Original Article

Voice Improvement after Medialization Thyroplasty in Unilateral Vocal Fold Paralysis

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Objective: To evaluate both subjective and objective voice changes after medialization thyroplasty in patients with unilateral vocal fold paralysis, and to assess the time to achieve maximum voice improvement after surgery.

Materials and Methods: Nineteen patients with unilateral vocal fold paralysis and undergoing medialization thyroplasty were recruited from May 2006 to December 2008. Voice recordings were performed before surgery and at 2, 4 and 6 months after surgery. Acoustic analysis (fundamental frequency, highest fundamental frequency, lower fundamental frequency, noise-to-harmonic ratio, and percent of jitter and shimmer) was calculated using the Multidimensional Voice Program. Maximum phonation time, perceptual evaluation, and a self-assessment visual analogue scale were also conducted. Data for the preoperative and three postoperative periods were compared.

Results: Jitter, shimmer, noise-to-harmonic ratio, and maximum phonation time showed significant improvements after medialization thyroplasty, and maximum improvement was found at the second postoperative month, with no significant change among the three postoperative periods. Subjective voice quality and loudness showed maximum improvement at the fourth and sixth months, respectively. Patients' self-assessment by visual analogue scale showed maximum improvement at the fourth postoperative, with up to 80% of their normal voice.

Conclusion: All objective measurements revealed maximum voice improvement at the second month after medialization thyroplasty, with marginal improvement thereafter. The subjective measurements demonstrated an improvement up to 80% of normal voice after surgery.

Keywords: Medialization thyroplasty, Laryngoplasty, Vocal fold paralysis, Voice, Acoustic analysis, Aerodynamic analysis

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Unilateral vocal fold paralysis (UVFP) is not uncommon in clinical practice, but its incidence has not been established. The common cause is recurrent laryngeal nerve injury from thyroid, cervical vertebrae or cardiothoracic surgeries, followed by thyroid, neck and mediastinal tumors. Approximately 20% of cases occur without identifiable cause. UVFP can cause glottic incompetence, resulting in various degrees of impairment of voice quality, aspiration and loss of auto-positive end expiratory pressure (dynamic laryngeal valve)[1,2]. However, dysphonia is the most common complaint. Treatment of UVFP is designed to improve the voice quality and eliminate aspiration[3]. Selection of the appropriate management depends on multiple factors, such as the potential for recovery, duration of symptoms, degree of impairment, presence of anatomic or surgical defects, patient's overall condition, and life expectancy. The most important consideration is the patients' need for voice improvement to comply with their occupational or social functions[3]. The mainstay of treatment is medialization procedures, including injection laryngoplasty and laryngeal framework surgery. The advantages and disadvantages of each technique were summarized in another study[4]. Surgical management of UVFP was first introduced in 1911 by Bruening[5], who injected paraffin into the paraglottic space. Since then, several materials have been injected to medialize the vocal fold, including teflon, gelfoam, fat, collagen, hydroxyapatite, and recently carboxymethylcellulose.

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Since its innovation by Isshiki et al[6] in 1974, medialization thyroplasty (thyroplasty type I) has become a popular technique for the management of glottic incompetence secondary to UVFP. The objective of this procedure is to improve voice quality by indirectly changing the position, tension and volume of the affected vocal fold[6]. This surgery has evolved over time and been modified by others[4].

Many studies have demonstrated significant improvements in the perceptual vocal characteristics and objective measures of the vocal function after surgery[4, 7-14]. However, to the best of our knowledge, the present study is the first in Thailand. The purposes of the present study are to evaluate the subjective and objective voice changes after medialization thyroplasty in UVFP patients, and to assess the time to develop maximum voice improvement after surgery.

Materials and Methods

The present study was carried out according to the Declaration of Helsinki. The Institutional Review Board approved the protocol (No. 173/2550). Informed consent was obtained from each subject to use their voice data. Patients with UVFP of different etiologies who visited the Department of Otorhinolaryngology, Faculty of Medicine Siriraj Hospital, from May 2006 to December 2008 were consecutively recruited. Medialization thyroplasty was performed if: 1) a recurrent laryngeal nerve was known to be sacrificed during surgery; 2) thyroarytenoid electromyography showed denervation; 3) there were no signs of recovery at least 6 months after injury; 4) there were severe aspiration, and 5) the patient desired voice improvement. Patients selecting medialization thyroplasty as their treatment were eligible for inclusion in the present study: however, patients who had previously undergone permanent injection laryngoplasty (such as teflon) or medialization thyroplasty were excluded.

