometimes coarse. Another troublesome symptom is significantly reduced phonation time on single exhalation, which causes greater effort related to voice production and fatigue accompanying phonation. The greater the glottic insufficiency, the higher the intensity of symptoms. Unsatisfactory voice quality significantly reduces the quality of life in such patients, which has been proven in multiple studies. A

significant problem of glottic insufficiency predominantly affects patients with unilateral vocal fold paralysis (UVFP) in position other than median [1,2]. Among causes of vocal fold paralysis, peripheral factors predominate relating to recurrent laryngeal nerve lesions. Other less frequent causes of UVFP include high vagus nerve injury due to neoplasms of the skull base, trauma to this region, as well as parapharyngeal space tumors.

The major cause of UVFP is lesion of the recurrent laryngeal nerve. A frequent cause of trauma to this nerve is iatrogenic, including thyroidectomy, thoracic, heart and cervical spine surgeries.

In rare cases, vocal fold paralysis is caused by the cricoarytenoid joint pathology. A relatively large group of patients with glottic insufficiency are patients with age-related atrophy or defect of vocal folds, following cordectomy in early stages of glottic cancer, or various other types of scars and grooves of vocal folds. The aim of therapy is to reduce insufficiency at the level of glottis during phonation. It includes phoniatic and speech rehabilitation, injection laryngoplasty and medializing thyroplasty. The greatest insufficiency, and hence the greatest dysphonia, is seen in patients with vocal folds paralysis and following cordectomy with total excision of the vocal muscle or extended cordectomy - type IV and V according to the European Laryngological Society (ELS) classification [3]. In this group of patients, voice rehabilitation is always necessary in the early stages of treatment, but it is rarely sufficient as a single method. Medialization of vocal folds with injection laryngoplasty only allows for temporary improvement of voice quality in UVFP. In patients after type IV or V cordectomy, injections are not recommended due to the absence of the vocal muscle, which could be displaced by the injected material [4]. In both groups, it is justified to perform permanent medialization intervention with external implantation - type I thyroplasty.

Type I thyroplasty, also referred to as medialization, is a surgical procedure performed on the laryngeal framework, which has been popularized by Isshiki since 1970s [2]. During the procedure, local anesthesia is applied as the voice improvement is monitored during the operation. It can be performed in every patient with severe and permanent glottic insufficiency who wants to obtain permanent improvement of voice by single procedure. For medialization of the vocal fold, various materials are used, depending on the surgeon's experience and preference:

- hand carved implants made of medical silicone
- Goretex tape
- titanium implants
- pre-formed silicone implants

MATERIALS AND METHODS

Between May 2015 and June 2016, type I thyroplasty procedure with local anesthesia was performed 8 times in the Otolaryngology Department of WUM. Among the patients qualified for the procedure, 6 patients had glottic insufficiency due to UVFP, the remaining 2 had undergone type IV laser cordectomy due to T1a vocal fold cancer.

All thyroplasty procedures were performed under local anesthesia. Prior to surgery, the patients received premedication

with Dormicum [*midazolam*] and one dose of steroids i.v. Neck tissues were infiltrated with 1% lidocaine with adrenalin. Horizontal incision was made at the level of the lower margin of the thyroid cartilage. Using a drill, a hole was made in the thyroid cartilage at the level of the vocal fold with the standard size of 6x12mm for men and 5x10mm for women (Fig. 1a.). An implant made from a silicone block was adjusted to the hole, shifting vocal fold tissues medially in patients with UVFP, or the remaining scar tissue in patients after cordectomy (Fig. 1b.). The size of the implant was adjusted by performing test medialization with voice quality assessment and concurrent fiberoptic assessment of glottic closure during phonation, the device being introduced through the nose. After application of the proper implant, skin and subcutaneous tissue were sutured (Fig. 2.). After surgery, an antibiotic was administered orally for 7 days. After the procedure, the patient was advised to avoid vocal effort (screaming, singing) or excess physical activity (mainly lifting and carrying weights) for approximately 2 weeks.

