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Office-based vocal fold augmentation with calcium hydroxylapatite: long-term results

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ABSTRACT:

Aim: We assessed long-term outcomes of vocal fold augmentation with calcium hydroxylapatyte performed under local anesthesia.

Material and methods: We enrolled 17 patients with glottic insufficiency due to unilateral laryngeal paralysis or insufficiency of internal laryngeal muscles (10 women, 17 men; mean age, 57.6±17.7 years; median age, 61 years; age range, 32-83 years). All patients underwent laryngeal augmentation under local anesthesia, through the oral cavity, with calcium hydroxylapatite (Radiesse) injected laterally to the vocal folds, unilaterally or bilaterally. We assessed voice quality before laryngeal augmentation and at 3 and 12 months. To that end, we performed videolaryngostroboscopy, perceptual assessment of voice, acoustic analyses, and aerodynamic assessments; moreover, participants completed the Voice-Related Quality of Life (VRQoL) questionnaire.

Results: After 3 months, we observed a statistically significant improvement on the perceptual assessment of voice with regard to the G and A parameters, and good outcomes were also observed at 12 months. On the acoustic analyses, MDVP_Jitt, MDVP_Shim, and MDVP_NHR improved to 2.5, 5, and 0.1, respectively, at 3 months, and to 1.9, 3.6, and 0.1, respectively, at 12 months. MPTa was prolonged to 12.2s and 11.9s at 3 and 12 months, respectively. Voice intensity improved from 67dB(A) before augmentation to 68dB(A) and 71dB(A) at 3 and 12 months, respectively. VRQoL scores improved to 19.5 and 20 at 3 and 12 months, respectively.

Discussion: Laryngeal augmentation with calcium hydroxylapatite performed under local anesthesia is associated with good long-term outcomes.

KEYWORDS: vocal fold augmentation, injection laryngoplasty, calcium hydroxylapatite, long-term outcomes

INTRODUCTION

Laryngeal augmentation, also referred to as injection laryngoplasty in the case of unilateral laryngeal paralysis, is performed in patients with glottic insufficiency. Laryngeal injection allows to improve the quality of voice impressively fast in patients with one-sided laryngeal paralysis, insufficiency of the intrinsic laryngeal muscles, atrophy of the vocal folds, scars of the vocal fold or the sulcus vocalis, and hence it can speed up the process of voice rehabilitation. After surgery, the voice has better quality, it is with longer maximum phonation time, and the patients report much better tolerance of vocal effort [1,5,8,9,11,16].

Seeking to maximally decrease the invasiveness of laryngeal augmentation, it is now more often performed under local anaesthesia in Europe and in the USA. Moreover, there is a constant search for the least absorbable materials in order to decrease the frequency of interventions. Those trends allow to perform laryngeal augmentation in patients with numerous systemic disorders, who present glottic insufficiency as a result of an iatrogenic unilateral laryngeal paralysis following surgery of the head, neck or thorax [12,13,14].

The ideal materials for laryngeal injection, in addition to a long tissue-persistence time, should be biocompatible, should not require special preparation right before their application, and should not pose any risk of transmitting an infectious disease. Furthermore, the operator should be able to apply them through a narrow needle [9]. Nowadays, the following are the longest-remaining ones within the larynx: autogenous fat, cal-

cium hydroxyapatite and polydimethylsiloxane. However, this view is confirmed only by few reports, while the majority of research regarding outcomes of laryngeal augmentation covers a 3- or 6-month observation [2,5,7,11,16].

Difficulties with long-term evaluation of laryngeal augmentation results from patients lost to follow-up. Various authors state that as many as 25% of patients do not come in for their check-up visits after laryngeal augmentation [5,8,15]. It may result from the health care system, which, for instance in the US, gives the patient right to choose the place of their post-operative check-ups, or - as Verma et al. report - it may result from deaths during several months of observation (as it was previously mentioned, patients with glottic insufficiency often suffer from chronic conditions) [15]. Verma et al. retrospectively evaluated indications, technique of augmentation and materials used over the years 2007-2009, and they established that 14% of patients who underwent augmentation procedure died during the observation period, as a result of coexisting chronic conditions [15].