Surgical technique

Medialization thyroplasty was performed by the same surgeon (Chongkolwatana C), using Netterville's technique[8] under local anesthesia with intravenous sedation. After topical nasal anesthesia, a flexible fiberoptic scope was placed in the hypopharynx and attached to a video monitor. Once the thyroid cartilage was identified, a window of approximately 5 x 12 mm in males and 4 x 10 mm in females was outlined, with the upper border along the line midway between the thyroid notch and the inferior border of the thyroid cartilage. The window was usually positioned close to the lower border of the thyroid cartilage, leaving an inferior cartilage strut strong enough to prevent fracture during the implant placement (2 – 3 mm). Depending on the thyroid cartilage angle, the anterior border of the window was placed 5 mm back from the midline in males, and 7 mm in females. The entire cartilage island was removed from the outlined window with a scalpel and, if calcified, a small otologic bur, leaving the inner perichondrium intact. The perichondrium was then incised at the superior, inferior, and posterior margins of the window, taking care not to pass into the laryngeal ventricle or the thyroarytenoid muscle. An elevator was used to gently separate the thyroarytenoid muscle and its overlying fascia from the inner perichondrium and push it aside medially.

The patient was then asked to phonate the vowel sound "/i/" or a short sentence, and the larynx was viewed on a video monitor to evaluate the glottal closure. This step enabled the surgeon to determine the relation of the window to the level of the true and false cords, and the location and degree of optimal medialization necessary. The shape of the implant was then carved from a silicone block and customized for each patient. The prosthesis was cut into anterior and posterior parts. The posterior half was inserted first, followed by the anterior half, which locked itself into position. The final position of the implant medialized the vocal process without contacting the muscular process of the arytenoids. The implant was removed and adjusted appropriately until a good voice quality was achieved.

The wound was closed in layers, with a Penrose drain left in place for 24 hours and the patients kept on absolute voice rest for 5 – 7 days. No perioperative antibiotic was used, except in cases of a prolonged and difficult operation or an immunocompromised patient.

Data collection

Voice recordings were performed before surgery and at 2, 4 and 6 months after surgery in a sound-proof room. The mouth-to-microphone distance was constant at 5 cm.

Acoustic analysis

Acoustic analysis was performed using the Computer Speech Lab (Model 4300, Kay Elemetrics Corporation, Lincoln Park, NJ, USA). A sustained vowel /a/ at habitual pitch and loudness was examined. The fundamental frequency (F_0), highest fundamental frequency (Fhi), lowest fundamental frequency (Flo),

noise-to-harmonic ratio (NHR), and percent of jitter (jitt%) and shimmer (shim%), were calculated using the Multidimensional Voice Program (MDVP).

Aerodynamic analysis

The maximum phonation time (MPT) in second was used as the aerodynamic parameter and derived while patients sustained a vowel sound /a/ at a comfortable pitch and loudness, and for as long as possible, after deep inspiration. The MPT was calculated using the Real Time Pitch Program. The longest phonation in three trials was recorded.

Perceptual evaluation

Patients read a phonetically balanced passage. The voice quality, pitch and loudness were evaluated independently by two highly experienced, speech-language pathologists using a similar protocol. A 4-point Likert scale was used to rate the severity of voice disturbance, where 0 represented "normal" voice and 1 – 3 represented "mild", "moderate" and "severe", respectively. The data were derived from the mean scores of both evaluators.

Subjective self-assessment by patients

A visual analog scale (VAS) was completed by patients to evaluate their own voice, with a ranking from one to ten (one is aphonic, and ten is normal voice).

Statistical analysis

All data were analyzed by using SPSS for Windows, Version 16.0 (SPSS Inc., Chicago, Ill., USA). Student's t-test and Wilcoxon signed-rank test were used to compare the parametric and non-parametric data, respectively. Any variables with a p-value less than 0.05 were considered statistically significant.

Results

The 19 patients comprised 6 male and 13 female patients, with a mean age of 51.7 ± 16.6 years (range: 19 – 80 years). The etiology of UVFP was iatrogenic (57.8%), neoplasm (21.1%), and idiopathic (21.1%). Fourteen patients (73.7%) had left UVFP, and the remaining (26.3%) had right UVFP. No airway obstruction, wound infection or implant extrusion occurred in the present study.

