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ORIGINAL SCIENTIFIC REPORT

The Long-Term Prognosis of Voice Pitch Change in Female Patients After Thyroid Surgery

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Abstract

Background Relatively large numbers of patients complain of lower-pitched voices after thyroidectomy. However, little is known about the risk factors for, prognosis of, or progression over time of, such changes, in female patients.

Methods We analyzed the data of 217 patients who underwent thyroid surgery and postoperative (2 weeks, and 3, 6, and 12 months after surgery) voice work-ups. To identify patients with lower-pitched voices, speaking fundamental frequencies (SFFs) were compared before and after surgery. The change was calculated for all patients (postoperative change in SFF, ΔSFF).

Results The mean ΔSFF was 8.35 ± 17.06 Hz and significant changes in voice pitch (ΔSFF ≥12 Hz) were evident in 93 (42.85 %) patients after surgery, mostly within 6 months, and only 18.4 % of patients had lower-pitched voices 1 year after surgery. On multivariate analysis, age (≥52 vs. <52 years) and extent of surgery remained significant predictors of lower-pitched voice after surgery. The ΔSFFs of older patients (≥52) were significantly greater than those of younger patients (<52) at the 2-week follow-up, but not at the 3-, 6-, or 12-month follow-ups. The ΔSFFs of patients who underwent total thyroidectomy were significantly higher than those who underwent lobectomy at the postoperative 2-week follow-up, but did not differ at the 3-, 6-, and 12-month follow-ups.

Conclusions Patients frequently experience a lower-pitched voice after thyroid surgery. Such problems develop more frequently in the early postoperative period, in aged patients, and in those who had undergone total thyroidectomy. However, over time, the changes usually decrease to levels similar to those of patients without these risk factors.

Introduction

Relatively large numbers of patients complain of similar voice symptoms after thyroid surgery, including easy vocal fatigue, difficulty with the high-pitched and singing voices, vague voice changes even in the absence of laryngeal nerve injury and vocal cord paralysis [1–4]. Between 37–87 % of patients suffer from such changes and related symptoms. [1, 3, 5, 6] The voice pitch is frequently lowered; about 18 % of patients experience such lowering after thyroidectomy. Acoustic parameters also significantly change from those of the habitual voice after thyroid surgery [7–10]. Several hypothetical explanations of the relevant

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mechanism have been advanced; none has yet been universally accepted. Inadvertent mechanical or thermal injury to the superior laryngeal nerve, dysfunction of the strap muscle caused by fixation of the muscle to the trachea [4, 8, 10, 11], mucosal changes attributable to changes in vascular supply and/or venous drainage of the larynx, [3] and orotracheal intubation, [12, 13] have been suggested as possible mechanisms. However, why do some patients experience pitch lowering when others do not? Do any patient-related risk factors exist? Are there risk factors other than surgery per se (for example: the surgical technique used and/or the extent of surgery)? We hypothesized that preoperative laryngeal status and structural vulnerability might affect voice outcomes after surgery. Age may also be a risk factor, because old laryngeal cartilage is significantly less yielding (because of calcification) than younger cartilage, and the laryngeal muscle can exhibit considerable atrophy. Also, vocal hygiene, vocal mucosal disease, and vocal history may be relevant in this context. We reviewed several studies on voice changes after thyroidectomy, but found that little was known. The primary objective of the present study was thus to evaluate whether patient-related factors were associated with the prevalence and prognosis of a lower-pitched voice following thyroid surgery.