The aim of the study was the evaluation of the long-term outcomes of laryngeal augmentation with calcium hydroxyapatite under local anaesthesia.

MATERIAL AND METHODS

Before commencing the study, the approval of the Bioethics Committee of the Medical University of Warsaw was obtained.

The study involved 17 patients qualified for laryngeal augmentation due to glottic insufficiency. It included 10 females and 7 males aged 57.6±17.7 years, with the median of 61, ranging from 32 to 83. Fifteen patients presented with glottic insufficiency as a result of unilateral laryngeal paralysis, while 2 patients – as a result of insufficiency of the intrinsic laryngeal muscles with secondary glottic insufficiency.

All patients underwent laryngeal augmentation under local anaesthesia, through oral access, by injecting calcium hydroxyapatite (Radiesse) lateral to the vocal fold/folds. Figure 1 shows the instruments used for the procedure.

The procedure began after anaesthetizing the root of the tongue, soft palate, oropharynx, laryngopharynx and laryngeal mucosa with 2% lidocaine solution (applied through spraying and pouring lidocaine solution into the larynx). While the patient was holding his/her tongue using a swab, the physician was sitting opposite to the patient, holding the endoscope in the left hand while injecting calcium hydroxyapatite using the right hand (Fig. 2). The endoscope, which was used to visualize the larynx, was a rigid endoscope manufactured by Xion with an integrated camera chip in its end, with 70-degree optics and an option of focus adjustment using the thumb of the holding hand, and it was connected to the stroboscope EndoStrobeE (Xion). Radiesse solution was injected through a 25-cm needle, with an angle of the needle adjusted to an individual patient's anatomy (Fig. 1). During the first injection, the solution was administered in the middle of the glottis length, lateral to the vocal fold (in the case of the paralysed larynx – lateral to the paralysed vocal fold, and in the case of glottic insufficiency – lateral to both vocal folds) (Fig. 3-4). Then, the patient was asked to pronounce vowels of different pitch, while the operator assessed the vocal fold closure on stroboscopy. If the patient's quality of voice was unsatisfactory (breathy with lowered volume) and the glottic insufficiency was observed, another injection was performed, posteriorly to the initial injection (Fig. 3).

In order to evaluate long-term effects of laryngeal augmentation, the quality of voice was assessed before augmentation as well as 3 and 12 months after laryngeal augmentation. Evaluation of the quality of voice was conducted in accordance with the functional evaluation of the voice quality protocol, which is designed for phono-surgical procedures, created by the European Laryngological Society (ELS) in 2001 [3]. Functional evaluation of the voice quality included laryngeal videolaryngostroboscopic examination, perceptual speaking voice assessment, acoustic analysis, aerodynamic evaluation and the patient's voice self-assessment.

Laryngeal videostroboscopic evaluation conducted using the EndoStrobeE by Xion allowed to evaluate the closure of the vocal folds. Moreover, regularity, symmetry and amplitude of the vocal folds' vibration, as well as mucosal wave were evaluated.

Perceptual voice assessment was conducted using the GRBAS scale after a short conversation with the patient [4]. Hoarseness (G parameter), roughness (R), breathiness (B), asthenia (A), and strain (S) were evaluated. The intensity of the parameters mentioned above were given on a 4-level scale, where 0 denotes the absence of pathology, 1 – mild degree, 2 – moderate degree, 3 – severe degree.

Extended phonation of [a] vowel at comfortable pitch and loudness allowed for an acoustic evaluation. This examination was conducted using the Multi-Dimentional Voice Program (MDVP) software by KAY, Model 4150, and the microphone Shure, SM 48 type, which was placed 20 cm before the patient's lips. The fundamental frequency of the patient's voice (F0: MDVP_F0), as well as Jitter, Shimmer, and NHR parameters (Jitter: MDVP_Jitt, Shimmer: MDVP_Shim, and NHR: MDVP_NHR, respectively) were evaluated.

