

Outcomes of Fat Injection Laryngoplasty in Unilateral Vocal Cord Paralysis

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Objective: To analyze outcomes following fat injection laryngoplasty in patients with unilateral vocal cord paralysis.

Design: Longitudinal outcomes evaluation study.

Setting: Tertiary referral voice center.

Patients: Thirty-three consecutive patients with unilateral vocal cord paralysis undergoing autologous fat injection laryngoplasty with preoperative and serial postoperative follow-up at Chang Gung Memorial Hospital, Taipei, Taiwan.

Intervention: Autologous fat injection laryngoplasty.

Main Outcome Measures: Voice laboratory measurements, Voice Outcome Survey, and 36-item Short Form Health Survey.

Results: Except for the physical functioning dimension of global health, voice-related subjective outcomes and acoustic variables of the patients significantly improved after surgery ($P < .05$). Compared with population norms, the mean (SD) scores of patients were inferior on the 36-item Short Form Health Survey dimensions of physical functioning (80.7 [22.3] vs 90.2 [17.4]) and role functioning—physical problems (65.0 [36.2] vs 80.2 [36.2]). Overall, 88.9% (24 of 27) of the patients were satisfied with their surgery.

Conclusions: Fat injection laryngoplasty seems to be effective in enhancing acoustic and quality of life outcomes in patients with unilateral vocal cord paralysis. The effect is sustainable over 12 months.

Arch Otolaryngol Head Neck Surg. 2010;136(5):457-462

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FOLLOWING INJURY TO THE course of laryngeal nerves, unilateral vocal cord paralysis (UVCP) is a frequent cause of dysphonia and dysphagia. The voices of patients with UVCP sound breathy and weak, and patients frequently report straining dyspnea when talking. Some also report aspiration or choking when drinking. Our previous study¹ showed that UVCP may significantly affect a patient's quality of life, compromising general health dimensions and voice-related outcomes.

Various therapy regimens have been developed to treat UVCP. Some patients with UVCP achieve near-normal voice quality and swallowing capability by voice therapy. In patients with uncompensated UVCP following speech therapy, extending the paralyzed vocal cord medially by surgical correction is considered. The most common procedures are type 1 thyroplasty and vocal cord injection augmentation laryngoplasty. The goal of therapy is to make the edge of the paralyzed vocal fold closer to the midline to facilitate glottal closure dur-

ing phonation and swallowing by allowing the functioning adducting vocal fold to more easily approximate the paralyzed side. These treatment options are variably effective in terms of perceptual voice quality.²⁻⁴

The most common way to evaluate voice quality perceptually is by applying the GRBAS (grade, roughness, breath-related voice, asthenia, and strain) or RBH (roughness, breathiness, and hoarseness) scale.^{5,6} Commercially available digital programs are available to analyze acoustic variables. Because the quality of life effects of UVCP are debilitating, general health and voice-related questionnaires have been developed to evaluate patients' general disabilities such as dysphagia, physical strain, and aspiration.^{7,8}

Autologous fat injection laryngoplasty is an easily accessible treatment option for UVCP.^{2,3,9,10} However, sustainability of treatment effect is inconclusive. By acoustic and aerodynamic evaluation, Umeno et al³ reported that 2 of 41 patients needed reinjection within 2 years. In contrast, McCulloch et al⁹ reported a 30% failure rate

