

Sex Differences in Pitch Range and Speech Fundamental Frequency After Arytenoid Adduction and Thyroplasty

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Summary: Objective. The purpose of this study was to clarify the sex differences in pitch range (PR) and speech fundamental frequency (SFF) after arytenoid adduction (AA) combined with type 1 thyroplasty (TP1) in patients with unilateral vocal fold paralysis (UVFP) and to assess the cause of these differences.

Study Design. This is a retrospective review of clinical records.

Methods. The records of 50 patients with UVFP for whom PR, SFF, and maximum phonation time (MPT) had been evaluated before and 1 year after AA combined with TP1 were analyzed. Patients consisted of 36 men and 14 women. In particular, in the 37 patients (24 men and 13 women) who had ≥ 2 semitones (STs) in preoperative PR (pre-PR), the differences and correlations between the pre-PR and the postoperative PR (post-PR), SFF, and MPT were compared between the sexes. We also discussed cases of post-PR deterioration and abnormal SFF.

Results. The characteristics of PR in men are narrow pre-PR (14.7 ± 11.5 STs) and significant extension of post-PR (22.6 ± 6.3 STs). MPT extended from 4.6 ± 2.5 seconds to 14.8 ± 7.2 seconds. In contrast, women had a wide pre-PR (18.1 ± 7.2 STs) and showed no significant post-PR extension (21.7 ± 7.8 STs). MPT extended from 5.1 ± 1.9 seconds to 16.8 ± 7.2 seconds. Although there were no significant changes in average SFF, as well as the highest and lowest pitch after the operation, the variance of the pre-SFF tended to converge into the physiological range in the post-SFF ($P = 0.08$).

Compared with the SFF data of normal adult controls, post-SFF in the normal range was 46.0% (23/50). In patients who showed a $>20\%$ improvement in PR, normal post-SFF appeared in 68.8% of the patients (11/16). Particularly in those women, 83.3% (5/6) showed a normal post-SFF. Men showed greater difficulty in recovery of normal PR, SFF, and MPT; however, there were fewer patients (4.2%; 1/24) with a PR deterioration of $>20\%$. Regarding women, although some patients showed a parallel recovery in PR and SFF to the normal range, there was a high rate of patients showing PR deterioration (30.8%; 4/13).

Conclusions. AA combined with TP1 resulted in the recovery of not only MPT but also PR and SFF. In addition, sex differences in operative effects were suggested. In men, although MPT is difficult to be fully recovered, PR deterioration was mild. In women, although MPT was more easily extended, PR deterioration occurred more readily because of operative effects such as hypermedialization of their smaller larynx. The post-PR variation appeared to be associated with SFF. Our results indicate the necessity to assess patients' PR and SFF even if their MPTs recover, particularly in patients with postoperative voice insufficiency.

Key Words: Vocal fold paralysis–Arytenoid adduction–Thyroplasty–Sex difference–Pitch range–Speech fundamental frequency–Maximum phonation time–Voice therapy.

INTRODUCTION

Arytenoid adduction (AA) combined with type 1 thyroplasty (TP1) can significantly improve a patient's hoarseness caused by unilateral vocal fold paralysis (UVFP).¹⁻³ However, although previous studies demonstrated that surgery improved maximum phonation time (MPT) in almost all patients, difficulties with real phonation and conversation still remained in some patients, even a few months after the operation. Therefore, we considered that evaluation of pitch range (PR)

and speech fundamental frequency (SFF) in addition to MPT is important to improve postoperative voice quality. To our knowledge, relatively few studies have analyzed PR as a post-AA parameter,⁴⁻⁸ and very few studies have focused on PR variation^{9,10} or sex differences¹¹ in any kind of thyroplasty. There have also been no reports that assessed the sex differences in not only PR but also SFF. We previously reported¹² a PR change in patients with UVFP after AA combined with TP1 and confirmed that postoperative PR (post-PR) improved in parallel with post-MPT recovery resulting from improvement of the glottic closure. Particularly in patients with a relatively narrow pre-PR, the higher part of the PR was extended after surgery. On the other hand, some patients showed a separation between PR and MPT improvement, with a deterioration of their post-PR. Therefore, we considered that further detailed assessment is required toward understanding the reason for such variations of post-PR.

In this study, we focused on the sex differences in the characteristics of pre-PR and post-PR. The larynx is anatomically different in the two sexes, and furthermore, the physiological values of voice parameters are also different. The postoperative

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change in SFF was also evaluated in each sex because abnormal preoperative SFFs recovered to the normal range after surgery in some clinical cases.

MATERIALS AND METHODS

Subjects

Fifty patients (36 men and 14 women) with UVFP whose PR, SFF, and MPT were evaluated at the Department of Otolaryngology at the International University of Health and Welfare, Mita Hospital, Japan for 4 years were included in the study.¹² All patients underwent conservative treatment and preoperative and postoperative voice rehabilitation and concurrently underwent AA combined with TP1.