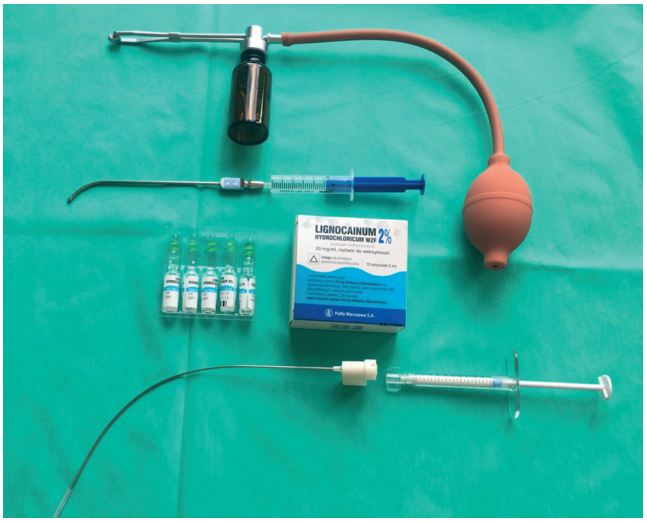

Fig. 1. Instruments used for laryngeal augmentation under local anesthesia from oral access. (top: a bottle with a douche and sprayer for application of anesthesia in spray, a syringe with a dispenser for application of anesthesia in laryngeal injection, ampules of 2% lidocaine, Radiesse with a 25-cm needle)

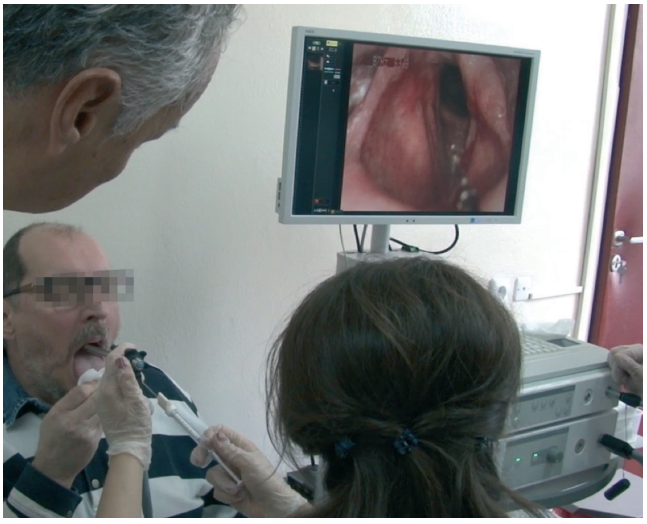

Fig. 2. Laryngeal augmentation procedure under local anesthesia from oral access.

Maximal Phonation Time of the [a] vowel (MPTa), at the comfortable pitch and laodness was evaluated using the DIVAS software. In this aerodynamic examination (MPTa), the patient performed phonation of the [a] vowel three times for as long as possible after a deep inhalation. The sound was recorded each time, and the result was expressed in seconds. For further analysis, the highest result was chosen. Furthermore, The patient's voice intensity was examined by using the microphone attached to a special cap, which was placed on the patient's head so that the microphone was placed 25 cm from the patient's lips. The voice intensity was given in db(A).

The patient's self-assessment was conducted using the questionnaire that was adapted and validated into the Polish language, which assessed the Voice-Related Quality of Life – VRQoL [14]. In this questionnaire, the patient responded to 10 questions, rating the intensity of voice-related problems on a scale ranging from 1 to 5. The total score of 10 indicated no reported voice problems, while the score of 50 showed maximum intensity of the voice problems reported by the patient.

The statistical analysis was conducted using Statistica 13.1 Dell software. Biographic information, as well as the results of the following parameters: G, R, B, A, S, MDVP_F0, MDVP_Jitt, MDVP_Shim, MDVP_NHR, MPTa, intensity and VRQoL for each visit (0, 3, 12) were expressed using descriptive statistics. Those included: mean value, standard deviation, median and range (of variation). The Friedman's rank test was used to verify whether there are statistically significant differences between the consecutive visits. If the p-value was lower than the assumed significance level $\alpha = 0.05$, it was tested which pairs of variables presented statistically significant differences. For that purpose, the non-parametric Wilcox singed-rank test was used. Due to multiple comparison, the Bonferroni correction was applied, with significance level $\alpha = 0.017$ ($\alpha = 0.05/3$).