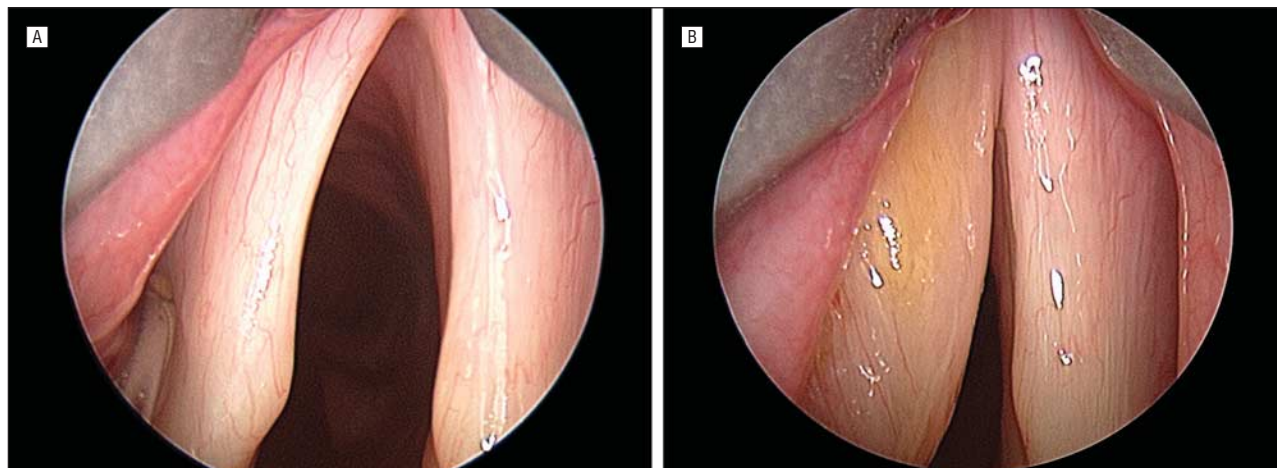


Figure 1. Perioperative laryngoscopic view of left vocal cord paralysis. A, Needle injection on the lateral aspect of the vocal process of the paralyzed side. B, Left vocal cord expansion immediately after fat injection.

by 2 years. Therefore, a comprehensive longer-term evaluation is needed to further investigate this issue. Aside from traditional perceptual or voice analyses, patient-reported subjective outcomes are also important. Subjective outcomes may include patients' general health status, disease-specific quality of life, and their satisfaction with care. The objectives of this study were to use generic and UVCP-specific outcomes surveys to longitudinally evaluate general and disease-related outcomes of patients with UVCP after fat injection laryngoplasty. Patient satisfaction was also surveyed.

METHODS

STUDY DESIGN

The study was conducted in a longitudinal nonrandomized manner. Thirty-three consecutive adult patients (aged ≥ 18 years) having a diagnosis of UVCP who underwent fat injection laryngoplasty were enrolled. Patients with a history of previous voice disorders or concomitant voice disorders were excluded. Diagnosis was made based on patient history and serial videostroboscopic findings that were consistent with UVCP. Joint palpation during surgery was performed to exclude cricoarytenoid joint fixation or dislocation. Patients had a history of UVCP for at least 6 months and had not responded to voice rehabilitation. The origin of UVCP and systemic comorbidity information, including hypertension, diabetes mellitus, and pulmonary, gastrointestinal, or cardiac condition, were screened and documented at study enrollment. When hyperactive supraglottic contraction was noted, some patients underwent postoperative voice rehabilitation.

Before and after surgery, all patients were administered the International Quality of Life Assessment Project's Taiwan version of the 36-item Short Form Health Survey (SF-36) (at baseline and 12 months after surgery)¹¹⁻¹³ and the Chinese (Taiwan) version of the Voice Outcome Survey (CVOS) (at baseline and at 1, 3, 6, and 12 months after surgery).¹⁴ Videostroboscopic examinations were conducted at baseline and at 3, 6, and 12 months after surgery. Patient satisfaction was surveyed at 3 months after surgery.

The study was approved by the institutional review board of Chang Gung Memorial Hospital, Taipei, Taiwan. Both outcomes surveys have been validated and were considered statistically equivalent to their original English versions.¹¹⁻¹⁴ Permission to use these surveys was obtained in advance.

FAT INJECTION LARYNGOPLASTY

Fat for injection was obtained from periumbilical subcutaneous tissue. A 2-cm incision was made under local infiltration of lidocaine hydrochloride, 1% or 2%. Several pieces of subcutaneous soft tissue were obtained. The harvested soft tissue was rinsed with a normal saline solution to remove blood clots. Fat globules were purified and resected to less than 1 mm³, and the separated fibrous band was discarded. An assistant nurse loaded harvested fat globules into a 1-mL syringe. Patients were sedated by intravenous infusion and were ventilated using a high-frequency jet ventilator connected via a thin plastic tube. The patient's vocal cord was exposed by inserting a rigid suspension laryngoscope, and the endoscopic surgical field was viewed using a telescopic imaging system. Approximately 0.5 to 2.0 mL of purified fat was injected into the paralyzed side on the lateral aspect of the vocal process at the posterior third of the membranous vocal cord using a high-pressure 18- or 19-gauge syringe (27200; Karl Storz, Tuttlingen, Germany). Ideally, the paralyzed vocal cord was augmented to achieve 20% to 30% bulging across the midline (**Figure 1**).

