

Quantitative microlaryngoscopic measurements of vocal fold polyps, glottal gap and their relation to vocal function

Virgilijus Uloza, Marius Kašėta, Rūta Pribušienė, Viktoras Šaferis¹, Vytautas Jokūžis², Adas Gelžinis³, Marija Bačauskienė³

Department of Otorhinolaryngology,

¹Department of Physics, Mathematics and Biophysics, Kaunas University of Medicine,

²UAB Elinta, ³Department of Applied Electronics, Kaunas University of Technology, Lithuania

Key words: microlaryngoscopic images; vocal fold polyps; acoustic voice parameters; glottal gap.

Summary. Objectives. The purpose of this study was to quantify the size of vocal fold polyps and to investigate the relationship between the glottal gap and parameters of acoustic voice analysis and phonetography.

Material and methods. Eighty-one microlaryngoscopic images and digital recordings of voices (acoustic analysis and phonetogram) acquired from the patients with vocal fold polyps (VFPs) were employed in this study. Vocal fold (VF) images were collected during routine direct microlaryngoscopy using Moller-Wedel Universa 300 surgical microscope, 3-CCD Elmo 768×576-pixel color video camera and a 300 W Xenon light source. Acoustic voice analysis and phonetography were established using Dr. Speech (Tiger Electronics Inc.) software. Microlaryngoscopic images were processed by original software created by ELINTA and displayed on a monitor. The relative lengths and widths of vocal fold polyps as well as percentage area of VFP were calculated. The Pearson's correlation was applied to reveal the correlation between VFP dimensions and acoustic voice parameters.

Results. There were no statistically significant differences between the dimensions of left and right vocal folds and VFPs. Statistically significant slight to mild correlations between measured dimensions of VFP acoustic and phonetogram parameters were revealed, with HNR and phonetogram area showing the strongest correlation to the size of VFPs.

Conclusion. The results of our study confirm that quantitative microlaryngoscopic measurements of vocal fold polyp and glottal gap dimensions may be a useful tool for objective assessment of glottic incompetence and voice impairment.

Introduction

Endoscopic examination of the larynx represents an essential part of the assessment of patients in clinical practice. Despite the recent advances in video laryngostroboscopy and microlaryngoscopy, which allow the clinician to examine fine details of the vocal folds, standard laryngoscopic methods only provide data for subjective analysis or allow only the determination of the relative size of laryngeal anatomical structures and suffer from a lack of information about the measured size of observed objects.

New techniques in videoendoscopic examination of the larynx are being developed to increase an accuracy of measurements of digital videostroboscopic images of the vocal folds (1) and to develop the precise measurement in absolute metric units (2). Employment

of two parallel laser beam projection system or two-point-light projection with double reflecting mirror technique as clip-on device allows definition of a metric scale within an endoscopic image (2, 3). This may be helpful in quantitative morphometric measurement of laryngeal lesions, voice diagnostics, and in monitoring during voice treatment.

Some studies have attempted to measure the glottic space from video laryngostroboscopic images objectively and determine the relationship between the relative glottic space and the degree of breathiness in dysphonic patients (4), to quantify criteria for prediction and evaluation of outcome of surgical treatment of unilateral laryngeal paralysis (5, 6). Authors found a positive correlation between glottic area and breathy voice in unilateral vocal fold paralysis and confirmed

that even only measurement of relative glottic space provides a direct assessment of glottic incompetence and objectively demonstrates the effect of surgical medialization (4, 5).

Only few studies have been devoted to investigation of correlation between voice quality and size of vocal fold lesions, so far. However, this is crucial toward understanding the contribution of vocal fold lesion size to overall voice quality. A grading scale for pediatric vocal fold nodules was elaborated and a positive correlation between the sizes of vocal nodules and perceptual voice characteristics was identified (7, 8). Unfortunately, there is a lack of research on relation between vocal fold lesion size and parameters of objective voice assessment.