All patients had undergone videolaryngostroboscopy examination with a rigid endoscope equipped with 70° camera (Xion Endo STROBE, Berlin, Germany) prior to surgery, in order to assess the insufficiency of the glottis, mobility of the vocal fold on the healthy side and to exclude any other co-existing pathology of the larynx. The voice quality was assessed on perceptive examination while speaking with the patient, based on the GRBAS scale proposed by Hirano. In this scale, each letter corresponds to different voice features, G is for general intensity of hoarseness, R - voice roughness (changing frequency of voice), B - breathiness (audible leakage of air during phonation), A - voice weakening or astheny, and S - strain. Each parameter is assessed on a scale from 0 to 3 (0 - normal, without perceived deviance, 1 - small deviance, 2 - moderate deviance, 3 - severe deviance). Also, acoustic testing was applied using the Multi-Speech program, Kay Elemetrics, Lincoln Park, NY. The patient's voice was recorded during free phonation vowel /a:/. For the study, the following have been used in voice analysis: fundamental tone in Hz - Fo, jitter - change in frequency (%), shimmer - change in amplitude (%), noise-to-harmonic ratio (NHR) describing the noise part of voice. Aerodynamic evaluation of voice was performed determining the maximal phonation time - MPT (DiVAS, XION). The patient tried 3 times to pronounce the vowel /a:/ as long as possible with comfortable intensity and volume, after a deep inhalation. The longest MPT time (in seconds) was studied. Also, patients were asked to complete self-assessment questionnaires to evaluate the quality of voice, including Voice Handicap Index - VHI and Voice-Related Quality of Life - VRQoL questionnaires. VHI consists of 30 questions. Each question requires one answer: 0 - never

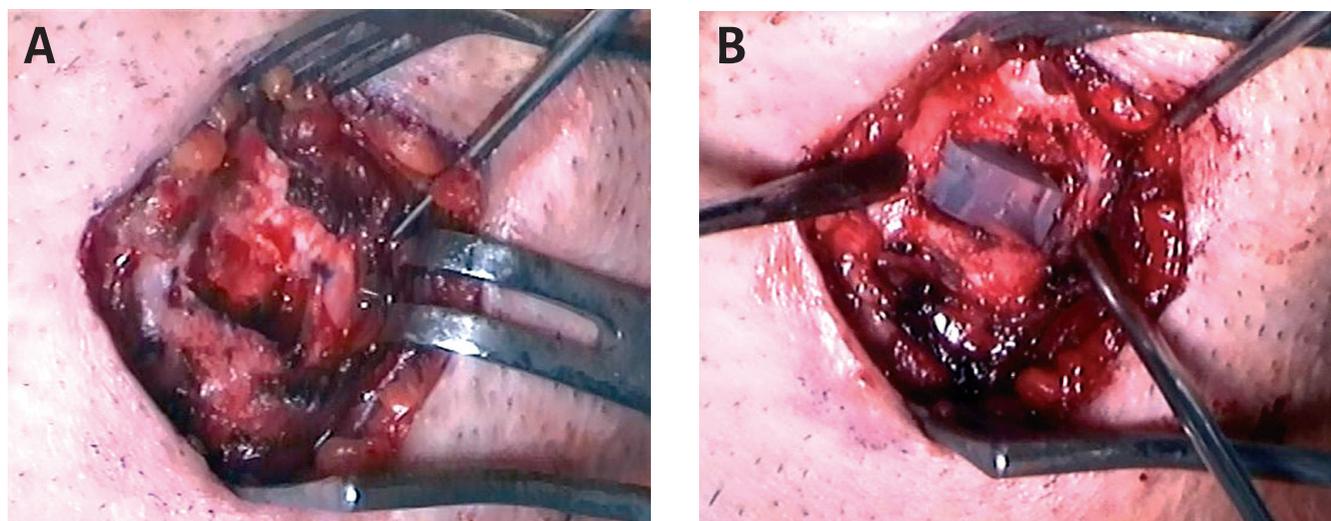
Tab. I. Demographics of the operated patients.

