Application of Pitch Range Evaluation Subsequent to Arytenoid Adduction and Thyroplasty

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Summary: Objective. The purpose of this study was to figure out the application of pitch range (PR) evaluation subsequent to arytenoid adduction (AA) combined with type 1 thyroplasty (TP1) in unilateral vocal fold paralysis (UVFP).
Study Design. Retrospective review of clinical records.
Methods. Subjects were 50 patients with UVFP for whom PR and maximum phonation time (MPT) could be evaluated before and 1 year after AA + TP1. Subjects were divided into two groups based on preoperative PR (pre-PR) (group 1: $\leq$1 semitone (ST); group 2: $\geq$2 ST). Correlations among pre-PR and post-PR, MPT, and age were assessed. We also evaluated PRs in subjects with PR deterioration and PRs by causative diseases.
Results. PR was significantly extended from a median of 17.0–22.0 ST in all subjects. Pre-PR was correlated with post-PR. Post-PR correlated with post-MPT in group 2 but not in group 1. There was no correlation between post-PR and age or causative diseases. The mean change in PR among subjects with PR deterioration (28.0%, 14/50) was −3.6 ST. Pre-PR and the improvement of post-PR were negatively correlated in group 2.
Conclusion. PR evaluation can be useful for predicting post-PR. The effects of age and causative diseases were small compared with other factors, such as pre-PR width and surgical effects. The successful surgery may improve both PR and MPT. However, several cases showed obvious discrepancy of those postoperative improvements. It will be necessary to assess this discrepancy, particularly in subjects with postoperative voice insufficiency.
Key Words: Vocal fold paralysis–Arytenoid adduction–Thyroplasty–Pitch range–Voice therapy.

INTRODUCTION

The introduction of arytenoid adduction (AA) and type 1 thyroplasty (TP1) has improved surgical outcomes for unilateral vocal fold paralysis (UVFP).[1] These procedures dramatically improve voice impairment, as well as voice parameters such as maximum phonation time (MPT).[2,3] Novel procedures, such as the fenestration approach,[3] nerve muscle pedicle flap implantation, and ansa cervicalis transfer, are an active subject of discussion.[4,5]

Notwithstanding the above, there remain patients who are not fully satisfied with their postoperative voice quality. Despite improvements in MPT, some patients suffer from a narrow pitch range (PR) and/or abnormal speech fundamental frequency (SFF). Several voice parameters have been used to evaluate the outcome of phonosurgery, such as perceptual voice quality, objective measurements of aerodynamic and acoustic parameters involving MPT, mean flow rate (MFR), Jitter%, and Shimmer%. Although some studies have reported the use of PR as the outcome of surgery,[6–10] only a few studies have described the details and features of PR after phonosurgery.[11] Thus, the significance of preoperative and postoperative PR evaluations is unclear.

PR is an important factor associated with intonation and expression in daily talking and singing. Moreover, the assessment of PR might provide an integrated view into total vocal function, given that other parameters can only address the quality of one tone. Factors that affect PR are diverse and intertwined, adding to the difficulty of understanding what PR is actually indicating. In this study, we assessed the correlation between PR and MPT, characteristics of subjects with PR deterioration, and differences in PR and MPT based on age and causative diseases, before and after performing AA combined with TP1 in individuals with UVFP. We aimed to determine factors that influence changes in PR and establish the use of PR evaluation for predicting the outcome of phonosurgery.

MATERIALS AND METHODS

Subjects

Fifty subjects (36 men and 14 women) were investigated from all 56 patients with UVFP who visited the Department of Otolaryngology at the International University of Health and Welfare Mita Hospital. All 56 patients were underwent conservative treatment and pre- and postoperative voice rehabilitation,[12,13] underwent AA and TP1 concurrently. Only 50 patients could be evaluated for PR preoperatively and for about 1 year postoperatively. Because the main purpose of this research was describing how PRs were changed in each patient after the same treatment, there is no control group.

The mean age was 59.5 ± 12.6 (mean ± standard deviation [SD]) years (range, 29–79 years). Vocal paralysis was on the left side in 37 subjects and on the right in 13. Causative diseases of UVFP included aortic aneurysm (n = 15), parapharyngeal tumor (n = 8), thyroid tumor (n = 8), esophageal cancer (n = 6), lung and thoracic tumor (n = 4), idiopathic etiology (n = 4), and others (n = 5).

Surgical procedures

Regarding to our procedure of AA, two nylon threads were sutured on the muscular process of the arytenoid cartilage without

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disengaging the cricothyroid joint.[1] When suturing proved difficult, a posterior thyroplasty window was prepared (Maragos' window).[14] One thread was pulled toward the lateral cricoarytenoid muscle and the other was pulled toward the TP1 window. After these threads were fixed to the thyroid cartilage, GORE-TEX was inserted into the TP1 window. Because surgery was performed under neuroleptic anesthesia without intubation,[15] the status of the voice could be monitored by phonation. And also, the condition of the vocal fold was observed microscopically during surgery.