Therefore, the purpose of this study was to elaborate a method for measuring of vocal fold polyp (VFP) dimensions acquired from microlaryngoscopic images and investigate the relationship between these measurements and parameters of acoustic voice analysis and phonetography.

Material and methods

Eighty-one microlaryngoscopic images and voice assessment data acquired from the patients with (VFPs) were employed in this study. The study group consisted of 42 women and 39 men. Age of patients ranged from 18 to 67 years (mean age, 41 ± 9.8 years). Acoustic voice parameters and data of phonetography of healthy persons (control group) were established in our previous studies (9–11). Ratio of subjects in the patients and control groups studied did not differ significantly with respect to age, gender, vocal training and usage, and smoking habits.

Acquirement of microlaryngoscopic images

Laryngeal images were acquired during routine direct microlaryngoscopy employing Moller-Wedel Universa 300 surgical microscope with 400 mm focus lens. A 3-CCD ELMO color video camera of 768×576 pixels and a 300 W xenon light source were used to record the laryngeal images. Distance between the microscope lens and the larynx was kept equal in all cases ($F=400$ mm). Relevant microlaryngoscopic images were digitized and stored with a MIGRA frame grabber.

Measurements of laryngeal and VFP dimensions were performed from the retrieved digital microlaryngoscopic images displayed on the monitor using original knowledge-based software created by ELINTA in the following steps:

A. Measurement of the length and the width of vocal fold.

Marking with the mouse two points (*a* and *b*) on the phonatory edge of vocal fold that defined the visible beginning and the end of the vocal fold. The third point (*c*) was marked on the phonatory edge of the vocal fold and the fourth point (*d*) on the lateral boundary. All the points were marked bilaterally. Manually traced distance *ab* was considered as the length and the distance *cd* as the width of the vocal fold (Fig. 1).

B. Measurement of the length and width of VFP.

Marking with the mouse two points on the edge of VFP so that the traced line EF connecting the dots would indicate the biggest length of the polyp, and the traced line GH connecting the second pair of the points would indicate the biggest width of the polyp (Fig. 2).

C. Calculation of the relative dimensions of vocal folds and VFP.

1. For the computation of the relative length and width of vocal folds and VFPs the calculation of the distances between the marked points was performed. It was assumed that the microlaryngoscopic image defines a system of coordinates with the point of origin in the upper left corner of the image. The top border of the image was set to be the “X” axis and left border of the image – the “Y” axis. The distances between the marked points were measured in pixels. Every point marked on the microlaryngoscopic image is characterized by (*x*, *y*) coordinates. The Euclidean distance measure *l* has been used to measure distance

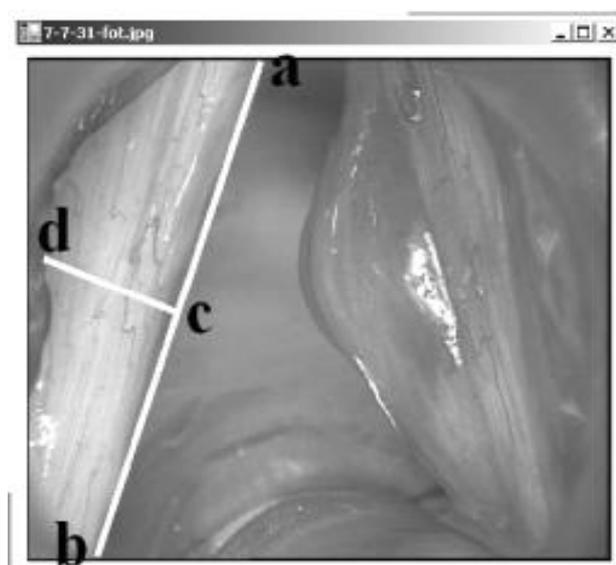


Fig. 1. Measurement of the length (*ab*) and the width (*cd*) of the vocal fold



Fig. 2. Measurement of the length (EF) and the width (GH) of the right vocal fold polyp