PATIENT	AGE	SEX	CAUSE OF GLOTTIC INSUFFICIENCY	VOICE REHABILITATION	VOCAL FOLD AUGMENTATION	DURATION OF GLOTTIC INSUFFICIENCY
1.	43	M	UVFP – Removal of vagus nerve neuroma	yes	No	6 years
2.	60	M	Type IV cordectomy	yes	Yes (fat)	3 years
3.	45	M	UVFP – Removal of parathyroid adenoma	yes	No	5 years
4.	63	M	Type IV cordectomy	yes		4 years
5.	81	F	UVFP - Idiopathic	yes	No	6 years
6.	46	M	UVFP – aortic arch surgery	yes	No	4 years
7.	66	M	UVFP – Removal of carotid paraganglioma	yes	yes (fat, calcium hydroxylapatite)	6 years
8.	44	M	UVFP - Removal of jugular foramen paraganglioma	yes	No	6 years

Tab. II. The results of the analyzed voice parameters in patients before thyroplasty.

PT	GRBAS	MPT (S)	FO (HZ)	JITTER (%)	SHIMMER (%)	NHR	VHI	VRQOL
1.	G2 R1 B2 A2 S1	5,2	144	5,1	7,2	0,163	62	23
2.	G2 R1 B2 A2 S1	7,9	135	15,3	14,7	0,642	81	34
3.	G3 R2 B3 A2 S2	4,0	138	5,7	26,0	0,476	36	20
4.	G2 R2 B3 A1 S1	5,2	183	3,8	7,7	0,157	28	18
5.	G3 R2 B3 A3 S2	3,9	*	*	*	*	99	44
6.	G3 R2 B3 A2 S2	10,6	197	19,4	5,5	0,34	62	32
7.	G2 R2 B2 A1 S1	11,9	185	2,55	3,76	0,218	56	29
8.	G3 R3 B3 A2 S2	3,0	143	4,05	11,437	0,305	75	33

* impossible acoustic voice analysis

**Fig. 1.** Intraoperative photography of thyroplasty: 1a - the cut out window in the thyroid cartilage on the left is readily seen, 1b - after placement of silicone medialization implant

Tab. III. The results of the analyzed voice parameters in patients after thyroplasty.

PT	GRBAS	MPT (S)	FO (HZ)	JITTER (%)	SHIMMER (%)	NHR	VHI	VRQOL	OBSERVATION PERIOD (MONTHS)
1.	G1 Ro Bo Ao So	14,8	109	0,51	4,1	0,102	24	18	12
2.	G2 R1 B1 A1 S1	13,8	144	4,9	13,1	0,273	59	14	12
3.	G1 Ro B1 Ao So	24,5	153,5	1,2	3,4	0,148	2	10	12
4.	G1 R1 B1 Ao So	8,5	82	1,05	6,68	0,155	20	11	6
5.	G2 R2 B1 A2 S2	17,3	125	2,26	10,09	0,25	64	27	6
6.	G1 R1 Bo Ao So	37,4	140	0,44	2,7	0,153	29	17	3
7.	G1 R1 Bo Ao So	18,4	134	0,49	1,39	0,146	22	15	1
8.	G2 R2 B1 A1 S1	8,4	199	5,6	7,38	0,151	50	20	1

Tab. IV. The differences in values of analyzed parameters of voice quality in patients after the thyroplasty.