RESULTS

All patients qualified for laryngeal augmentation under local anaesthesia showed good tolerance of this procedure, and therefore no intervention was interrupted before completion. None of the patients during a 12-month observation period showed hypersensitivity to calcium hydroxyapatite.

While prior to laryngeal augmentation 100% of patients presented with incomplete closure of the vocal folds, following the augmentation procedure full closure of the vocal folds was observed in 36.4% of patients after 3 months and in 33.3% of patients after 12 months, or a significant improvement in vocal fold closure was noticed (Fig. 5), and thus an improvement in the quality of voice was seen.

Each parameter of the perceptual speaking voice assessment improved significantly after laryngeal augmentation (Table 1). A statistically significant decrease in hoarseness and breathiness between the visit before the injection and 3 months after augmentation was observed. Median scores on subjective

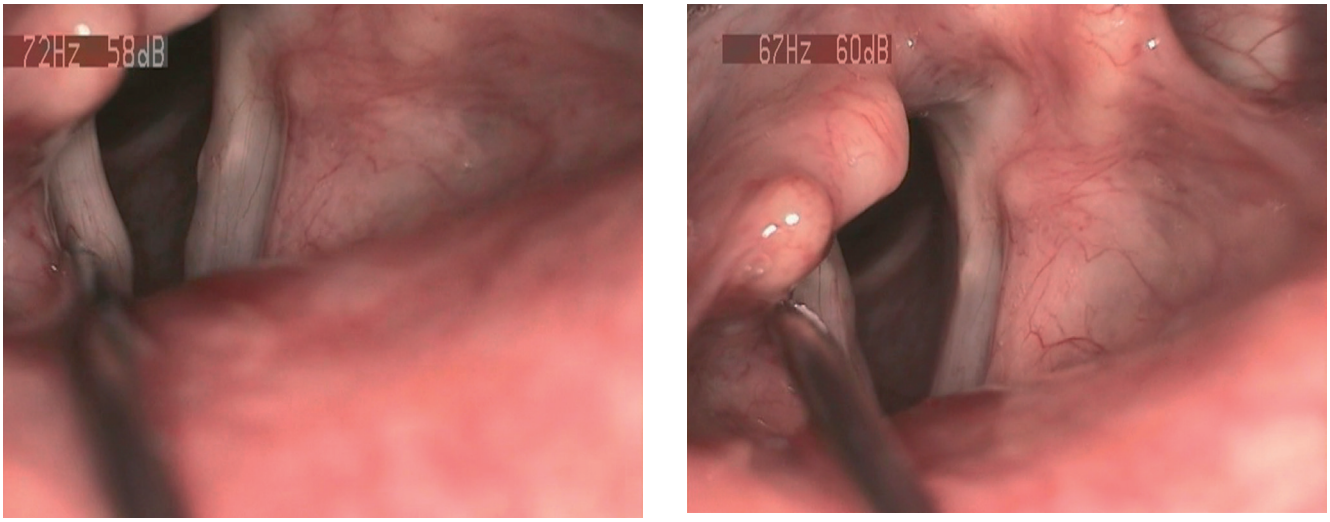

Fig. 3. Injection in the middle and in the posterior 1/3 and lateral to the right vocal fold in patients with right-sided laryngeal paralysis.

evaluation after 3 and 12 months following laryngeal augmentation were similar for most parameters.

The acoustic analysis showed a significant improvement in the quality of voice after injection laryngoplasty with the calcium hydroxyapatite. The improvement was observed for each parameter (MDVP_Jitt, MDVP_Shim, MDVP_NHR) and it lasted up to 12 months after surgery. The results are presented in Table 1.

After laryngeal augmentation, a three-fold prolongation of MPTa was observed, and it lasted up to one year after calcium hydroxyapatite injection (Table 1). Similarly, the voice intensity parameter improved, and this effect lasted up to 12 months after surgery.

In the case of the VRQoL, the p-value obtained from the Friedman's test was lower than the assumed significance level of 0.05. Therefore, the Wilcox singed-rank test with the Bonferroni correction was used to test whether there are any statistically significant differences between the paired visits. The p-value was 0.025 for the first and 3-month visit, and 0.043 for the first and 12-month visit respectively. In this case, the p-values were greater than the assumed significance level of 0.017, hence, despite significant improvement for this parameter, no statistically significant differences were shown.