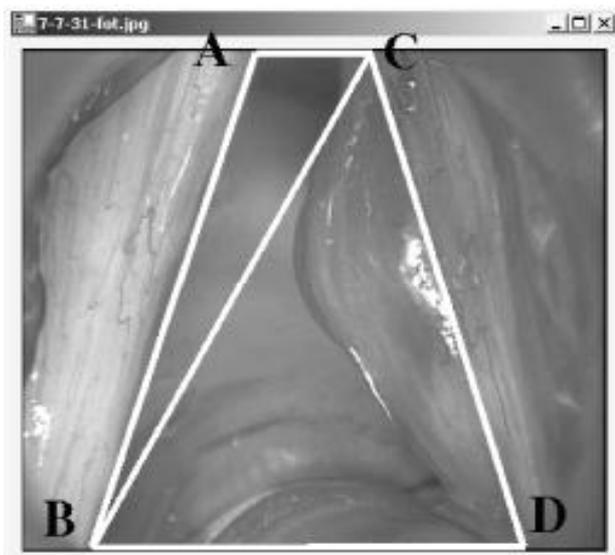


Fig. 3. Calculation of the comparative glottal gap area (CGGA) as the sum of the areas of ABC and BCD triangles

between two points:

$$l = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

2. For the computation of the relative area of the VFP (*RAVFP*), the polyp was treated as a half of an ellipse. Thus, *RAVFP* was calculated using the following formula (12):

$$S = \frac{\pi w l}{2},$$

where: *S* stands for area in pixels, $\pi=3.14$, *l* is the calculated length of the structure, and *w* is the calculated width of the structure.

3. For revealing the relative glottal gap area, the previously marked points on phonatory edge of vocal folds were used. When connected by lines, these points formed a trapezium *ABCD* (Fig. 3). Then, the *ABCD* trapezium was divided into two triangles (*ABC* and *BCD*), and area of each triangle was calculated using the Heron's formula (12):

$$S = \sqrt{p(p-a)(p-b)(p-c)},$$

where: *S* is the area of the triangle, *P* is the perimeter of the triangle, and *p* is a half of the perimeter of the triangle.

$$p = \frac{P}{2} = \frac{a+b+c}{2},$$

where: *a*, *b*, and *c* are the lengths of each side of the triangle.

In this case, the first triangle has *AB*, *AC*, and *BC* sides, and the second triangle has *BC*, *BD*, and *CD* sides, respectively (Fig. 3). The sum of the areas of the *ABC* and *BCD* triangles was treated as the comparative glottal gap area (*CGGA*).

4. Finally, in the digitized microlaryngoscopic images, a percentage VFP area (*PVFPA*) was calculated as:

$$PVFPA = \frac{RAVFP}{CGGA} \times 100.$$

In the present study, the relative units of glottic and VFP areas were used because exact measurements cannot be determined. The *CGGA* and *RAVFP* areas as well as linear measurements of vocal folds on the digitized images are dependent on the distance from the microscope. Despite the fact that pixels are objective values, a calibration based on the distance between the microscope and vocal folds is required (5). Therefore, mathematical transformations mentioned above were used in this study to determine the normalized measurements.

Voice assessment

Acoustic analysis. Tree-second segments of the sustained phonation at habitual pitch and loudness of vowel /a:/ were recorded in a soundproof 2.5×1.5 m room through the D60S Dynamics Vocal (AKG Acoustics) microphone placed at 10.0 cm distance from the mouth coupled to a digitized Sony Mini Disc Recorder MDS-101. The recordings were made in the

“wav” file format at 44 100 samples per second rate. There were 16 bits allocated for one sample. Voice samples were analyzed using Tiger Electronics Dr. Speech software (Voice Assessment, Version 3.0). Acoustic voice-signal parameters measured included: 1) fundamental frequency (F_0), 2) perturbation of frequency (percent of jitter), 3) amplitude (percent of shimmer), 4) harmonic to noise ratio (HNR), and 5) turbulent noise as normalized noise energy (NNE) at 44 100 Hz sampling frequency. The beginning of the phonation sample (0.25 s) was cut off, and the subsequent 3.0 seconds were used for the measurements, thus minimizing variability due to sampling errors. The remaining parts of the sustained vowel (a) were discarded. This ensured that the beginning and the end of voicing did not influence the final result.