	PATIENT 1	PATIENT 2	PATIENT 3	PATIENT 4	PATIENT 5	PATIENT 6	PATIENT 7	PATIENT 8	MEAN CHANGE OF PARAMETERS – ALL PATIENTS
Change in MPT (s)	↑9,6	↑5,9	↑20,5	↑3,3	↑13,4	↑26,8	↑6,5	↑5,4	↑11,4
Change in Fo (Hz)	↓35	↑9	↑15,5	↓101		↓57	↓51	↑56	↓23,4
Change in Jitter (%)	↓4,59	↓10,4	↓4,5	↓2,75		↓18,9	↓2,06	↑1,55	↓5,95
Change in Shimmer (%)	↓3,1	↓1,6	↓22,6	↓1,02		↓2,7	↓2,37	↓4,057	↓5,35
Change in NHR	↓0,061	↓0,369	↓0,328	↓0,002		↓0,187	↓0,072	↓0,154	↓0,167
Change in VHI	↓38	↓67	↓34	↓8	↓35	↓27	↓41	↓24	↓34,25
Change in VRQoL	↓5	↓22	↓8	↓7	↓33	↓12	↓14	↓13	↓14,25

happens, 1 – rarely, 2 – sometimes, 3 – often, 4 – always. The overall score is between 0 and 120. The greater the score, the worse the quality of voice. VHI (≤ 30) corresponds to slight deterioration of voice quality, (31-60) - moderate, (61-90) - severe, (91-120) – very severe. The VRQoL questionnaire consists of 10 questions. Similarly, each question requires one answer: 1 – I never have problems with it, 2 – minor problem, 3 – moderate problem, 4 – major problem, 5 – it could not get any worse. The overall score is between 10 and 50. The greater the score, the worse is the voice-dependent quality of life. Reassessment of all parameters was conducted during follow-up visits at 1, 3, 6 and 12-month intervals after thyroplasty.

RESULTS

Medialization thyroplasty was performed in 8 patients (7 males and 1 female) aged 43 to 81, with the mean age of 56.

In 6 patients, the glottal insufficiency was caused by UVFP. In 5 of them, the cause of the paralysis was determined, while