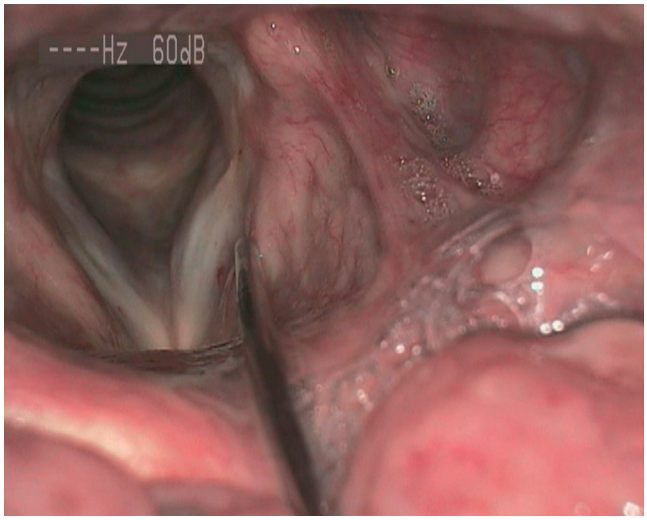

Fig. 4. Injection in the middle and lateral to the left vocal fold in patients with sulcus vocalis and intrinsic laryngeal muscle insufficiency.

DISCUSSION

Laryngeal augmentation performed under local anaesthesia using calcium hydroxyapatite results in a long-term improvement of the voice quality. Good general voice quality, as well as a significant decrease in breathiness lasted up to 12 months after surgery. Additionally, the patients reported a significant improvement of the voice-dependent quality of life, and the effect lasted up to a year after the injection. Also, other voice quality parameters (acoustic evaluation and aerodynamic evaluation) improved significantly after surgery, and the effect lasted up to one year. This spectacular improvement in all voice quality parameters is associated with an improvement of the vocal fold closure, which also lasted up to 12 months after surgery in this study.

Similarly, good voice self-assessment parameters were observed by Rosen et al. after 12 months of observation in pa-

Tab. I. Functional voice evaluation prior to, 3 and 12 months following laryngeal augmentation.

VOICE EVALUATION		G	R	B	A	S	MDVP_F0	MDVP_JITT	MDVP_SHIM	MDVP_NHR	MPTA	INTENSITY	VRQOL
Prior to laryngeal augmentation	Średnia ± SD	1,9±0,6	0,9±0,7	1,8±0,7	1,6±0,6	1,2±0,5	163,0±69,0	5,6±4,1	9,6±5,5	0,3±0,2	6,8±5,0	68,3±6,3	25,6±7,0
	Mediana	*2,0	1	2	*2,0	1	132,3	4,1	9,1	0,2	3,9	67	24
	Zakres	(1–3)	(0–2)	(1–3)	(1–3)	(0–2)	(95,9–354,3)	(1,4–16,8)	(2,2–20,3)	(0,1–0,6)	(2–16,1)	(59–82)	(12–37)
3 months after laryngeal augmentation	Średnia ± SD	0,9±0,9	0,7±0,8	0,8±0,8	0,6±0,7	0,4±0,8	164,7±56,2	3,8±4,8	7,3±6,1	0,3±0,3	11,1±6,5	70,9±6,3	21,1±6,5
	Mediana	*1,0	1	1	*0,5	0	155,9	2,5	5	0,1	12,2	68	19,5
	Zakres	(0–3)	(0–2)	(0–2)	(0–2)	(0–2)	(99–278,8)	(0,4–17,9)	(1,9–-23,5)	(0,1–0,9)	(4,6–25,8)	(64–82)	(14–30)
12 months after laryngeal augmentation	Średnia ± SD	1±0,9	0,7±0,5	0,8±1,0	0,3±0,5	0,5±0,8	170,6±48,7	2,2±1,1	4,2±2,1	0,1±0,0	12,5±6,4	71,6±5,9	21,4±6,2
	Mediana	1	1	0,5	0	0	158,1	1,9	3,6	0,1	11,9	71	20
	Zakres	(0–2)	(0–1)	(0–2)	(0–1)	(0–2)	(129,6–263,3)	(1–4)	(2,2–6,8)	(0,1–0,2)	(3,5–20,1)	(64–80)	(13–28)