Acoustic analysis

Jitter, shimmer and NHR significantly reduced after surgery, and maximum voice improvement was developed at the second month after surgery, with no significant change for the two other postoperative periods (Table 1). In contrast, the fundamental frequency had no statistical significance between the preoperative and postoperative data.

Aerodynamic analysis

MPT significantly increased after surgery, with the maximum improvement at the second postoperative month. MPT appeared to increase marginally between the second and fourth postoperative months, but no statistically significant difference was found beyond the second month (Table 1).

Perceptual evaluation

Perceptually, the voice quality improved significantly after surgery. The preoperative rating of voice quality dropped from 1.95 (moderate disorder) to 1.05, 0.84 and 0.66 at the second, fourth and sixth postoperative months, respectively (Table 2). In addition, statistical improvement of loudness was found after surgery, with the maximum improvement at 6 months postoperatively. In contrast, no significant change in pitch was demonstrated from the preoperative to the postoperative periods.

Table 1. Objective voice measures (mean±standard deviation) before and after medialization thyroplasty.

	Pre-operation	2 months post-operation	4 months post-operation	6 months post-operation
F_0 (Hz)				
• Male	135.60±49.60	152.80±22.80	150.30±24.50	150.10±18.90
• Female	206.40±46.80	200.70±33.90	213.90±46.90	202.20±42.20
Jitt (%)	4.30±3.70	1.80±0.90*	1.80±1.00	2.00±1.30
Shim (%)	8.10±6.30	4.00±1.60*	3.70±1.70	4.50±1.80
NHR	0.20±0.10	0.14±0.03*	0.13±0.03	0.14±0.05
MPT (sec)	7.90±3.70	14.00±6.30*	14.20±6.60	14.20±7.20

*P-value less than 0.05 compared to preoperative data
F_0, fundamental frequency; Jitt, jitter; Shim, shimmer; NHR, noise-to-harmonic ratio; MPT, maximum phonation time

Table 2. Perceptual evaluation (mean±standard deviation) before and after medialization thyroplasty

	Pre-operation	2 months post-operation	4 months post-operation	6 months post-operation
Speech pathologist				
• Voice quality	1.95±0.50	1.05±0.57*	0.84±0.47**	0.66±0.55
• Pitch	0.92±0.63	0.79±0.67	0.74±0.60	0.53±0.44
• Loudness	1.24±0.67	0.74±0.63*	0.53±0.49**	0.24±0.20***

**P*-value less than 0.05 compared to preoperative data
***P*-value less than 0.05 compared to 2nd month
****P*-value less than 0.05 compared to 4th month

Subjective self-evaluation by patients

The mean VAS was 3.7, 7.2, 7.8 and 8.1 preoperative and at the second, fourth and sixth months, postoperative, respectively (Figure 1). A significant statistical improvement was found from the preoperative to the postoperative period. VAS developed maximum improvement at the fourth month, with no significant change between postoperative months 4 and 6 (Table 2). However, no patient assigned a full score (normal voice) postoperatively.

About 10% of the patients had complained about communication via telephone before surgery, but all reported significant improvement after surgery. Seven out of nineteen patients (36.8%) had some degree of aspiration, although none required nasogastric tube feedings. Of those 7, 4 had no more aspiration after the operation, while 3 still had liquid aspiration, which was much improved.

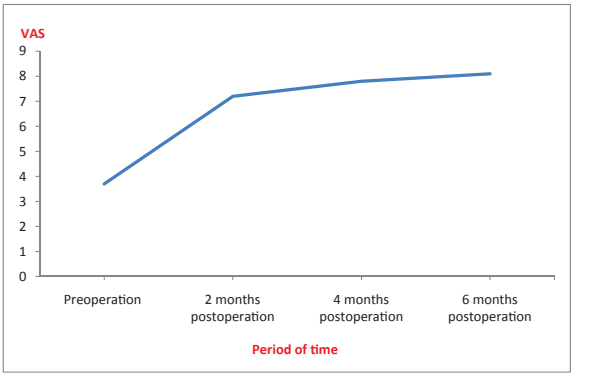

Figure 1. Subjective self-evaluation by patients before and after medialization thyroplasty.

