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Objective Analysis of Voice after Microlaryngoscopic Surgery in Patients with Vocal Polyps at Different Anatomical Sites

Zheng-Ping Shi, and Hsing-Won Wang*

Department of Otolaryngology-Head and Neck Surgery,
Tri-Service General Hospital, National Defense Medical Center,
Taipei, Taiwan, Republic of China

Background: Vocal polyps are a common, benign disorder of the larynx, which is most often treated by surgical excision. The aim of this study was to compare the postoperative changes in voice that correspond to the anatomical locations of vocal polyps. **Methods:** A retrospective study was conducted. Twenty-one patients were diagnosed with a polyp on the anterior third of the vocal fold (group I) and 17 patients with a polyp on the middle third (group II). Acoustic and phonatory function analyses were performed before surgery and six weeks thereafter. **Results:** Whereas postoperative jitter and shimmer decreased, the postoperative harmonic-to-noise ratio and maximal phonation time increased in all patients ($P < 0.05$). Jitter, harmonic-to-noise ratio, and maximal phonation time tended to improve more after surgery in group I, whereas shimmer tended to decrease more in group II. Only the increase in harmonic-to-noise ratio after surgery in group I was significantly greater than that in group II ($P < 0.05$). **Conclusion:** Surgery led to greater improvement in the harmonic-to-noise ratio in patients with a polyp on the anterior third than in those with a polyp on the middle third of the vocal fold. This implies that a polyp on the anterior third produces more disturbance in the harmonic component of the voice than does a polyp on the middle third of the vocal fold.

Key words: acoustic analysis, microlaryngoscopic surgery, phonatory function, vocal polyps

INTRODUCTION

Vocal polyps, the most common benign lesions of the adult larynx, are thought to result from voice misuse and overuse. They usually appear as unilateral lesions in the lamina propria and are located at the free edge of the vocal fold, commonly between the anterior and middle thirds of the vocal cord. Patients present with hoarseness and breathiness because vocal polyps disturb glottal closure and produce irregular vocal fold movements. Treatment options include voice therapy and surgical excision. Surgical removal by microlaryngoscopic techniques is recommended in most cases, particularly if the patient has a history of smoking[1]. Disease severity can be assessed with a thorough medical examination and voice history, perceptual assessment of the voice, videolaryngostroboscopy (VLS), acoustic analysis, or aerodynamic analysis. Acoustic and aerodynamic analyses are part of a comprehensive, integrated evaluation that enhances the quality of the diagnosis, even though they are not considered primary diagnostic procedures. These analyses can be used to support clinical judgments and can provide quantitative documentation of vocal function, as well as additional insight into underlying vocal mechanisms. Such analyses have the additional advantage of evaluating the efficacy of treatments and monitoring changes in voice quality[2,3]. Several studies have investigated vocal function before and after the removal of vocal polyps with objective analysis[4-8]. However, no comparison of the postoperative change in vocal function in patients with vocal polyps at different anatomical locations has been reported. The goal of this study was to investigate postoperative functional changes in the voice based on the location of the vocal polyp using acoustic analysis and examination of phonatory function.

MATERIALS AND METHODS

Patient Selection

We reviewed our medical records, compiled from June 2002 to June 2004, and enrolled 38 patients in the current study. The patients were initially evaluated for a unilateral

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*Corresponding author: Hsing-Won Wang, Department of Otolaryngology-Head and Neck Surgery, Tri-Service General Hospital, No. 325, Sec. 2, Cheng-Gong Road, Taipei 114, Taiwan, , Republic of China. Tel: +886-2-8792-7192; Fax: + 886-2-8792-7193; E-mail: w0512n@ms15.hinet.net

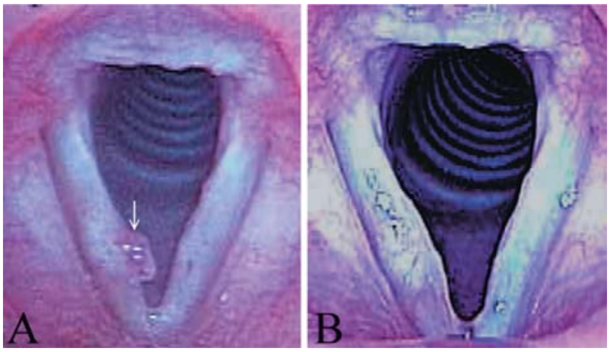

Fig. 1 A 38-year-old female was diagnosed with a polyp (arrow) on the anterior third of the right vocal fold. Pre-operative (A) and post-operative (B) videolaryngostroboscopic images are shown