Materials and methods

Subjects

We conducted a retrospective analysis of prospectively collected data on patients scheduled to undergo thyroidectomy at Seoul St. Mary's Hospital between July 2012 and June 2014. All patients were recommended to undergo the same preoperative (2 weeks before surgery) and postoperative (2 weeks, 3, 6, and 12 months after surgery) voice work-ups. Each work-up featured fiber-optic laryngoscopy, videostroboscopic examination, perceptual voice analysis, and acoustic analysis. Patients were excluded according to the following criteria: (1) male gender; (2) external radiation or radioactive iodine therapy; (3) previous head-and-neck surgery, including thyroid surgery; (4) performance of modified radical neck dissection to eradicate cervical lymphatic metastases; (5) performance of partial laryngeal or tracheal resection to treat tumor invasion; (6) use of an endoscopic or robotic approach; and, (7) failure to complete all pre- and postoperative voice work-ups over the 12 postoperative months: Data on a total of 508 patients were reviewed; 291 patients were excluded; and 217 were included. The following data were extracted from patient files and analyzed as candidate parameters predicting a lower-pitched voice: age in years, voice abuser status, smoking status, presence of laryngeal disease, pathology, tumor size, extent of surgery, and need for central node dissection. Voice abusers included not only elite or professional voice users, but also non-vocal, non-professional users (e.g., lawyers, doctors, salaried employees, and even full-time homemakers with several children); such persons considered themselves voice abusers when they answered questionnaires. We evaluated the larynx via fiber-optic laryngoscopy and videostroboscopy, and regarded any benign pathological lesion of the larynx as laryngeal disease. Thus, we considered laryngopharyngeal reflux disease, vocal edema, vocal nodules, vocal polyps, sulcus vocalis, Reinke's edema, granulomas, and epiglottic cysts, as diseases. If any laryngeal disorder requiring surgery was found (e.g., vocal polyps or cysts), laryngeal surgery was performed at the time of thyroid surgery to minimize the use of general anesthesia. The institutional review board of our institution approved the protocol of our study.

Criteria for discrimination of lowered pitch

The speaking fundamental frequency (SFF) is the average fundamental frequency (the lowest frequency of a complex periodic sound) measured during performance of a vocal or speech task, and is a basic acoustic measure used for clinical evaluation of voice disorders, such as a lowered pitch. To identify patients with lower-pitched voices, SFF were compared before and after surgery. Changes in all patients were calculated (postoperative change in SFF, ΔSFF = preoperative value of SFF—postoperative value of SFF). If the ΔSFF was >12 Hz, the patient was considered to have a lower-pitched voice. [9, 10].

Voice work-up

Each work-up featured fiber-optic laryngoscopy, videostroboscopic examination, perceptual voice analysis, and acoustic analysis.

Fiber-optic laryngoscopic and videostroboscopic examinations

We examined the entire larynx, including the mucosal status and the presence of vocal fold diseases, using fiber-optic laryngoscopy (Machida Instruments, Tokyo, Japan) and videolaryngostroboscopy (model 9200C; KayPENTAX, Lincoln Park, NJ, USA). A diagnosis of vocal fold disease was made by two speech therapists and one otolaryngologist by consensus.

Perceptual voice analysis

The grade, roughness, breathiness, asthenia, and strain (GRBAS) score is widely used by many professional bodies. Each voice was scored using the five GRBAS parameters: grade = overall degree of voice deviance; roughness = irregular fluctuation of the fundamental frequency; breathiness = turbulent noise produced by air leakage; asthenia = overall voice weakness; and strain = impression of tenseness or excess effort when speaking. Each parameter was scored on a scale of 0–3 (0, normal; 1, slight disturbance; 2, moderate disturbance; and 3, severe disturbance). Voice samples were recorded for all patients who were instructed to read "Sanchaek (a walk)" at a comfortable volume and rate. Each patient's voice was also perceptually evaluated during conversation. The patients provided information on their voice history and social history. A GRBAS score was given at the end of the evaluation session. Next, the recorded audiotapes were replayed after the evaluation session to reconsider the GRBAS scores. The voices were judged by two speech therapists and one otolaryngologist by consensus.

Acoustic analysis

Acoustic analysis is a validated (and useful) tool employed to quantitatively characterize the voice in terms of dysphonia. Patients were instructed to produce the vowel "a" at a comfortable volume and constant pitch. Each vowel pronunciation was recorded at a constant mouth-to-microphone distance of 5 cm using Computerized Speech Lab (CSL, model 4150; KayPENTAX). All digital recordings were made in a quiet room. Each patient sustained an "a" for at least 3 s at a comfortable pitch level. The task was repeated four times or more, and the fourth trial was often the recorded sample. Each analysis was made using the multi-dimensional voice program (MDVP, model 5105, ver. 3.1.7; KayPENTAX). The parameters that were considered in the analysis were the fundamental frequency, perturbations of the fundamental frequency (jitter), amplitude (shimmer), glottal noise (i.e., the noise-to-harmonic ratio), and the speaking fundamental frequency (SFF). The software defines normal jitter values up to $N < 1.1$ % and shimmer values up to $N < 3.8$ %. The normal noise-to-harmonic ratio is $N < 0.2$.