Phonetogram (PG). PGs were recorded according to the recommendations of the Union of European Phoniaticians (13). Tiger Electronics Dr. Speech software (Phonotogram) and multidirectional microphone D60S Dynamic Vocal (AKG Acoustics) were employed for the registration and assessment of the PG. Seven parameters of PG were evaluated: 1) pitch range (PR) in semitones (smt.), 2) maximum frequency (F-max) in Hz, 3) minimum frequency (F-min) in Hz, 4) intensity range (IR) in dB (A), 5) maximum intensity (I-max) in dB (A), 6) minimum intensity (I-min) in dB (A), 7) phonetogram area (S) in dB (A)×smt.

Statistics

Statistical analysis was performed using SPSS 15.0 for Windows. Confidence interval (CI) of 0.95 was chosen for statistical evaluation and significance level of 0.05 was chosen for testing statistical hypotheses. After testing for normality, parametric and nonparametric criteria (Student *t* and Mann-Whitney *U* tests) were used to compare unpaired quantitative samples. The correlation between the voice parameters and dimensions of VFP was tested using Pearson's correlation coefficient (*r*).

Results

There were no statistically significant differences

between the dimensions of the left and the right vocal folds (Table 1) that reflect a correct coherence of optical axis of the microscope and laryngoscope and constant distance between the microscope lens and the larynx.

In 42 cases, VFP was found on the left vocal fold and in 39 cases – on the right one. Despite the wide range of variation of the length and width of VFP, there were no statistically significant differences between the mean dimensions of the VFP on the left and the right sides ($P>0.05$).

Statistical analysis revealed a statistically significant difference between mean values of the most important acoustic parameters (jitter, shimmer, NNE) of VFP patients comparing to the controls with patient group having worse results (Table 2).

Increases of mean acoustic voice parameters reflecting pitch and amplitude perturbation, and turbulent noise in voice signal of VFP patients group objectively confirmed a deteriorated voice quality. These results correspond with the literature data (9–11).

Mean parameters of phonetogram are listed in Table 3. Statistically significant differences between phonetogram parameters of healthy female and male subjects were revealed in the previous study (10); therefore, in the present study parameters of phonetograms for male and female VFP patients were evaluated separately. Data in Table 3 demonstrate a statistically significant decrease in the mean values of the main parameters of phonetogram and quantitatively confirm a deteriorated voice quality and voice capability in both male and female VFP patients' subgroups.

Correlation analysis revealed statistically significant slight to mild correlations between measured dimensions of VFP (relative length, width of VFP and PAVFP), acoustic and Phonetogram parameters (Table 4). Of these parameters, HNR and Phonetogram area showed the strongest correlation with the size of VFP.

Discussion

Measurements of actual size of pathological lesions and anatomical structures are of great clinical importance in practical medicine, as it provides objective

Table 1. Comparison of length and width of left and right vocal folds

Parameter	Left side (N=81)		Right side (N=81)		P
	mean	SD	mean	SD	
Length (pixels)	357.10	20.65	353.96	25.07	0.496
Width (pixels)	102.03	22.28	98.42	21.36	0.294

Table 2. Comparison of mean values of acoustic voice parameters in VFP patients' and control groups

Parameter	VFP patients (N=81)		Controls (N=90)		P
	mean	SD	mean	SD	
Jitter (%)	0.54	0.68	0.18	0.04	<0.001
Shimmer (%)	3.58	2.68	1.51	0.51	<0.001
NNE (dB)	-4.95	3.90	-14.43	2.68	<0.001
HNR	22.25	6.79	-	-	-
Mean Fo (Hz), M	134.25	32.12	126.9	26.7	0.104
Mean Fo (Hz), F	193.21	29.84	227.1	30.8	<0.001

NNE – normalized noise energy; HNR – harmonic to noise ratio; VFP – vocal fold polyps; SD – standard deviation.