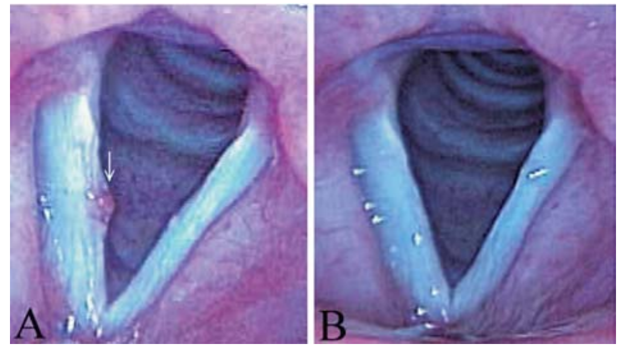

Fig. 2 A 58-year-old female was diagnosed with a polyp (arrow) on the middle third of the right vocal fold. Pre-operative (A) and post-operative (B) videolaryngostroboscopic images are shown.

vocal lesion and subsequently underwent microlaryngeal phonosurgery. A vocal polyp was confirmed by intraoperative findings and histopathology, and had a maximal diameter of $\leqq$ 4 mm in all patients. Microlaryngoscopy revealed that there were no lesions, including reactive nodes, on the contralateral vocal fold. After surgery, the patients were instructed to rest their voices for 2 weeks. Rigid optic VLS, acoustic analysis, and phonatory function analysis were conducted preoperatively and 6 weeks postoperatively. The postoperative VLS image was reviewed in detail, and there was no residual or new vocal lesion noted in any of the patients. The location of the subject's vocal polyp was determined by two independent otorhinolaryngologists, blinded to patient status, according to the preoperative VLS video (Figs 1 and 2) and the patients were classified into one of two groups. Group I comprised 21 patients with a polyp on the anterior third of the vocal cord, including the junction of the anterior and middle thirds. The remaining 17 patients, in whom the polyp was on the middle third of the vocal cord, were placed in group II.

Surgery

Under general anesthesia, a laryngoscope was inserted into the larynx to expose the site of the lesion. The polyp was stabilized throughout the excision using a left- or right-handed, heart-shaped grasper. An incision was made along the base of the polyp with straight microscissors, and the polyp was removed. After hemostasis was assured, the laryngoscope was removed.

Videolaryngostroboscopy

All the patients underwent a rigid VLS pre- and postoperatively. VLS was performed with a Karl Storz 70 degree rigid telescope (model 8706 CJ; Karl Storz, Germany) connected to a CCD camera (model 20222130; Karl Storz) and light source. Recordings were made in either super VHS format or digital format (Kay Instrument, Lincoln Park, NJ, USA).

Acoustic and Phonatory Function

The patients underwent standardized acoustic recording and phonatory function studies conducted by a well-trained technician in a soundproofed room. The microphone was kept at a constant distance of 15 cm from the subjects' mouths and they were asked to enunciate a sustained 'e'. A 2 s sample of data was analyzed using Computer Speech Laboratory Software (Dr. Speech, version 4; Tiger DRS, Inc., USA) and the fundamental frequency (Fo), jitter, shimmer, and harmonic-to-noise ratio (HNR) values were tabulated. Maximal phonation time (MPT) was measured using a computer cursor to track the display of the airflow and acoustic signals over a waveform. Data were tabulated on a spreadsheet for analysis.

Data Collection and Analysis

Data collected before and after surgery were entered into a statistical program (SPSS 13). A paired samples t test was used to compare pre- and postoperative values, and Student's t test was used to analyze the preoperative values of the two groups. Statistical significance was defined as $P < 0.05$.

RESULTS

The age of the 38 patients ranged from 24 to 69 years, with a mean age of 45.3 years. Group I consisted of 15 males (mean age, 44.6 years) and 6 females (mean age, 49.2

Table 1 Statistic of acoustic analysis and phonatory function before surgery

Gender	Group	N		Fo (Hz)	Jitter (%)	Shimmer(%)	HNR (dB)	MPT (sec)
Male	I	15	Mean	136.78	0.61	2.36	21.1	12.01
			SD	40.88	0.75	1.23	5.39	5.95
	II	5	Mean	132.5	0.25	2.61	23.16	13.94
			SD	21.95	0.06	1.63	7.53	7.06
			p	0.825	0.085	0.72	0.51	0.555
Female	I	6	Mean	205.08	0.32	2.77	22.94	8.94
			SD	22.78	0.29	1.96	6.63	4.27
	II	12	Mean	243.68	0.39	2.23	26.55	10.08
			SD	27.4	0.37	1.68	5.82	2.74
			p	0.009	0.67	0.556	0.252	0.568