Thyroidectomy-related voice questionnaire (TVQ)

The thyroidectomy-related voice questionnaire (TVQ) was developed at our institution. It is a self-assessment tool that measures voice quality. We have demonstrated that the questionnaire is a simple and effective screening tool with which to detect pre- and post-thyroidectomy voice-related disorders that can affect voice quality. [14–16] The TVQ comprises 20 questions; responses to each are scaled from a minimum of 0 (no voice alterations or symptoms) to a maximum of 80 (highest voice impairment and multiple vocal symptoms).

Surgery

All patients were operated upon in the same manner by the same surgeon. Thyroidectomy was performed by extracapsular dissection and recurrent laryngeal nerves were identified and preserved. To preserve the external branch of the superior laryngeal nerve, we performed an accurate dissection of the vessels of the superior pole that were singularly ligated as distally as possible and close to the thyroid capsule. When the external branch of the superior laryngeal nerve could not be readily identified, no further dissection was performed.

Postoperative voice rehabilitation

Voice rehabilitation involves both direct and indirect voice therapy. Direct voice therapy featured vocal function exercises (VFEs). Each VFE is a series of voice manipulations that are designed to strengthen and balance the laryngeal musculature and to balance the airflow with muscular effort. A VFE features four steps, as described by Stemple et al. [17]. Indirect voice therapy featured a vocal hygiene program including the following aspects: voice rest, adequate hydration, reduction/elimination of laryngeal irritants, reduction of vocal abuse and hard glottal attack, reduction of vocal loudness and speech rate, elimination of chronic throat clearing and coughing. [18] VFEs were performed by all patients with lower-pitched voices evident after voice work-up at 2 weeks. After each VFE, for the patients who did not show restoration of lowered pitch, indirect voice therapy was applied for 1 further month to improve the condition of the larynx. After indirect voice therapy, VFE was performed once more by these patients for 6 weeks, and the same evaluations were repeated.

Statistical analysis

Statistical analyses were performed using SPSS software (ver. 18.0 for Windows; SPSS, Chicago, IL). Univariate associations between individual clinical features and changes in the voice parameter (ΔSFF) were detected using the Chi-squared, Fisher's exact, or Student's t test, as appropriate. Multivariate analysis featuring logistic regression was performed on factors exhibiting prognostic potential in univariate analyses. The cutoff value of the age for predicting lower-pitched voice (52 years) was chosen to maximize the sensitivity and specificity of receiver

operation characteristic curve analysis. Values of $P < 0.05$ were considered to indicate statistical significance.

Results

Characteristics of the patients

A total of 217 female patients were included in this study with mean age of 50.9 (range 20–80 years; standard deviation: 11.6) years. Total thyroidectomy was performed in 148 (68.2 %) patients and lobectomy in 69 (31.8 %). Central neck dissection was performed in all 203 patients with malignant pathology. The pathologic results were benign in 14 (6.5 %) patients and malignant in 203 (93.5 %). The mean tumor size was 0.94 ± 0.91 (cm). Four (1.8 %) patients were current smokers, one (0.5 %) was a former smoker and 212 (97.7 %) were non-smokers. Fifty-three (24.4 %) patients regarded themselves as occupational voice abusers and 49 (22.6 %) patients had laryngeal mucosal disease: vocal edema in 14 (6.4 %; vocal nodules in 12 (5.5 %); laryngopharyngeal reflux (LPR) in 10 (4.6 %); sulcus vocalis in 5 (2.3 %); vocal polyps in 4 (1.8 %); Reinke's edema in 2 (0.9 %); a granuloma in 1 (0.4 %); and an epiglottic cyst in 1 (0.4 %). Two patients with vocal polyps underwent simultaneous microlaryngeal surgery. Two other patients with vocal polyps requested nonsurgical follow-up. Patients with vocal nodules were educated in terms of vocal hygiene, voice rest, and necessary medication (proton pump inhibitors), and were followed-up by a voice specialist. Patients with sulcus vocalis, granuloma, and epiglottic cysts were educated about their diseases; none desired intervention; all were followed-up by a voice specialist.