VOICE LABORATORY MEASURES

Acoustic recording and phonation studies were performed in all patients. Serial videostroboscopic examinations were performed in each patient to confirm the diagnosis of UVCP and the vocal cord position. A voice sample was obtained by asking the patient to read a standard passage and to sustain a vowel in conversational pitch and loudness. The maximal phonation time represents the amount of time that patients can sustain /a/. A stable segment from the midportion of the vowel voice sample was used for acoustic analysis. Acoustic characteristics of the recorded voice were digitalized and measured using a computerized speech laboratory system (CSL4300B, software version 5.05; Kay Elemetrics Corp, Lincoln Park, New Jersey). From the recorded sample data, fundamental frequency, jitter (frequency perturbation), shimmer (perturbation of amplitude), and harmonic to noise ratio values were tabulated. Patients were also instructed to produce sustaining /s/ and /z/ as long as possible, and the SZ ratio was assessed by a speech language pathologist (H.-F.C.).

SURVEYS

UVCP-Related Health

The VOS was originally developed by Gliklich et al¹⁵ and comprises Likert-type scales evaluating physical and social prob-

Table 1. Voice Outcome Survey^a

Survey Item
1. In general, how would you say your speaking voice is? a. Excellent b. Good c. Adequate d. Poor or inadequate e. I have no voice
The Following Items Ask About Activities That You Might Do in a Typical Day
2. To what extent does your voice now limit your ability to be understood in a noisy area? a. Limited a lot b. Limited a little c. Not limited at all
3. During the past 2 weeks, to what extent has your voice interfered with your normal social activities or with your work? a. Not at all b. Slightly c. Moderately d. Quite a bit e. Extremely
4. How often do you have trouble with food or liquids going "down the wrong pipe" when you eat or find yourself coughing after eating or drinking? a. All the time b. Most of the time c. Sometimes d. Rarely e. Never
5. Do you find yourself "straining" when you speak because of your voice problem? a. Not at all b. A little bit c. Moderately d. Quite a bit e. Extremely

^aBy Gliklich et al.¹⁵ Reprinted with permission from Elsevier Limited.

lems associated with UVCP (**Table 1**). The first question is global and asks about voice quality, with 5 possible responses. The other questions ask about phonation (items 2 and 5 in Table 1), social functioning (item 3), and swallowing (item 4). Survey items and total scores are normalized on a scale of 0 (worst) to 100 (best) based on published algorithms.¹⁵ The VOS was designed to evaluate patients with UVCP. It was translated into Mandarin Chinese (CVOS) following a standard survey validation process.¹⁴

General Health

The SF-36^{12,13} is a generic quality of life measure with 8 domains of general health, including physical functioning, role functioning—physical problems, bodily pain, general health, vitality, social functioning, role functioning—emotional problems, and mental health. The recall period for the SF-36 is 4 weeks. Scores are tabulated according to published algorithms^{12,13} on a scale of 0 (worst) to 100 (best). The Taiwanese population norms that we used were previously obtained by randomized testing among 4290 Taiwanese adults.^{12,13}

Patient Satisfaction

Modified from the model by Rubin et al,¹⁶ the Patient Satisfaction Survey (PSS) was used to measure the satisfaction levels of patients with UVCP about the following 6 features: overall

Table 2. Origins of Unilateral Vocal Cord Paralysis Among Patients

Origin	No. (%) ^a (n=33)
iatrogenic	
Thyroidectomy	10 (30.3)
Skull base surgery	2 (6.1)
Coronary artery bypass graft surgery	2 (6.1)
Pneumectomy	1 (3.0)
Mediastinoscopy or thoracoscopy	1 (3.0)
Cervical spine surgery	1 (3.0)
Other	1 (3.0)
Idiopathic	7 (21.2)
Benign lung tumor in remission	1 (3.0)
External laryngeal trauma	3 (9.1)
Other	4 (12.1)

^aDue to rounding, percentages do not total 100.

evaluation of surgical experience, perioperative discomfort, postoperative discomfort, professional skill of caregiver, personal manner of hospital staff, and explanation of condition by caregiver. Patients rated each feature on a scale with possible answers of excellent, very good, good, fair, or poor. The PSS is in traditional Chinese format, and its internal consistency has been verified (Cronbach $\alpha > 0.80$).

STATISTICAL ANALYSIS

All data were stored in a database (Access 7.0; Microsoft Corp, Redmond, Washington). Analyses were performed using a statistical software package (STATA; StataCorp LP, College Station, Texas).