Discussion

Improvement of voice parameters, comprising jitter, shimmer, NHR and MPT, reached a plateau at the second month postoperative. Although some parameters appeared to improve marginally from 2 to 4 months after surgery, no statistically significant difference was found between the three follow-up periods.

The authors noted that there were only slight voice improvements after the second month. Patient's adaptation might have played a role in this improvement. All voice measurements might have developed their maximum improvement earlier than 2 months or even at the first month, postoperatively. This would be consistent with Lundy et al.[15] reported significant improvement of the voice outcomes from the preoperative to the postoperative assessments, and all voice parameters had stabilized at 1-month postoperatively, without any significant change at 1-year postoperatively (range: 12 – 60 months). Due to the expense and geographic distances involved, the authors did not follow up the patients at 1 month.

Billante, et al[10] reported the acoustic and aerodynamic measures of voice had improved 3 months after surgery, with some parameters (jitter, shimmer, intensity, and airflow rate) further improved at 1 year. From the study of Schindler et al[16], significant improvements of voice quality (acoustic, aerodynamic) in patients with UVFP had been achieved through voice therapy. Hence, voice therapy may play a role in these different results. The fluctuations of jitter, shimmer and NHR in the present study may fall within the range of intrasubject variability with no statistical significance.

The fundamental frequency changes observed after the operations had varied in multiple previous studies. The frequency changes increased in the study of Sridhara et al[13] and Sasaki et al[17], but remained constant in studies by others[7,9,14]. In contrast, the frequency decreased in the study by Billante et al[10], who explained that once glottal contact had been restored, a patient had no further benefit from compensation with a higher-pitched voice (compensatory falsetto), resulted in decreasing voice pitch. From the authors' observation, Thai patients using Thai tonal language rarely use compensatory falsetto. These inconsistencies may therefore vary among different cultures and/or

languages. Another reason might relate to differences in the technical manner in which the voice was used to calculate fundamental frequency (conversation or prolonged vowel) and the duration of the voice segment used for analysis (range: 1000 – 3000 milliseconds).

Perceptually, both voice quality and loudness continued statistically significant improvements up to 6 months after surgery. This correlated with the VAS that scores showed increase degree of satisfaction during the 6 months postoperative. The postoperative pitch did not change compare to the preoperative data, probably the reasons were similar to the variations in fundamental frequency changes described earlier. The postoperative VAS ranged from 7.2 – 8.1. Patient satisfaction with their own voice is a primary goal of the medialization procedure, and should be considered the most important outcome. The results can be used for preoperative counselling to explain to patients that their voice can be expected to return to 70% – 80% of their original voice.

Acoustic and aerodynamic measurements of voice quality did not significantly improve over the 6-month postoperative period. Patients' adaptation may be the cause of inconsistency between the subjective and objective measurements.

From the present study, all subjective and objective measurement improved significantly after medialization thyroplasty. However, all parameters were still outside the normal range (as only normative data of MPT exists in Thai people, the authors used Taiwanese data because of the ethnic proximity)[18,19]. The probable reason is that medialization thyroplasty cannot correct the fine-tuning control of the intrinsic laryngeal muscles.

Although the effects of medialization thyroplasty on aspiration in UVFP patients was not the main purpose of the present study, but the data showed improvement in aspiration in most patients after the surgery. From the study by Pou et al[20], 96% of their aspirated patients benefited from medialization thyroplasty.

Conclusion

The results of the present study showed significant voice improvement consistent with other thyroplasty studies. All objective measurements revealed the maximum voice improvement at the second month after medialization thyroplasty, with marginal improvement thereafter. Subjective measurements demonstrated that the improvement varied from four to six months after surgery. However, no voice outcomes returned to normal range.

What is already know on this topic?

Medialization thyroplasty is a common procedure to correct glottic incompetence permanently in UVFP patients. Although overall improvement has been found in several studies, the outcome of some parameters and the time to develop maximum improvement differ from study to study due to variations in the surgical techniques.

What this study adds?

This is the first Thai study to evaluate voice outcomes after medialization thyroplasty in UVFP patients. ENT physicians who operate with this technique can use the results during preoperative counselling to help patients set realistic expectations.

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Potential conflicts of interest

The authors declare no conflicts of interest.

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