Lower-pitched voice after thyroid surgery and predictive risk factors

The results of acoustic, perceptual, and subjective analysis presurgery and at post-operative week 2 are summarized in Table 1. The mean value of ΔSFF was 8.35 ± 17.06 Hz and significant changes in voice pitch (ΔSFF ≥12) were evident in 93 (42.9 %) patients at 2 weeks after surgery. Significant changes in voice pitch (ΔSFF ≥12) were evident in 59 (27.2 %), 42 (19.4 %), and 40 (18.4 %) patients at 3, 6, and 12 months, respectively, after surgery (Fig. 1). Briefly, 42.9 % of female patients suffered significant falls in voice pitch after surgery; most improved within 6 months; and only 18.4 % of patients had lower-pitched voices 1 year after surgery. The mean values of SFF were 189.12 ± 21.275, 180.77 ± 23.857, 183.07 ± 23.318, 185.50 ± 19.796, and 184.73 ± 21.962 Hz preoperatively, at 2 weeks, and at 3, 6, and 12 months postoperatively, respectively. The mean values of the TVQ scores were 15.82 ± 15.216, 36.09 ± 16.773, 33.77 ± 15.320, 31.54 ± 15.839, and 33.37 ± 22.37, respectively, at the same times.

The results of univariate and multivariate analyses of parameters predicting a lower-pitched voice at 2 weeks following thyroid surgery are summarized in Table 2. On univariate analysis, age (age ≥52 vs. age <52 years), laryngeal disease, and extent of surgery (total vs. lobectomy) were significant predictors of an ΔSFF ≥12. Significant variables identified in the univariate analyses were further evaluated in the Cox regression multivariate model. After adjusting for other retained variables, age (age ≥52 vs. age <52 years) and extent of surgery remained significant predictors of ΔSFF ≥12 Hz at 2 weeks after surgery.

Table 1 Acoustic, perceptual, and subjective analyses of female patients preoperatively and 2 weeks after thyroid surgery ($n = 217$)

Analysis	Parameter	Preop	Postop (2 weeks)	*P* value
Acoustic	Fo	198.9 ± 22.7	190.7 ± 25.6	<0.001*
	SFF	189.1 ± 21.8	180.8 ± 23.9	<0.001*
	Jitter	1.51 ± 1.24	1.51 ± 1.14	0.319
	Shimmer	4.24 ± 2.12	4.73 ± 2.50	0.009*
	NHR	0.16 ± 0.40	0.14 ± 0.03	0.488
Perceptual	Grade	10.64 ± 0.60	0.91 ± 0.59	<0.001*
	Roughness	029 ± 0.49	0.51 ± 0.59	<0.001*
	Breathiness	0.49 ± 0.59	0.59 ± 0.63	0.043*
	Asthenic	0.00 ± 0.68	0.04 ± 0.20	0.011*
	Strain	0.02 ± 0.13	0.27 ± 3.60	0.310
Subjective	TVQ	15.82 ± 15.21	36.09 ± 16.77	<0.001*

F0 fundamental frequency; *SFF* speech fundamental frequency; *NHR* noise to harmonic ratio; *TVQ* thyroidectomy-related voice questionnaire

* $P < 0.05$

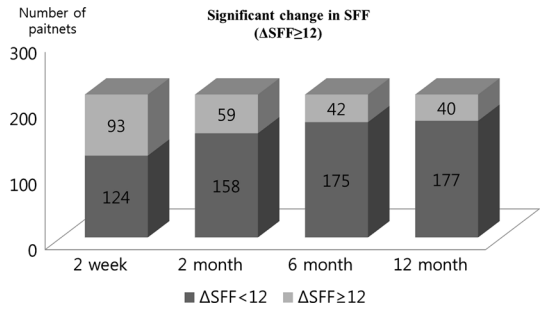

Fig. 1 The time course of the proportion of patients exhibiting significant changes in SFF (ΔSFF ≥12 Hz) ($n = 217$). *SFF* speech fundamental frequency; *ΔSFF* the difference in speech fundamental frequency (preoperative value of SFF—postoperative value of SFF)