Wilcoxon signed rank test was used to compare survey scores (SF-36 and CVOS) and voice acoustic variables at baseline and 12-month follow-up.^{12,13} Kendall W was used to compare voice acoustic variables and CVOS data at 1-, 3-, 6-, and 12-month follow-up. $P < .05$ was considered statistically significant.

RESULTS

STUDY POPULATION

The mean (SD) age among 33 patients with UVCP at study enrollment was 45.9 (16.6) years (age range, 15-78 years); 24 were female (72.7%), and 9 were male (27.3%). The UVCP was left sided in 19 patients (57.6%) and right sided in 14 patients (42.4%); known origins were recurrent laryngeal nerve lesion in 24 patients (72.7%) and vagal nerve lesion in 3 patients (9.1%). All patients were symptomatic, and no vocal cord was in the medial position after surgery. The origins of UVCP are given in **Table 2**. Among the cohort, 13 patients (39.4%) had comorbidity (including 1 patient with benign lung tumor in remission). No vocal cord returned movement at the last postoperative visit.

VOICE QUALITY IMPROVEMENT

Changes in voice laboratory measures among the patients are given in **Table 3**. The mean fundamental frequency and shimmer remained unchanged after surgery. Twelve-month follow-up jitter, harmonic to noise ratio, maximal

Table 3. Postoperative Voice Quality Outcomes

Variable	Value, Mean (SD)				
	Baseline (n=33)	Follow-up, mo			
		1 (n=33)	3 (n=27)	6 (n=23)	12 (n=25)
Fundamental frequency, Hz	194.1 (54.6)	198.7 (47.8)	189.2 (40.7)	186.5 (46.8)	195.1 (36.6)
Jitter, %	2.7 (1.7)	1.7 (1.0) ^a	1.3 (0.7) ^a	1.5 (1.4) ^a	1.2 (0.6) ^{a,b}
Shimmer, dB	1.0 (0.8)	0.7 (0.7)	0.8 (1.2)	1.4 (2.2)	2.3 (2.7)
Harmonic to noise ratio, dB	2.9 (7.5)	10.2 (4.7)	10.9 (4.5)	10.9 (5.7)	11.6 (2.7) ^b
Maximal phonation time, s	5.9 (4.8)	8.6 (4.7)	9.8 (4.3)	10.1 (5.2)	11.2 (3.4) ^b
SZ ratio	2.5 (1.7)	1.7 (1.1)	1.6 (0.9)	1.5 (0.9)	1.4 (0.7) ^b
CVOS total score	46.3 (12.9)	74.6 (10.9)	78.6 (11.7)	82.9 (8.9)	79.1 (11.3) ^b

Abbreviation: CVOS, Chinese (Taiwan) version of the Voice Outcome Survey.

^aSignificantly different among 1-, 3-, 6-, and 12-month follow-up ($P < .05$, Kendall W).

^bSignificantly different between baseline and 12-month follow-up ($P < .05$, Wilcoxon signed rank test).

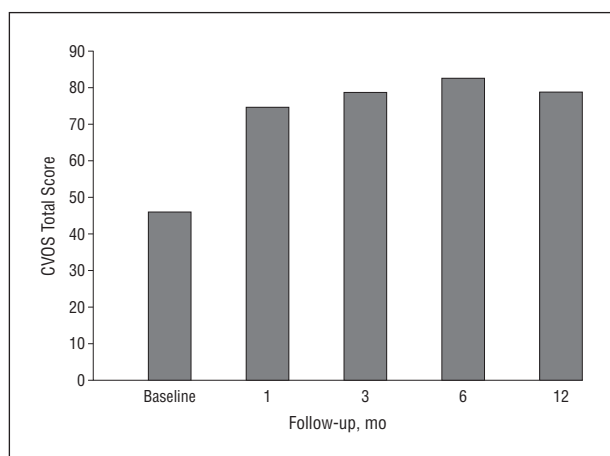


Figure 2. Chinese (Taiwan) version of the Voice Outcome Survey (CVOS) total scores at different follow-up time points after surgery.

phonation time, and SZ ratio variables were significantly superior to those at baseline ($P < .05$). Except for jitter, the surgical effects on voice quality remained stable at 1-, 3-, 6-, and 12-month follow-up ($P > .05$).