Measurement of voice parameters

PR, SFF, perceptual voice quality, MPT, MFR, Jitter%, and Shimmer% were measured and evaluated. To ensure precise measurements, the parameters were measured by specialists, specified speech therapists, and graduates of a university of music. However, those were not double blinded. MFR was measured by Phonatory function Analyzer PS-77E (NAGASHIMA MEDICAL INSTRUMENTS CO., LTD., Tokyo, Japan) and Jitter%, and Shimmer% were assessed by CSL MODEL4500 (RION Co., Ltd.). PR and SFF were measured by semiobjective way with a keyboard and pitch meter, without using a mouthpiece. PR measurements began with the relaxed phonation of the vowel /a/, followed by moving into the upper register. After measuring the highest pitch, the lowest pitch was recorded. SFF was also measured in vowel /a/.

Preoperative evaluation was performed at least 6 months after having UVFP (12 months after idiopathic UVFP) when the paralysis was seemed to be completed. About the postoperative measurement, our routine evaluations were performed after surgery, 1 month later, and every few months thereafter. To avoid too much complication, we used the only value at around 1 year after the operation. Regarding the baseline of PR, which is PR before having UVFP, we could not evaluate their baseline PRs in this research.

Assessment of voice parameters

Comparison of ordinary voice parameters. MPT, MFR, Jitter%, and Shimmer% were used to evaluate surgical outcome.

Assessment of PR. Many subjects with UVFP intrinsically had preoperative PRs (pre-PRs) of less than 1 semitone (ST), and it was difficult to distinguish between voice and voiceless sounds. Thus, the population of pre-PRs showed bimodality. To compare the width of pre-PR with post-PR and SFF, these subjects were divided into two groups. The 13 subjects (mean age, 59.6 years; range, 46–79 years; 12 men and 1 woman) with a pre-PR of 1 ST and lower were assigned to group 1. The 37 subjects (mean age, 58.3 years; range, 29–79 years; 24 men and 13 women) with a pre-PR of more than 2 ST were assigned to group 2 (pre-PRs in group 2 were all $\geq$7 ST in this study). In group 1, voiceless sounds or extremely narrow PRs ($\leq$1 ST) were assumed to be 1 ST. Postoperative changes in PR and SFF were only assessed in group 2.

PR and MPT changes

Correlations between PR and MPT before and after surgery were evaluated to compare how PR and MPT reflect glottic closure in all subjects (group 1 + group 2), group 1, and group 2. The following were evaluated: post-PR versus pre-PR, pre-MPT, post-MPT, and subject age.

Differences between post-PR and MPT by causative diseases

Differences in post-PR, post-MPT, and subject age were assessed in the following four groups: (1) subjects with a suspicion of recurrent nerve paralysis (RNP) (25 subjects with thoracic aortic aneurysms, lung and thoracic tumors, or esophageal tumors); (2) subjects with vagus nerve paralysis (eight subjects with parapharyngeal tumors); (3) subjects with thyroid tumors (eight subjects); and (4) subjects with idiopathic etiology (four subjects). Mean PR and MPT of subjects with RNP were compared with the other groups using the *t* test.

Assessment of subjects with PR deterioration

Cases in group 2 for which PR narrowed postoperatively were assessed. Improved or deteriorated PR (post-PR − pre-PR, unit; ST) was evaluated, and the improvement (or deterioration) rate of PR ((post-PR − pre-PR)/pre-PR, unit; %) was also used to confirm the differences based on individual primary vocal function.

Statistical analysis

Because pre-PR in all cases was consisted of group 1 ($\leq$1 ST) and group 2 ($\geq$7 ST), the Wilcoxon signed rank test and Spearman's rank correlation coefficient were used. The *t* test and Pearson correlation coefficient were used for other analyses. Statistical analyses were performed with *SPSS* software.

RESULTS

Ordinary voice parameters

Table 1 shows postoperative changes in ordinary voice parameters. Mean MPT increased from 4.7 to 15.4 seconds, mean MFR decreased from 742.9 to 237.4 mL/s, Jitter% decreased from 7.21 to 2.08%, and mean Shimmer% decreased from 12.48 to

TABLE 1.
Preoperative and Postoperative Changes in Ordinary Voice Parameters (*t* Test, Mean ± SD)

	Number of Subjects	Preoperative	Postoperative	*P* Value (*t* Test)
MPT (s)	50	4.7 ± 2.3	15.4 ± 7.2	<0.001
MFR (mL/s)	36	742.9 ± 447.5	237.4 ± 107.9	<0.001
Jitter%	29	7.21 ± 5.35	2.08 ± 2.24	<0.001
Shimmer%	29	12.48 ± 7.97	5.68 ± 6.39	<0.001