Time course of voice pitch after thyroid surgery by age

Changes in voice parameters after thyroid surgery by patient age (≥52 and <52 years) are summarized in Fig. 2. The mean values of the preoperative F0 and SFF were 194.94 ± 22.24 and 183.49 ± 21.72, respectively, in older patients (≥52 years). The mean values of the preoperative F0 and SFF were 202.80 ± 22.48 and 194.71 ± 19.35, respectively, in younger patients (<52 years). Significant differences in the preoperative SFF and F0 were evident between the two groups ($p = 0.010$* and $p < 0.001$, respectively*). The proportion of patients with significant changes in SFF (ΔSFF ≥12) was significantly higher in older patients at the 2-week postoperative follow-up, but not at the 3-month follow-up (Fig. 2a).

In older patients, the mean values of SFF were 183.49 ± 21.721, 170.89 ± 20.395, 176.13 ± 21.382, 182.88 ± 18.678, and 183.97 ± 21.572 Hz preoperatively, and at 2 weeks, and 3, 6, and 12 months, postoperatively, respectively. In younger patients, the mean values of SFF were 194.71 ± 19.355, 190.57 ± 23.058, 189.95 ± 23.205, 188.09 ± 20.604, and 185.48 ± 22.416 Hz at the same times. The values of SFF of older patients were significantly lower than those of younger patients both

Table 2 Univariate and multivariate analyses of parameters predicting a lower-pitched voice at 2 weeks after thyroid surgery ($n = 217$)

Parameter	No	ΔSFF (Hz)	Univariate analysis		Multivariate analysis		
			ΔSFF ≥12 Hz (%)	*P* value	Odds ratio	95 % CI	*P* value
Age in years							
≥52	108	12.6 ± 18.1	57 (52.8)	0.003*	2.07	1.180–3.634	0.011*
<52	109	4.1 ± 14.9	36 (33.0)				
Voice abuser							
Yes	53	7.1 ± 16.9	20 (37.7)	0.386			
No	164	8.8 ± 17.2	73 (44.5)				
Smoking status							
Never/former	213	8.3 ± 17.2	90 (42.3)	0.19			
Current	4	9.3 ± 14.9	3 (75.0)				
Laryngeal disease							
Yes	49	14.1 ± 20.5	27 (55.1)	0.049*			0.112
No	168	6.7 ± 15.7	66 (39.3)				
Pathology							
Benign	14	4.7 ± 12.6	5 (35.7)	0.057			
Malignant	203	8.6 ± 17.4	88 (43.3)				
Tumor size							
≥2	12	6.5 ± 15.9	4 (33.3)	0.493			
<2	205	8.5 ± 17.2	89 (43.4)				
Extent of surgery							
Total	148	10.1 ± 18.1	73 (49.3)	0.005*	2.146	1.148–4.014	0.017*
Lobectomy	69	4.6 ± 14.1	20 (29.0)				
Central node dissection							
Yes	14	4.7 ± 12.6	5 (35.7)	0.057			
No	203	8.6 ± 17.4	88 (43.3)				

ΔSFF the difference in speech fundamental frequency (preoperative value of SFF—postoperative value of SFF); *CI* confidence interval