Table 3. Comparison of mean values of phonetogram parameters in VFP patients and control groups

Parameter	Females			Males		
	Mean±SD		P	Mean±SD		P
	patients (N=42)	controls (N=36)		patients (N=39)	controls (N=54)	
PR (smt.)	20.2±7.9	30.2±4.1	<0.001	21.4±7.6	35.7±4.9	<0.001
F-max. (Hz)	491.7±194.2	891.9±157.1	<0.001	348.6±137.9	683.4±142.5	<0.001
F-min. (Hz)	146.4±29.8	160.4±48.4	0.123	97.9±27.9	86.5±15.6	0.014
IR (dB(A))	31.2±9.6	42.8±5.8	<0.001	35.3±8.5	48.2±6.3	<0.001
I-max. (dB(A))	78.8±9.6	91.2±7.1	<0.001	84.6±8.7	94.7±6.7	<0.001
I-min. (dB(A))	47.5±1.7	48.4±4.5	0.234	49.4±2.6	46.5±1.2	<0.001
S (smt.×dB(A))	259.7±131.3	725.7±160.4	<0.001	272.5±111.8	915.1±175.1	<0.001

PR – pitch range; IR – intensity range; S – phonetogram area.

Table 4. Correlation between the relative length and width of VFP, PVFPA, acoustic voice parameters and parameters of phonetogram

Parameter	VFP		PVFPA
	length	width	
Acoustic			
Jitter (%)	0.149	0.221*	0.233*
Shimmer (%)	0.076	0.135	0.150
NNE (dB)	0.254*	0.208	0.271*
HNR	-0.276*	-0.278*	-0.326**
Mean Fo (Hz)	-0.273*	-0.333**	-0.309**
Phonetogram			
PR (smt.)	-0.265*	-0.114	-0.297**
F-max. (Hz)	-0.392**	-0.316**	-0.405**
F-min. (Hz)	-0.116	-0.272*	-0.172
IR (dB(A))	-0.202	-0.106	-0.182
I-max. (dB(A))	-0.146	-0.027	-0.084
I-min. (dB(A))	0.207	0.313*	0.371**
S (smt.×dB(A))	-0.397**	-0.241*	-0.434**

*Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level.

additional information, which is crucially important for diagnostics, planning of treatment and assessment of outcomes of therapeutical or surgical management (4–6, 14). On the other hand, in laryngology, these measurements are of great interest for scientific purposes revealing the impact of actual size of vocal fold mass lesions in pathogenesis of voice disorders and would be helpful elaborating automatic methods of image and voice analysis (9, 15).

Several methods of measurements of video laryngostroboscopic images and glottic gap providing with the relative or absolute measures and their clinical implications have been described in the literature (1, 2, 5). However, these models of glottic gap measurement seem to be impractical in cases when part of glottis is occupied by some pathological growth. A few models for automatic detection of the boundaries of a selected object images have been developed (16). However, these models are based on gradient values and may have a limited ability to determine the lateral margin of VFP. Other authors advocated a mathematical equation that could estimate the length of the intermembranous part of the vocal fold. They conclude that it is possible to estimate the normal expected length of the intermembranous portion of the male and female vocal folds based on body height (17).

Digital direct microlaryngoscopic images were employed in the present study for the measurements providing with the high quality and resolution pictures of the anatomical structure of vocal folds and VFP. These features of microlaryngoscopic images could be considered as advantageous comparing with video laryngostroboscopic images. On the other hand, some limitations of direct microlaryngoscopy were acknowledged: the view of the entire larynx is limited by the laryngoscope and therefore anterior commissure is not always visible while posterior part of glottis is occupied by the intubation tube. These factors may reduce the precision of the measurements.

In the present study, the relative units of measurement were used and therefore PAVFP was calculated on the basis on the percentage of the glottic space occupied by VFP. Despite the fact that the shape of

VFP not in all cases corresponds to the exact ellipse shape and, therefore, decreases accuracy of the measurement, statistically significant slight to mild correlations between measured dimensions of VFP (relative length, width of VFP and PAVFP), acoustic and phonetogram parameters were established in the present study (Table 4).