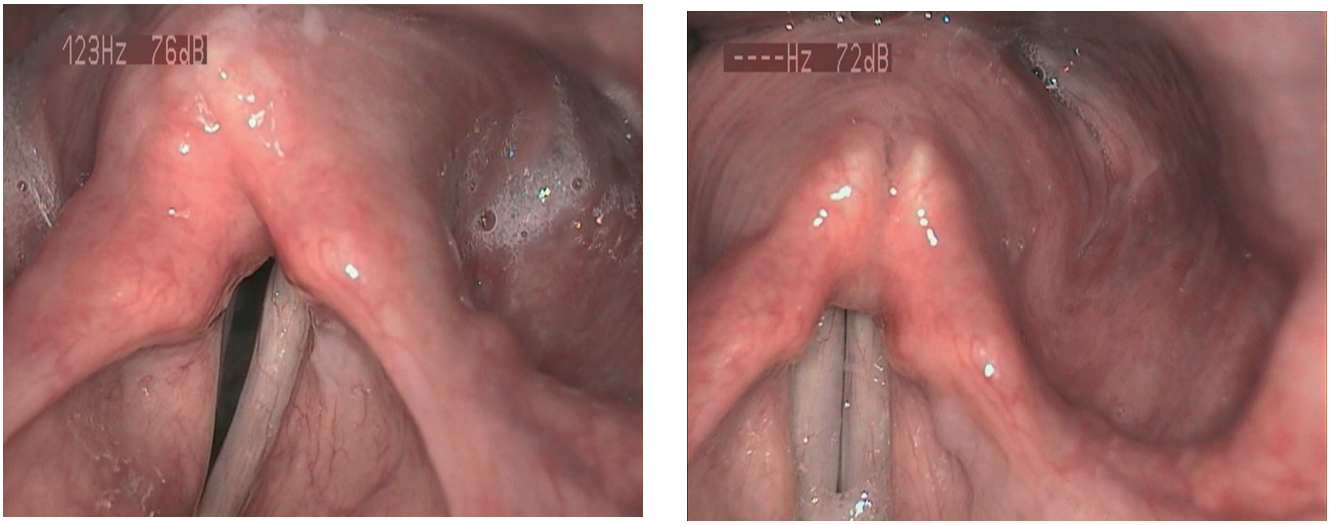

Fig. 5. Videolaryngostroboscopy examination in the patient with right-sided laryngeal paralysis prior to and 12 months after laryngeal augmentation.

tients undergoing laryngeal augmentation with calcium hydroxyapatite, both under local and general anaesthesia [10]. The authors analysed data obtained from 11 different facilities [10]. Significant improvement in voice quality, assessed using the VHI-10 questionnaire, was reported in 67% of patients, while satisfactory improvement in the quality of voice was observed in 81% of patients one year after surgery [10].

The results of the record evaluation and the aerodynamic evaluation correspond with the results obtained by Kwon et al [6]. The authors performed 33 procedures of laryngeal augmentation using calcium hydroxyapatite in patients with glottic insufficiency. The values of MPTa in their patients were 13.6 seconds and 12.8 seconds after 3 and 12 months respectively following surgery, and those results correspond very well with the results obtained in our study (12.2 and 11.9 seconds respectively).

The results obtained in this study prove an unquestionable advantage of calcium hydroxyapatite - a long time of its persistence within the tissues of the larynx. Thus, after augmentation with calcium hydroxyapatite, a long-term improvement in the quality of voice is to be expected.

However, it should be noted that calcium hydroxyapatite must be injected lateral to the vocal fold. Injection of the material too close to a free margin of the vocal fold may cause stiffness and

consequently the necessity for surgical removal of the material. Another difficulty in application of the Radiesse is its high density. The solution is administered through a 25-cm needle with a small diameter, which requires a great force. It can make it difficult to control the amount of the injected material, which is necessary to prevent an excessive medial displacement of the vocal fold.

CONCLUSIONS

Laryngeal augmentation with calcium hydroxyapatite under local anaesthesia brings good long-term outcomes, improving both the quality of patient's voice and the quality of life.

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