N = number; SD = standard deviation; Fo = fundamental frequency; HNR = harmonic-to-noise ratio; MPT = maximal phonation time

years). Group II consisted of 5 males (mean age, 49.8 years) and 12 females (mean age, 42.3 years). The preoperative data of the two groups are shown in Table 1. There was no statistically significant difference between the males in groups I and II, whereas Fo in group II females was significantly greater than Fo in group I females (P= 0.009). Table 2 shows the values for all patients before and after surgery. Postoperative Fo, jitter, and shimmer decreased, whereas postoperative HNR and MPT increased. Except for Fo, the differences in all the variables reached statistical significance. We subsequently analyzed the difference between pre- and postoperative values according to the anatomical location of the unilateral vocal polyp (Table 3). Representative postoperative results from both groups of patients included a decrease in Fo, jitter, and shimmer, and an increase in HNR and MPT. Fo was not statistically significantly different in either group. In group I, jitter, shimmer, HNR, and MPT improved significantly after surgery. In group II, shimmer, HNR, and MPT also improved significantly postoperatively. The mean value for jitter was 0.53% preoperatively and 0.30% postoperatively in group I, and 0.35% preoperatively and 0.22% postoperatively in group II. The mean value for shimmer was 2.48% preoperatively and 1.79% postoperatively in group I, and 2.34% preoperatively and 1.56% postoperatively in group II. The mean value for HNR was 21.62 dB preoperatively and 27.06 dB postoperatively in group I, and 25.55 dB preoperatively and 28.46 dB postoperatively in group II. The mean value for MPT was 11.13 s preoperatively and 15.43 s postoperatively in group I, and 11.22 s preoperatively and 14.58 s postoperatively in group II. The improvement in jitter (absolute/relative difference in mean values) was 0.23/43.4% in group I and 0.13/37.1% in group II. The improvement in shimmer was 0.69/27.8% in group I and 0.78/33.3% in group II. The improvement in HNR was 5.44/25.2% in group I and 2.91/11.4 % in group II. The improvement in MPT was 4.3/38.6% in group I and 3.36/29.9% in group II. Jitter, HNR, and MPT in group I tended to improve more than in group II after surgery, whereas shimmer tended to improve more in group II. Only the greater postoperative increase in HNR in group I relative to that in group II was statistically significant (P = 0.045).

Table 2 Comparison of preoperative and postoperative data in all of 38 patients

		Fo (Hz)	Jitter (%)	Shimmer (%)	HNR (dB)	MPT (sec)
Pre-OP	Mean	180.75	0.45	2.42	23.38	11.17
	SD	58.8	0.54	1.5	6.21	5.1
	Mean	176.61	0.27	1.69	27.69	15.05
Post-OP	SD	58.19	0.22	1.12	6.13	4.94
	p	0.438	0.005	<0.001	<0.001	<0.001

DISCUSSION

Acoustic parameters provide objective and noninvasive measures of vocal function. Perturbation measures and harmonic-to-noise computations have emerged as the most robust measures[3]. Jitter and shimmer are the most com-

Table 3 Analysis of preoperative and postoperative data of group I and II

Group	N		Fo (Hz)		Jitter (%)		Shimmer (%)		HNR (dB)		MPT (sec)	
			Pre-OP	Post-OP	Pre-OP	Post-OP	Pre-OP	Post-OP	Pre-OP	Post-OP	Pre-OP	Post-OP
I	21	M	156.3	152.9	0.53	0.3	2.48	1.79	21.62	27.06	11.13	15.43
		SD	47.95	50.84	0.66	0.28	1.43	1.25	5.66	5.95	5.6	5.56
		p		0.693		0.022		<0.001		<0.001		0.001
II	17	M	210.9	205.9	0.35	0.22	2.34	1.56	25.55	28.46	11.22	14.58
		SD	58.01	54.31	0.31	0.1	1.63	0.95	6.32	6.44	4.57	4.16
		p		0.391		0.124		0.049		0.034		<0.001