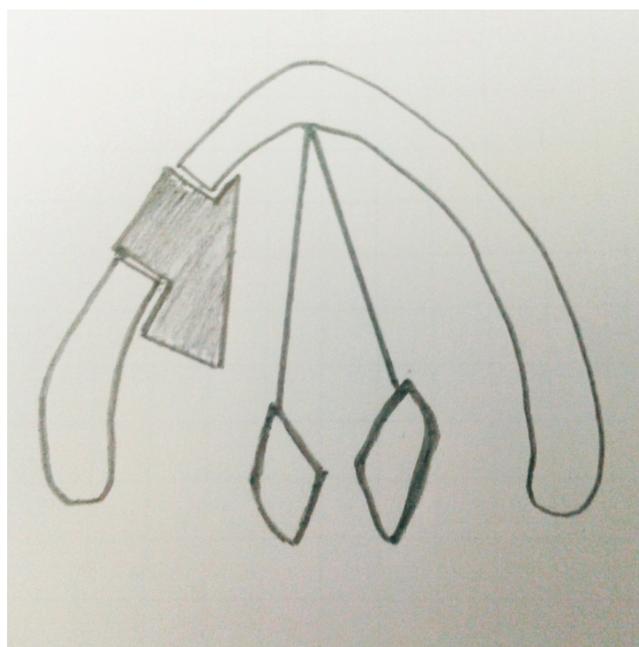


Fig. 2. Diagram of the transverse section of larynx with medialization implant

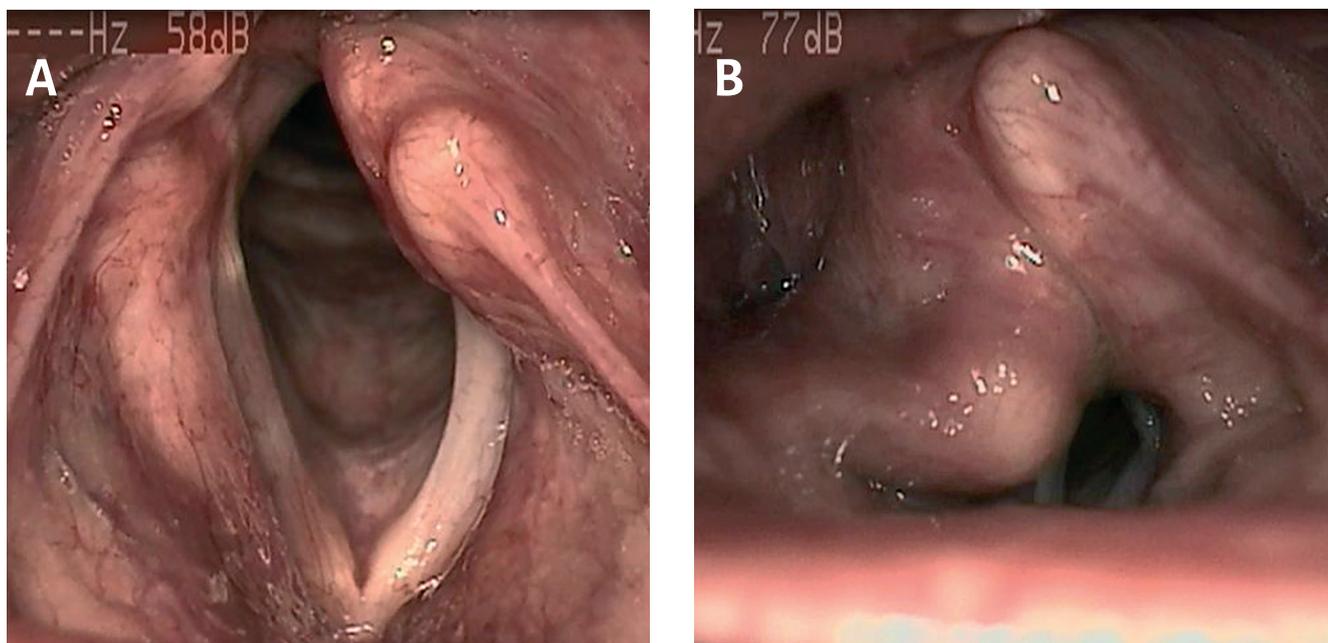


Fig. 3. VLS examination in a patient with UVFP prior to thyroplasty: 3a - during free breathing, 3b - during phonation.