* $P < 0.05$

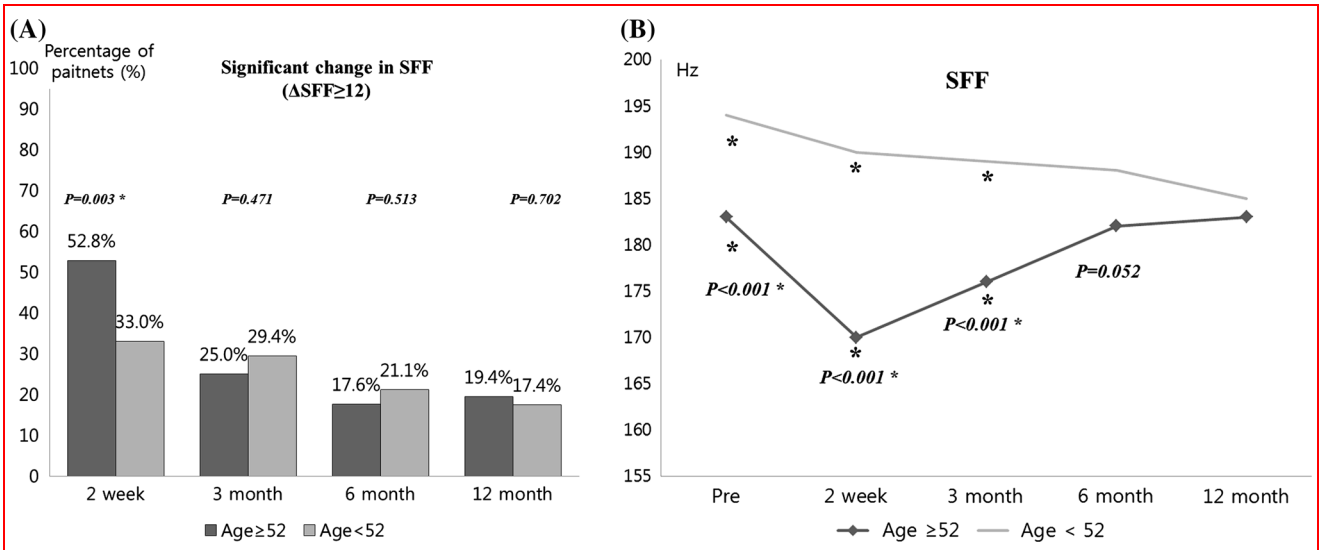

Fig. 2 Changes in voice parameters over time after thyroid surgery by patient age (≥52 and <52 years) ($n = 217$). The time course of (**a**) the proportion of patients exhibiting significant changes in SFF (ΔSFF ≥12 Hz) and (**b**) the SFF values. (*$p < 0.05$) *SFF* speech fundamental frequency; *ΔSFF* the difference in speech fundamental frequency (preoperative value of SFF—postoperative value of SFF); *TVQ* thyroidectomy-related voice questionnaire

preoperatively, and at 2 weeks and 3 months postoperatively (Fig. 2b).

In older patients, the mean TVQ scores were 14.24 ± 14.256, 35.37 ± 17.3112, 32.75 ± 15.806, 30.93 ± 15.009, and 34.23 ± 24.360 preoperatively, and at 2 weeks, and 3, 6, and 12 months, postoperatively, respectively. In younger patients, the mean TVQ scores were 17.38 ± 16.024, 36.81 ± 16.265, 34.79 ± 14.822, 32.14 ± 16.678, and 32.50 ± 20.248 at the same times. TVQ scores increased significantly postoperatively in both age groups and did not differ by age.

Time course of voice pitch after thyroid surgery according to extent of surgery

Changes in voice parameters after thyroid surgery according by the extent of surgery are summarized in Fig. 3. The mean preoperative F0 and SFF values were 199.1 ± 24.8 and 188.2 ± 21.8, respectively, in the total thyroidectomy group. The mean preoperative F0 and SFF values were 198.4 ± 17.1 and 190.9 ± 20.0, respectively, in the lobectomy group. The preoperative SFF and F0 values did not differ significantly between the two groups ($p = 0.813$ and $p = 0.399$, respectively). The proportion of patients with significant changes in SFF (ΔSFF ≥12 Hz) was significantly higher among those who underwent total thyroidectomy, at the 2-week postoperative follow-up, but no between-group difference was evident at the 3-, 6-, or 12-month follow-ups (Fig. 3a).

In patients who underwent total thyroidectomy, the mean values of SFF were 188.3 ± 21.8, 178.2 ± 24.2, 181.4 ± 22.9, 184.8 ± 19.7, and 183.8 ± 20.8 Hz preoperatively, and at 2 weeks, and 3, 6, and 12 months postoperatively, respectively. In patients who underwent thyroid lobectomy, the mean values of SFF were 190.9 ± 20.1, 186.3 ± 22.3, 186.8 ± 24.0, 186.9 ± 20.2, and 186.8 ± 24.3 Hz at the same times. The SFF values of patients who underwent total thyroidectomy were significantly lower than those of patients who underwent lobectomy at the postoperative 2-week follow-up, but no between-group difference was evident at the 3-month follow-up (Fig. 3b).