M = mean; SD = standard deviation

monly used of the perturbation measures. Jitter represents a short-term (cycle-to-cycle) variation in Fo of a signal. The short-term (cycle-to-cycle) variation in the amplitude of a signal is termed 'shimmer'. Jones et al.[9] found a significant correlation between jitter and the subjective assessment of hoarseness, demonstrating that jitter is most effective for monitoring treatment responses. Dejonckere et al.[10] used the Multidimensional Voice Program of Kay to evaluate the correlation between the perceptual grade, roughness, breathiness, asthenia, and strain (GRBAS) scale and acoustic measurements. Jitter and shimmer correlate strongly with three elements (grade, roughness, and breathiness) of perceptual evaluations. Even though perturbation measures of the voice signal are made intermittently, strong subharmonics or modulations become unreliable; values of < 5% are considered reliable[3]. HNR is the ratio of the acoustic energy of the stable harmonic component to that of the noise. It was first reported in 1982 and has been successfully applied to evaluate the effectiveness of the treatments for hoarseness[11,12]. The simplest aerodynamic parameter of voicing is MPT. MPT is reduced in laryngeal disorders with incompetent glottal closure and is a valuable measure in monitoring the effects of surgical treatments in selected disorders of the larynx.

A vocal polyp is a mass that covers the vocal fold, which results in an irregularity of vibration and incomplete closure of the glottis. The prevention of complete glottal closure by the intrusion of an additional surface mass induces interharmonic noise into the vocal signal, and asymmetric structural changes in the vocal cords induce waveform perturbations[4]. These factors contribute to an increase in jitter and shimmer, and a decrease in HNR and MPT. With the removal of a mass lesion, several mechanisms can improve vibratory function. When the mass is located in part or in its entirety along the medial edge, vocal fold modulation of the air flow is restored by removal of the mass, airflow leakage is improved, and glottal efficiency is increased. After surgery, the symmetry of the vocal fold mass is restored, resulting in the stability and vibratory equivalence of each vocal fold. Removal of a mass also creates a smooth edge, facilitating improved vocal fold contact, and thereby allowing the normal generation of subglottic pressure and better amplitude of vocal fold vibrations[7]. The present study shows a significant decrease in jitter and shimmer and a significant increase in HNR and MPT when pre- and postoperative values were compared in all patients. Jitter, shimmer, HNR, and MPT are useful in evaluating the efficacy of surgery in patients with vocal polyps. These results are consistent with those reported by Uloza, who evaluated 32 cases of vocal polyps[4].

Although there was no statistically significant difference in preoperative HNR and MPT, the mean values of the two parameters in patients with polyps on the anterior third of the vocal fold were lower than those in patients with polyps on the middle third (Table 1). Accordingly, a polyp on the anterior third of the vocal fold tended to disturb the harmonic component of voice and phonation time more strongly. In all patients, acoustic and phonatory function analyses after the operation were made in circumstances of no vocal lesion. We compared the postoperative data with the normal data from a study by Chu et al.[13]. Except for postoperative jitter in males and MPT in females, the mean values for the postoperative parameters in our study were consistent with those of Chu's study. Postoperative jitter in males ($0.3 \pm 0.28\%$) was higher and postoperative MPT in females (12.62 ± 2.62 s) was lower than those in Chu's study (jitter in males, $0.21 \pm 0.08\%$; MPT in females, 19.7 ± 3.7 s). This might be attributable to the fact that most of our patients were middle-aged.

Shimmer tended to decrease more after surgery in patients with a polyp on the middle third of the vocal fold than in those patients with a polyp on the anterior third, implying that the removal of a polyp on the middle third reduces perturbation more than the amplitude of the voice. The improvement in HNR after surgery in patients with a polyp on the anterior third was greater than that in patients with a polyp on the middle third. This confirms that a polyp on the anterior third causes a greater decrease in HNR than does a polyp on the middle third. Moreover, a polyp on the anterior third tended to cause greater deterioration of both jitter and MPT. Therefore, a polyp on the anterior third might result in more irregularity of vibration and a larger glottal gap. However, factors such as smoking and gastroesophageal reflux, which might affect the improvement in the voice after surgery, were not analyzed, and this is one limitation of this study. The small number of cases analyzed is also a drawback.

CONCLUSION

Acoustic analysis and MPT are practical noninvasive tools for evaluating vocal function before and after microlaryngeal phonosurgery. Using these measures, we found that the surgical removal of vocal polyps caused greater improvement in HNR in patients with a polyp on the anterior third of the vocal fold. We conclude that a polyp on the anterior third produces more disturbance in the harmonic component of the voice than does a polyp on the middle third of the vocal fold. Studies of larger series are required to investigate the postoperative improvement in vocal function in patients with vocal polyps at different sites.

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