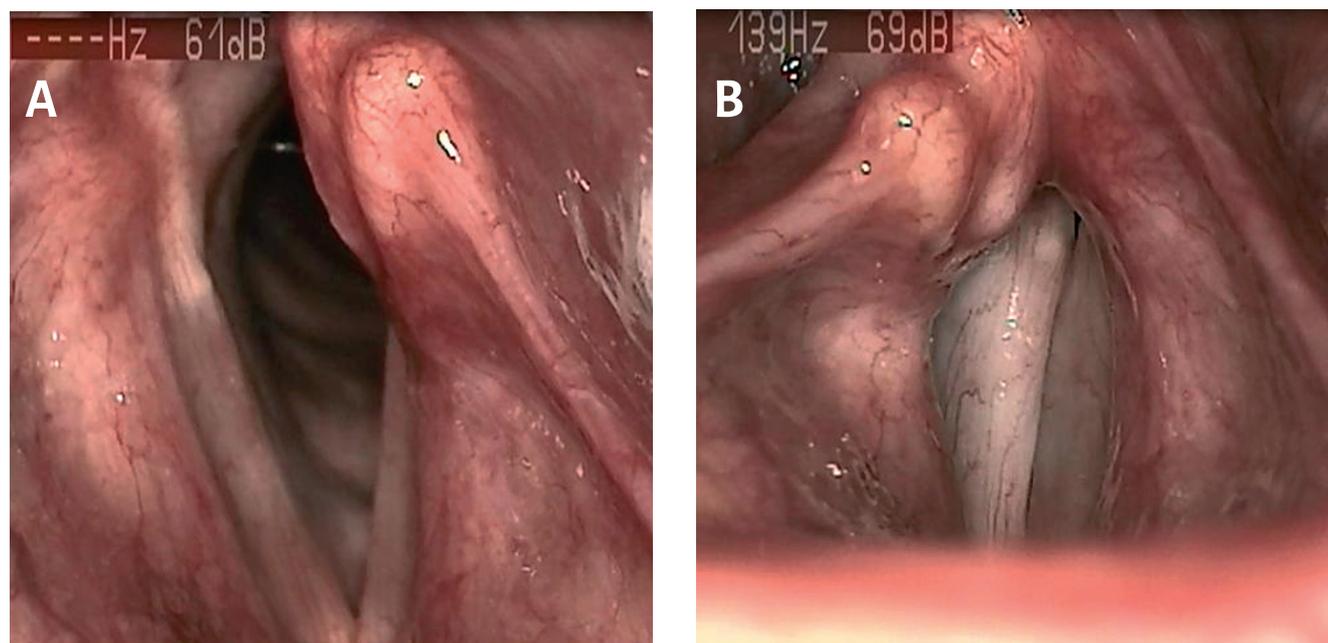


Fig. 4. VLS examination of the same patient 6 month after medialization thyroplasty: 4a - free breathing, 4b - phonation.

no cause was found in patient No 5. In patients 1, 7 and 8, the paralysis was caused by high injury to the vagus nerve. Additionally, patient No 8 presented coexisting paralysis of ipsilateral nerves VII, IX and XII. Patients No 3 and 6 presented paralysis of the recurrent laryngeal nerve. Patients No 2 and 4 had undergone type IV laser cordectomy due to the vocal fold cancer. The duration of glottal insufficiency in the studied group was between 3 and 6 years, 5 years on average. All patients were subject to phoniatric rehabilitation for over 12 months. The voice quality remained unsatisfactory despite rehabilitation. Three patients had undergone vocal fold augmentation with temporary improvement of voice quality.

In all patients, considerable glottic insufficiency was found on videostroboscopic examination prior to surgery (Fig. 3a. and 3b.). In both post-cordectomy patients (No 2 and 4) and two patients with UVFP, compensatory mechanisms with formation of pseudoglottis with vestibular folds were noticed. Mobility of vocal folds on the healthy side was normal in all cases. On replay analysis, the grade of hoarseness (G) was described as moderate in 4 patients, and severe in the remaining four. The presence of air in voice (B) was described as moderate in 3 patients, and severe in 5. In all patients, MPT was shorter than normal (20s) and was between 3.0 and 11.9s, 6.5s on average. Acoustic voice analysis parameters were abnormal in all patients and deviated from norm significantly. Fundamental tone frequency was significantly increased in males (135 – 197Hz). Jitter value ranged from 2.55% to 19.4% (7.9% on average). Shimmer values were increased ranging from 3.76% to 26.0% (7.2% on average). Also, the voice quality self-assessment results indicated considerable impairment. In the studied patients, VHI ranged from 28 to 99 points, 62.4 on average. VRQoL was between 18 and 44 points, 29.1 on average.

All thyroplasty procedures were uncomplicated. No patient complained about inconveniences relating to local anesthesia.

During follow-up visits, VLS examination was performed and considerable improvement in glottic closure was seen in all patients (Fig. 4a., 4b.). Table 3 shows voice quality results in patients after medialization thyroplasty on the latest assessment since the operation. Based on the replay analysis, the general level of hoarseness (G) was described as slight in 5 patients and moderate in 3. The breathiness was described as normal in 3 patients and slight in the remaining 5. MPT increased in all patients. The change of MPT was between 3.3 and 26.8s, 11.4 on average. Two patients achieved MPT longer than 20s. As far as the studied acoustic voice parameters in patients after surgery were concerned, Fo decreased by 23.4

Hz on average, while jitter and shimmer decreased significantly (jitter - by 2.06% to 18.9%, 5.9% on average; shimmer - 1.6% to 22.6%, 5.3% on average). After treatment, the patients evaluated the quality of their voices to be much higher, VHI value decreasing by 34.2 points on average (in the range of 8-67 points). The quality of voice improvement positively affected the voice-dependent quality of life, the VRQoL score decreased by 14.2 points on average (ranging from 5 to 22 points).