The mean age of all the patients was 59.5 ± 12.6 (mean \pm SD) years old (range, 29–79 years), and the mean was 59.9 ± 12.9 years old in men and 58.5 ± 12.0 years old in women (Table 1). Figure 1 shows the distribution of age in each sex. The details of the paralytic side and causative diseases were described in our previous report.¹²

METHODS

Surgical procedures

Surgical procedures were performed on patients in whom voice therapy was ineffective.^{13,14} Surgical procedures involved AA combined with TP1 using Gore-Tex under neuroleptic anesthesia without intubation,¹⁵ as described previously.^{1,12} This surgical procedure is selected for all UVFP patients with significant impairment.^{1–4,16–18}

Measurement of voice parameters

PR, SFF, perceptual voice quality¹², MPT, mean flow rate (MFR), jitter %, and shimmer % were measured and evaluated in our routine evaluations. Preoperative evaluation was performed at least 6 months after the onset of UVFP (12 months after onset of idiopathic UVFP). Postoperative evaluations were performed about 1 year after the operation. Details of the instruments used were described in our previous report.¹²

The parameters were measured by specific doctors, speech therapists, and graduates of a music university. PR and SFF were measured in a semi-objective way with a keyboard and

pitch meter, without using a mouth piece. These measurements were not performed in a double-blinded manner. PR measurements began with the relaxed phonation of the vowel “/a/”, followed by moving into the upper register. The highest pitch was measured first, followed by the lowest pitch. SFF was also measured in the vowel “/a/”.

Assessment of voice parameters

Comparison between the pre-PR, post-PR, and MPT. The variation in pre-PR, post-PR, and MPT of all patients were compared between the sexes.

Investigation of pre-PR, post-PR, and SFF. To compare the width of pre-PR with post-PR and SFF, the patients were divided into two groups. The 13 patients in group 1 with a pre-PR of 1 ST and lower because of an almost voiceless breathy hoarseness were excluded from the study.¹²

The data of 37 patients in group 2 (58.3 ± 12.9 ; 29–79 years old) with a pre-PR of >2 STs were investigated. Group 2 consisted of 24 men and 13 women. The mean age of the men was 58.8 ± 13.8 (29–79 years old) and of women was 57.2 ± 11.4 (36–73 years old). The pre-PRs in group 2 were all ≥ 7 STs.

Because PRs were measured to evaluate postoperative change in each individual and also there was no record of exact absolute frequencies, the ST as a unit of PR had been used. Therefore, to confirm how the tendency of post-PR value was changed by using absolute value (Hz), the statistical analysis of the extent of PR in which unit was transformed to Hz was additionally performed in group 2.

Assessment of sex differences in PR improvement and deterioration. Postoperative changes in PR were compared between patients with $\geq 20\%$ and $\leq 20\%$ improvement and deterioration. To account for the diversity of phonation between individuals, the rate of PR variation ($[\text{post-PR} - \text{pre-PR}] / \text{pre-PR}$) was used to compare between individuals. In particular, in the patients showed $>20\%$ PR deterioration, the tendencies of PR, MPT, age, and sex were examined. Furthermore, the relationship of post-SFF and the rate of PR variation was assessed.

Statistical analysis. Because the distribution of pre-PR in all patients was bimodal (consisting of groups 1 and 2), the

TABLE 1.
Preoperative and Postoperative Changes in PR and MPT in Each Sex, and the Rate of Patients Showing a Deterioration of $\geq 20\%$ (All Patients)

	Number of Patients (Male/Female)	Age (Years Old)	PR (STs)			MPT (s)		
			Preoperative	Postoperative	P Value	Preoperative	Postoperative	P Value
All patients	50 (36/14)	59.5 ± 12.0	15.6 ± 10.5	22.3 ± 6.7	$<0.001^*$	4.7 ± 2.3	15.4 ± 7.2	<0.001
Men	36 (36/0)	59.4 ± 12.9	14.7 ± 11.5	22.6 ± 6.3	$<0.001^*$	4.6 ± 2.5	14.8 ± 7.2	<0.001
Women	14 (0/14)	58.5 ± 12.0	18.1 ± 7.2	21.7 ± 7.8	0.144	5.1 ± 1.9	16.8 ± 7.2	<0.001
Patients showing deterioration ($\geq 20\%$)	5 (1/4)	64.8 ± 4.2	23.8 ± 5.2	17.0 ± 5.0	0.001	4.2 ± 0.8	14.3 ± 4.6	0.008

Notes: Rate of deterioration = $(\text{post-PR} - \text{pre-PR}) / \text{pre-PR}$ (Average \pm SD).

* Wilcoxon rank sum test was used in statistical analysis. (Others were examined by paired *t* test.)

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