Of these parameters, HNR and phonetogram area correlated with the size of VFP most strongly. The pattern of irregularities of vibration is rather evident in cases of neoplastic growth (like a VFP) and mass imbalance between the vocal folds. Disruption of the laminar structure of the vocal fold by VFP tissue changes the mass, stiffness, and geometry of the affected vocal fold resulting in a perturbed phonatory behavior and increased values of jitter, shimmer consistent with the rough voice quality. Moreover, prevention of full glottal approximation by the intrusion of an additional surface mass can induce turbulent noise into the vocal signal giving audible breathiness and increased values of HNR. Possibly, it may be the most sensitive and complex acoustic voice parameter, because it includes pitch and amplitude perturbation, as well as turbulent noise in voice signal (5). On the other hand, phonetogram area, as the most resumptive parameter of phonetogram, has shown the strongest correlation with VFP dimensional measurements. Thus, results of current study have shown that the size of VFP directly correlates with a deteriorated voice quality as determined by acoustic and phonetogram measures. This corresponds to practical clinical evidence and some theoretical and experimental presumptions (9).

Conclusion

Results of the present study confirm that quantitative microlaryngoscopic measurements of vocal fold polyp and glottal gap dimensions may be a useful tool for objective assessment of glottic incompetence and voice impairment.

Acknowledgement

This study was supported by EU project Eureka E13681 "INFOLARYNX."

Kiekybiniai mikrolaringoskopiniai balso klosčių polipų, balso plyšio matavimai, jų ryšys su balso funkcija

Virgilijus Uloza, Marius Kašėta, Rūta Pribuišienė, Viktoras Šaferis¹, Vytautas Jokūžis², Adas Gelžinis³, Marija Bačauskienė³

Kauno medicinos universiteto Ausų, nosies ir gerklės ligų klinika, ¹Fizikos, matematikos ir biofizikos katedra, ²UAB „Elinta“, ³Kauno technologijos universiteto Taikomosios elektronikos katedra

Raktažodžiai: mikrolaringoskopiniai vaizdai, balso klosčių polipai, akustiniai balso parametrai.

Santrauka. *Tyrimo tikslas.* Išmatuoti balso klosčių polipus, įvertinti balso plyšio dydžio ryšį su akustiniais balso ir fonetogramos parametrais.

Tiriamųjų kontingentas ir tyrimo metodai. Studijos metu išanalizuotas 81 mikrolaringoskopinis vaizdas ir skaitmeniniai balso įrašai (akustiniai ir fonetogramos), užregistruoti pacientams, sergantiems balso klosčių polipais. Balso klosčių skaitmeniniai vaizdai gauti tiesioginės mikrolaringoskopijos metu naudojant „Moller-Wedel Universa 300“ chirurginį mikroskopą, „3-CCD Elmo“ 768×576 taškų spalvotą vaizdo kamerą ir „300 W Xenon“ šviesos šaltinį. Akustinė balso analizė atlikta ir fonetogramos registruotos naudojant dr. Speech (Tiger Electronics Inc.) programinę įrangą. Mikrolaringoskopiniai vaizdai perkelti į kompiuterį ir analizuoti naudojant originalią ELINTA sukurtą programą. Apskaičiuotas santykinis balso klosčių polipų ilgis ir plotis, taip pat procentinis balso klosčių polipų plotas. Pearson'o koreliacijos koeficientas apskaičiuotas ištyrus ryšį tarp balso klosčių polipų matmenų ir balso parametrų.

Rezultatai. Nenustatyta statistiškai reikšmingo skirtumo tarp balso klosčių bei polipų kairės ir dešinės pusės. Nustatyta silpna bei vidutinė koreliacija tarp balso klosčių polipų matmenų ir fonetogramos parametrų. Stipriausia koreliacija nustatyta tarp balso klosčių polipų matmenų, HNR ir fonetogramos ploto.