DISCUSSION

Laryngeal framework surgery, known as thyroplasty, is aimed to improve the glottic closure and reduce turbulent flow of air during phonation, or to modify the pitch without injury to vocal fold mucosa [2]. Thyroplasty techniques have been grouped functionally by Isshiki, and promoted since 1974 [1]. In 2001, ELS proposed their own functional classification of surgical methods to the laryngeal framework [2]. Medialization thyroplasty (type I) is the most common procedure on the laryngeal framework. The main purpose is to achieve full phonation closure at the glottis and hence improvement of the patients' quality of voice, elongation of the maximal phonation time and reduction of effort associated with speech production. The authors described various materials used for medialization of the vocal fold. However, there is a lack of thoroughly conducted studies that would compare the results obtained using various implants [5]. Initially, one of the commonly accepted indications for medialization thyroplasty was glottic insufficiency due to UVFP. Nowadays, a few authors report application of medialization techniques in patients after laser cordectomy [4]. Results obtained using the same surgical method in both groups cannot be compared. In UVFP patients, despite atrophy of the paralyzed muscles, there is vocal muscle tissue, lamina propria and epithelium on the surface of the vocal fold, which, after successful relocation to the midline, allow to recreate proper closing conditions during phonation. However, even after medialization procedure, normal amplitude of vibration of the paralyzed fold or symmetry of vibration cannot be achieved but the mucosal wave is usually present on the paralyzed side. After reaching optimal conditions, voice assessment parameters can normalize, and the patients consider their voice perfectly normal and report that it sounds 'like before'. Many authors confirm, in their studies, an improvement of voice self-assessment tested with VHI questionnaire after thyroplasty [5-7]. Even more studies indicate an increase in MPT in UVFP patients after medialization, which seems to be an appropriate and objective parameter evaluating decrease of glottic insufficiency during phonation [5,6,8-12]. Some au-

thors present an improvement of acoustic analysis parameters, mainly F_0 , jitter and shimmer [6, 9-12]. In patients after type IV cordectomy, there is no tissue apart from a scar covering the thyroid cartilage, thus the tissue that is relocated medially serves the purpose of improving conditions for phonation closure, which prolongs MPT and reduces phonation effort; however, the quality of voice, due to rigidity of the scar tissue, will never be normal [4]. Remacle et al. emphasize that thyroplasty is much more difficult to perform after cordectomy than in UVFP patients [4]. In our study, patients after cordectomy (No 2 and 4) achieved MPT and acoustic parameters improvement following thyroplasty, however, the effect was not as considerable as in UVFP patients. Similar results are reported by Remacle et al. [4].

Quality of voice results after medialization thyroplasty presented by various authors encourage to apply this procedure in both UVFP patients and after cordectomy for permanent improvement of quality of voice and life. Contrary to injection laryngoplasty, which should be repeated due to material resorp-

tion, thyroplasty is one-time and permanent intervention [13].

Some authors also propose, apart from vocal fold medialization, adduction of the arytenoid cartilage, particularly in patients with severe glottic insufficiency. However, the available studies comparing results after medialization and medialization accompanied by arytenoid adduction do not show significant difference in improving voice parameters between both groups [5,14].

SUMMARY

Glottic insufficiency therapy is a long-term process and the patients should be aware that they may not benefit from rehabilitation - and then, different methods should be considered. Currently, it seems that surgical treatment of glottic insufficiency should be considered at earlier stages. Medialization thyroplasty remains the standard procedure in glottic insufficiency for permanent improvement of the quality of voice.

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Corresponding author: Anna Rzepakowska, Klinika Otolaryngologii WUM, ul. Banacha 1a, 02-097 Warszawa, tel. 022 599 27 16, mail: arzepakowska@wum.edu.pl

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