In patients who underwent total thyroidectomy, the mean TVQ scores were 16.49 ± 16.079, 37.32 ± 16.759, 34.27 ± 15.845, 32.33 ± 15.822, and 34.10 ± 21.981 preoperatively, and at 2 weeks, and 3, 6, and 12 months, postoperatively, respectively. In patients who underwent thyroid lobectomy, the mean TVQ scores were 14.36 ± 13.167, 33.43 ± 16.614, 32.71 ± 14.208, 29.87 ± 15.861, and 31.79 ± 23.284 at the same times. The TVQ score significantly increased postoperatively in both groups, and did not differ by the extent of surgery.

Discussion

We defined the presence of a ‘lower-pitched voice after thyroid surgery’ if the SFF was reduced by more than 12 Hz at the postoperative 2-week follow-up. To exclude

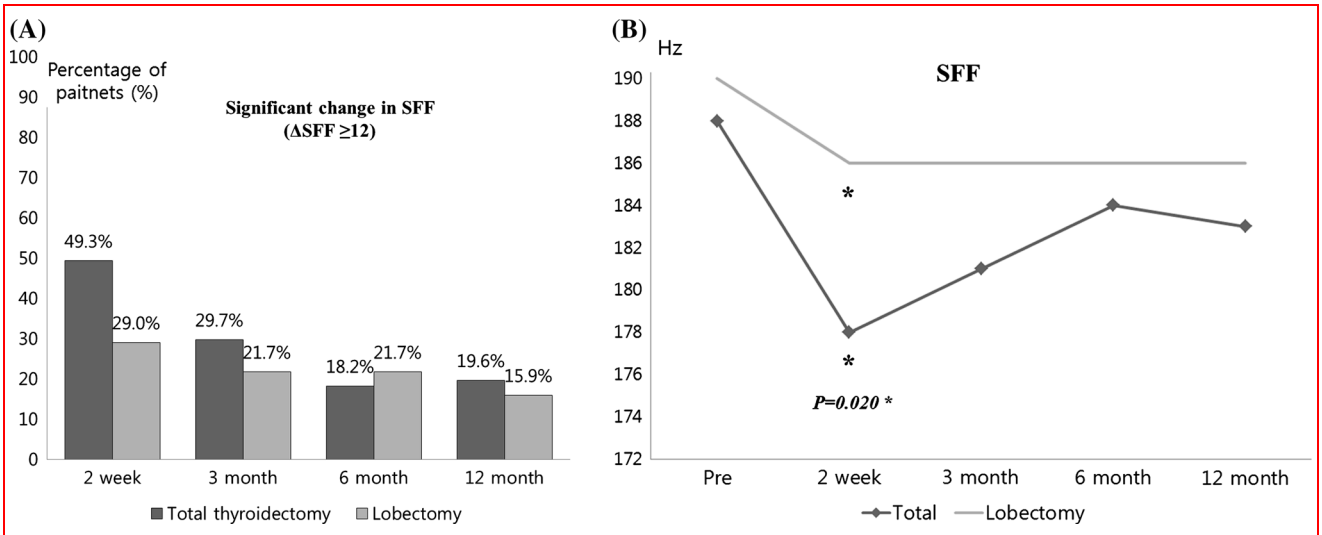

Fig. 3 Changes in voice parameters over time after thyroid surgery according to extent of surgery (Total and Lobectomy) ($n = 217$). The time course of (**a**) the proportion of patients exhibiting significant changes in SFF (ΔSFF ≥12) and (**b**) the SFF values. (*$p < 0.05$) *SFF* speech fundamental frequency; *ΔSFF* the difference in speech fundamental frequency (preoperative value of SFF—postoperative value of SFF); *TVQ* thyroidectomy-related voice questionnaire