UVCP-RELATED SUBJECTIVE OUTCOMES IMPROVEMENT

The mean (SD) CVOS total score improved from 46.3 (12.9) at baseline to 79.1 (11.3) at 12-month follow-up ($P < .05$). Except for item 5 in Table 1 (straining during speech), the surgical effects on voice-related subjective outcomes remained stable at 1-, 3-, 6-, and 12-month follow-up ($P > .05$) (Table 3 and **Figure 2**).

GENERAL HEALTH IMPROVEMENT

The mean preoperative and postoperative SF-36 subscale scores among the study patients are listed in **Table 4**, along with age- and sex-adjusted general Taiwanese population norms. Compared with population norms, the patients had significantly lower scores on all 8 SF-36 subscales before surgery ($P < .05$). Except for physical functioning, general health dimensions had significantly improved 12 months after surgery. Physical

functioning and role functioning—physical problems scores remained inferior to population norms.

PATIENT SATISFACTION

Cronbach α for the PSS is 0.95, indicating good internal consistency. The survey return rate was 81.8% (27 of 33). The PSS results showed that most patients were satisfied with their surgery, with the distribution of satisfaction levels being skewed to the left (**Table 5**). Overall, 88.9% (24 of 27) of patients rated their experience as excellent, very good, or good. Professional skill of caregiver and personal manner of hospital staff received the highest ratings. Perioperative discomfort and postoperative discomfort were minor. There were no poor ratings.

COMMENT

Unilateral vocal cord paralysis comprises a wide variety of diseases ranging from viral infection to direct trauma from surgery. In Taiwan, the most frequent cause of UVCP is complicated thyroidectomy.¹⁷ Unilateral vocal cord paralysis may lead to glottic insufficiency, significantly compromising vocal ability and breath control.¹⁸ Patients with UVCP may also report breathy dysphonia, aspiration when drinking or eating, or ineffective cough.¹⁹ Fang et al¹ and Schneider et al²⁰ found that UVCP significantly affects a patient's quality of life, as seen by profound impairments in all general health dimensions and in voice-related outcomes. It is generally agreed that UVCP can significantly affect a patient's general health status by compromising phonation, swallowing, and social functioning. Aside from conventional voice acoustic analysis, subjective quality of life assessment is important in reporting UVCP outcomes.^{14,15,19}

Different therapy regimens have been developed to treat UVCP, with variable reported effectiveness; these include speech and swallowing rehabilitation, type 1 medialization thyroplasty,²⁰ and fat injection augmentation laryngoplasty. Laccourreye et al²¹ reported a 90% success rate in swallowing rehabilitation, as well as significant improvement in selected speech and voice vari-

Table 4. Preoperative and Postoperative Subscale Scores and Population Norms on the Taiwan Version of the 36-Item Short Form Health Survey

Subscale	Subscale Score, Mean (SD)			
	Population Norm (n=4290)	Study Cohort		
		Preoperative (n=33) ^a	Postoperative (n=27)	Change ^b
Physical functioning	90.2 (17.4)	73.0 (23.9)	80.7 (22.3) ^a	7.6 (23.9)
Role functioning—physical problems	80.2 (36.2)	38.1 (39.0)	65.0 (36.2) ^a	29.7 (38.5)
Bodily pain	80.2 (21.6)	62.2 (25.8)	79.9 (17.7)	19.7 (19.7)
Vitality	66.5 (19.4)	46.7 (15.1)	62.5 (12.8)	18.3 (17.0)
Role functioning—emotional problems	78.3 (37.3)	52.5 (41.7)	75.6 (30.6)	20.5 (45.3)
Social functioning	86.1 (17.4)	50.0 (25.6)	81.3 (17.0)	29.8 (28.9)
General health	67.5 (22.8)	44.2 (18.4)	58.7 (19.0)	17.2 (18.4)
Mental health	72.3 (17.1)	57.2 (14.6)	68.6 (15.8)	13.5 (18.5)

^aSignificantly different compared with population norm ($P < .05$, Wilcoxon signed rank test).

^bExcept for physical functioning, significantly different between preoperative and postoperative ($P < .05$, Wilcoxon signed rank test). Calculated as postoperative minus preoperative value.