Išvados. Šios studijos duomenys patvirtina, jog kiekybinė mikrolaringoskopinių balso klosčių polipų ir balso plyšio vaizdų analizė gali būti naudinga norint objektyviai įvertinti balso plyšio nesandarumą ir balso pokyčius.

Adresas susirašinėti: M. Kašėta, KMU Ausų, nosies ir gerklės ligų klinika, Eivenių 2, 50009 Kaunas
El. paštas: mariuska13@yahoo.com

References

- Speyer R, Wieneke GH, Kersing W, Dejonckere PH. Accuracy of measurements on digital videostroboscopic images of the vocal folds. *Ann Otol Rhinol Laryngol* 2005;114(6):443-50.
- Schubert S, Hoppe U, Döllinger M, Lohscheller J, Eysholdt U. High-precision measurement of the vocal fold length and vibratory amplitudes. *Laryngoscope* 2002;112(6):1043-9.
- Schade G, Leuwer R, Kraas M, Rassow B, Hess MM. Laryngeal morphometry with a new laser 'clip on' device. *Lasers Surg Med* 2004;34(5):363-7.
- Jeannon JP, Carding PN, Wilson JA. Vocim analysis of laryngeal images: is breathiness related to the glottic area? *Clin Otolaryngol Allied Sci* 1998;23(4):351-3.
- Omori K, Kacher A, Slavik D, Blaugrund S. Quantitative videostroboscopic measurement of glottal gap and vocal function: an analysis of thyroplasty type I. *Ann Otol Rhinol Laryngol* 1996;105(4):280-5.
- Umeno H, Chitose SH, Sato K, Nakashima T. Efficacy of additional injection laryngoplasty after framework surgery. *Ann Otol Rhinol Laryngol* 2008;117(1):5-10.
- Shah RK, Woodnorth GH, Glynn A, Nuss RC. Pediatric vocal nodules: correlation with perceptual voice analysis. *Int J Pediatr Otolaryngol* 2005;69:903-9.
- Shah RK, Feldman HA, Nuss RC. A grading scale for pediatric vocal fold nodules. *Otolaryngol Head Neck Surg* 2007;136(2):193-7.
- Uloza V, Saferis V, Uloziene I. Perceptual and acoustic assessment of voice pathology and the efficacy of endolaryngeal phonosurgery. *J Voice* 2005;19(1):138-45.
- Uloza V, Pribuisiene R, Saferis V. Multidimensional assessment of functional outcomes of medialization thyroplasty. *Eur Arch Otorhinolaryngol* 2005;262(8):616-21.
- Pribuisiene R, Uloza V, Kupcinskas L, Jonaitis L. Perceptual and acoustic characteristics of voice changes in reflux laryngitis patients. *J Voice* 2006;20(1):128-36.
- Frey H, Felmy W-G. *Matematikos žinynas. (Manual of mathematics.)* Kaunas: Šviesa; 1996.
- Schutte HK, Seidner W. Recommendations by the Union of European Phoniatrists (UEP): Standardizing voice area measurement/phonetography. *Folia Phoniatr (Basel)* 1983;35(6):286-8.
- Milonas D, Matjošaitis A, Jievaltas M. Transition zone volume measurement – is it useful before surgery for benign prostatic hyperplasia? *Medicina (Kaunas)* 2007;43(10):792-7.
- Verikas A, Gelzinis A, Valincius D, Bacauskiene M, Uloza V. Multiple feature sets based categorization of laryngeal images. *Comput Methods Programs Biomed* 2007;85(3):257-66.
- Chan TF, Vese LA. Active contours without edges. *IEEE Trans Image Process.* 2001;10(2):266-77.
- Filho JA, de Melo EC, Tsuji DH, de Giacomo Carneiro C, Sennes LU. Length of the human vocal folds: proposal of mathematical equations as a function of gender and body height. *Ann Otol Rhinol Laryngol* 2005;114(5):390-2.

Received 22 February 2008, accepted 18 April 2008
Straipsnis gautas 2008 02 22, priimtas 2008 04 18