any transient effect of mucosal changes after endotracheal intubation, which usually subside within 2 weeks after surgery, we performed the first postoperative voice work-up at 2 weeks. To allow meaningful statistical analysis, we focused on the percentage drop in SFF that was of clinical significance. The cutoff value was determined on the basis of published data on acoustic analyses of voice after thyroid surgery; previous works on lower-pitched voice; our previous data; and our clinical experience [9, 10]. Using a cutoff of 12 Hz, about 42 % of female patients suffered from a significant drop in voice pitch after surgery; most improved within 6 months; and only 18 % of patients retained lower-pitched voices 1 year after surgery. Despite recovery of voice pitch, the subjective symptom scores of the TVQ questionnaire showed that problems persisted for more than 12 months. This means that, although voice pitch recovered in most patients, a considerable number of patients still suffered from and complained about voice-related symptoms, reporting (for example): 'I feel strained when producing voice'; 'I feel vocal fatigue after a long conversation'; 'I can hardly make a loud voice'; 'I have lots of sputum in my throat'; and 'I feel like something is stuck in my throat'.

The mean value of voice pitch in aged patients was lower than that in younger patients before surgery in the present study, in agreement with data of previous reports. The voice pitch during speaking usually reduces with age in females, consistent with the findings of many studies. Several authors have reported that SFF tends to decrease markedly upon aging. [19–21] Changes in the hormonal environment with age should be considered when explaining voice changes to older females. Such changes include increased production of progesterone, which in turn is hypothesized to trigger atrophy of the vocal fold mucosa and thyroarytenoid muscles. [19, 20, 22–24] The reasons why older persons are more vulnerable to pitch changes after thyroid surgery remain to be investigated, but we suggest the answer lies in age-related changes to the laryngeal structure. The framework of the larynx consists of several cartilages connected by membranes and ligaments, and moved by muscles. [25] The forces exerted on cartilages by the extrinsic laryngeal muscles may play a role in the regulation of voice pitch by changing the geometry of the laryngeal framework and hence that of the vocal folds [8, 26]. Calcification of laryngeal cartilage begins early in adulthood, and becomes more extensive with age; also the physical properties of the laryngeal cartilages change significantly (to become less yielding) [25, 27–29]. The vocal cord mucosa also undergoes significant alteration and laryngeal muscles show considerable involution, tending toward atrophy [30, 31]. When some regions of the strap muscles are damaged, other (intact) intra- and extra-laryngeal muscles with analogous functions generally compensate for the functional deficit. The extrinsic laryngeal muscles of the elderly exhibit considerable atrophy; are weak; and are vulnerable to external trauma. Calcified, less yielding laryngeal cartilage may also adversely affect the compensatory effort of intact muscles. However, a good deal of further work is required.

Surgical extent was another independent predictor of a lower-pitched voice in the present study. Compared to patients underwent thyroid lobectomy, those who

underwent total thyroidectomy had lower SFF values and were at higher risk of a clinically significant drop in the SFF; however, these between-group differences gradually decreased over time (3 months), in part-agreement with the data of earlier reports. Vicente et al. [32] found that an early negative voice outcome was more common in patients who underwent total thyroidectomy than in others; all disturbances resolved by 6 months. However, they did not evaluate parameters related to voice pitch. Ryu et al. [33] reported that patients who underwent total thyroidectomy (compared to lobectomy) experienced poorer voice outcomes (as measured by GRABA scores, acoustic voice parameters, the VHI, Fmax, and pitch range). These between-group differences gradually decreased over time, but the Fmax remained persistently low, over a narrower pitch range, for up to 6 months after thyroidectomy. Etiologies lowering pitch after thyroid surgery, including mechanical or thermal injury to the superior laryngeal nerve, mucosal congestion caused by to endotracheal intubation, and strap muscle injury during surgery [4, 8, 10–13] may be twice as prevalent when total thyroidectomy (compared to lobectomy) is performed; this may explain why the rate of altered voice pitch increases with the extent of thyroidectomy.

In conclusion, a considerable number of female patients develop a lower-pitched voice after thyroid surgery. Such problems develop more frequently in older patients and those who have undergone total thyroidectomy. Voice pitch is usually improved within 3–6 months after surgery, but patients may still suffer from voice-related subjective symptoms. Detailed preoperative explanations, and counseling in terms of the time course of voice pitch change, are very important when planning thyroid surgery.

Compliance with ethical standards

Conflict of interests None.

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