Table 5. Patient Satisfaction at 3 Months After Surgery

Satisfaction Feature	No. (%) ^a (n=27)				
	Excellent	Very Good	Good	Fair	Poor
Overall evaluation of surgical experience	8 (29.6)	6 (22.2)	10 (37.0)	3 (11.1)	0
Perioperative discomfort	6 (22.2)	6 (22.2)	9 (33.3)	6 (22.2)	0
Postoperative discomfort	6 (22.2)	7 (25.9)	9 (33.3)	5 (18.5)	0
Professional skill of caregiver	12 (44.4)	5 (18.5)	8 (29.6)	2 (7.4)	0
Personal manner of hospital staff	12 (44.4)	4 (14.8)	9 (33.3)	2 (7.4)	0
Explanation of condition by caregiver	9 (33.3)	6 (22.2)	11 (40.7)	1 (3.7)	0

^aDue to rounding, percentages do not total 100.

ables. Similar findings were noted by Umeno et al³ and by Shaw et al,⁴ with preparalytic levels restored to voice acoustic outcomes, including harmonics to noise ratio, peak prominence, long-term average spectrum, and phonation, pitch perturbation, and amplitude perturbation quotients. However, the failure rate of initial treatment may reach 30% to 45% at 2 to 4 years.⁹ The present study shows that acoustic variables, including respiratory control (maximal phonation time and SZ ratio) and voice quality (harmonic to noise ratio) (Table 3), as well as voice-related subjective outcomes (CVOS total score [Table 3 and Figure 2]), can reach optimal levels as early as 1 month after surgery. The effects then stabilize and can be sustained to 12 months after surgery (there was little change in these variables at 3-month, 6-month, and 1-year follow-up [$P > .05$, Kendall W]). In contrast, jitter and straining during speech (item 5 in Table 1) continue to improve to 12-month follow-up (Table 3 and Figure 2). Initial overcorrection of a paralyzed vocal cord may disturb the vocal fold vibration and result in a strained unstable voice. Continuing improvement is attributed to modest degradation of the injected fat. In a previous study,²² one-third of the initially injected fat was retained after 12 months; however, intracordal fat injection augmentation did not alter fundamental frequency or shimmer of the voice. Although results of a previous study¹ suggested that intensity control (shimmer) is an important voice outcomes predictor, the small sample size

and large measurement variation (mean [SD], 2.3 [2.7] dB [Table 3]) in the present study failed to demonstrate improvement in shimmer at 12 months.

It is well known that dysphonia influences not only physical health but also social communication and self-confidence.¹⁹ The effects of various voice problems on quality of life have been discussed in the literature.^{19,23,24} However, few investigations focused specifically on UVCP. Previous studies^{19,23,25} among patients with dysphonia revealed that this mild voice disorder can seriously disturb quality of life. In the present study, profound effects were observed in almost all dimensions of general health at baseline for this study cohort with UVCP. Fat injection laryngoplasty improved the quality of life among these patients, as seen by a return to almost normative levels of SF-36 subscale scores. Physical functioning and role functioning—physical problems dimensions of health remained inferior to population norms at 12 months after surgery. Further study is needed to explore possible contributing factors (such as poor pulmonary or cardiac function), especially among patients who have fully recovered from their original benign lesions.

In conclusion, UVCP can compromise phonation, swallowing, and social functioning, significantly affecting a patient's general health. In this study, we show that fat injection laryngoplasty is a feasible treatment to improve not only voice but also quality of life outcomes. Patients are generally satisfied with their surgical expe-

rience. Optimal outcomes can be achieved as early as 1 month after surgery and may be sustained to 12 months. Pitch perturbation and straining during speech continue to improve to 12 months after surgery.

Submitted for Publication: June 8, 2009; final revision received November 16, 2009; accepted January 1, 2010. **Correspondence:** Pa-Chun Wang, MD, MSc, Department of Otolaryngology, Cathay General Hospital, 280 Jen-Ai Rd, Section 4, Taipei, Taiwan 106 (drtony@tpts4.seed.net.tw).

Author Contributions: Dr Fang had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Fang, Li, Wang, and Chuang. *Acquisition of data:* Fang, Li, and Gliklich. *Analysis and interpretation of data:* Chen. *Drafting of the manuscript:* Fang, Chen, and Wang. *Critical revision of the manuscript for important intellectual content:* Fang, Li, Gliklich, and Chuang. *Obtained funding:* Fang. *Administrative, technical, and material support:* Fang, Li, Gliklich, Chen, Wang, and Chuang. **Financial Disclosure:** None reported.

Additional Information: Permission to use the Voice Outcome Survey may be obtained from the authors or from Outcome Sciences Inc, Cambridge, Massachusetts.

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