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Functional voice and swallowing outcomes after robotic thyroidectomy by a gasless unilateral axillo-breast approach: comparison with open thyroidectomy

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Abstract

Background Voice and swallowing alterations are common complaints after thyroidectomy, even in the absence of laryngeal nerve impairment. However, voice and swallowing functions after robotic thyroidectomy have not been thoroughly investigated. This study compared the functional outcomes for voice and swallowing after robotic thyroidectomy and conventional open thyroidectomy.

Methods The study prospectively analyzed the voice and swallowing functions of patients with thyroid nodules who underwent robotic thyroidectomy by a gasless unilateral axillo-breast (GUAB) approach (50 cases) or by conventional open thyroidectomy (61 cases) from September 2009 to October 2010. Videolaryngostroboscopy or flexible laryngoscopy was performed pre- and postoperatively. Subjective voice and swallowing alterations were assessed by questionnaire preoperatively and then 1 day, 1 week, 1 month, 3 months, and 6 months postoperatively. In addition, objective acoustic voice analysis was performed using a Multidimensional Voice Program, with Voice Range Profiles and maximum phonation times measured preoperatively and then 1 week, 1 month, 3 months, and 6 months postoperatively.

Results Subjective postoperative voice function was significantly better in the robotic group at 1 day, 1 month, and 3 months postoperatively than in the open group. The mean values of fundamental frequency, jitter, shimmer and noise-to-harmonic ratio before and after surgery did not differ between the two groups. However, the frequency range and the highest frequency were significantly better in the robotic group than in the open group at 3 months postoperatively. Subjective swallowing function did not differ between the two groups.

Conclusion Postoperative voice function is better with robotic thyroidectomy using the GUAB approach than with conventional open thyroidectomy. This is an advantage of robotic thyroidectomy by the GUAB approach in addition to the excellent cosmesis.

Keywords Axillo-breast approach · Endoscopic thyroidectomy · Postthyroidectomy syndrome · Robotic thyroidectomy · Swallowing · Voice

Recently, robotic thyroidectomy using the da Vinci Surgical System has been developed to eliminate neck scaring and to overcome limitations of endoscopic thyroid surgery such as an inadequate surgical view and inaccurate instrument manipulation [1–6]. The da Vinci Surgical System offers many advantages over traditional endoscopic thyroidectomy including improved surgical ergonomics and surgical dexterity. It provides a magnified high-resolution three-dimensional view, hand-tremor filtration, fine-motion scaling, and precise and multi-articulated motion of innovative instruments.

In robotic or endoscopic thyroidectomy, axillary and breast approaches or modifications of these procedures are the most widely used [1, 3–5, 7–13]. The advantages of robotic or endoscopic thyroidectomy using the extracervical approach over conventional open thyroidectomy

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include better cosmetic results and magnified surgical views.

Robotic thyroidectomy can be performed safely for appropriately selected patients with thyroid nodules. Several authors have described its feasibility and safety, reporting surgical outcomes comparable with those of conventional open thyroidectomy, although it has been performed by only a very limited number of surgeons due to the difficulty of the technique and the need for a period of training [1–6, 14].

In recent years, increasing attention has been paid to the subjective symptoms and functional outcomes of endoscopic or robotic thyroidectomy and minimally invasive thyroidectomy including postoperative pain, paresthesia, hyperesthesia, voice and swallowing functions, and cosmesis [3, 5, 13, 15–18]. Robotic thyroidectomy using a gasless transaxillary or axillo-breast approach is reported to provide better postoperative cosmesis and less postoperative neck paresthesia than open thyroidectomy [3–5, 19]. However, functional voice and swallowing outcomes after robotic thyroidectomy have not been thoroughly investigated, although one study has evaluated subjective postoperative voice and swallowing symptoms using a questionnaire [19].

The current study aimed to compare postoperative voice and swallowing functions after robotic thyroidectomy with those after conventional open thyroidectomy in the absence of impairment to the recurrent laryngeal nerve (RLN) or the external branch of the superior laryngeal nerve.

Methods

This prospective study involved a consecutive cohort of patients with thyroid nodules who met the inclusion criteria and underwent robotic thyroidectomy using a gasless unilateral axillo-breast (GUAB) approach or a conventional open thyroidectomy with or without central compartment neck dissection from September 2009 to October 2010. All the patients were followed up for at least 6 months after the operation.

The exclusion criteria specified age younger than 18 years or older than 70 years and vocal cord lesions including vocal nodules, vocal polyps, Reinke's edema, and vocal cord paralysis. Patients with postoperative evidence of RLN or paralysis of an external branch of the superior laryngeal nerve also were excluded as well as patients who did not consent to evaluation of voice and swallowing functions. Patients were ineligible for the study if they had a history of neck or thyroid surgery or had undergone reoperation, completion thyroidectomy, or lateral compartment neck dissection with thyroidectomy. Male patients were excluded to obtain a homogenous analysis of acoustic parameters. Patients with anaplastic and medullary cancer also were excluded.

No randomization for robotic versus open thyroidectomy was performed. The indications for robotic thyroidectomy included follicular neoplasm or benign thyroid nodules smaller than 5 cm in diameter and differentiated thyroid carcinoma smaller than 3 cm at its largest diameter with or without a minimal extrathyroidal extension or a small central or lateral compartment lymph node metastasis. We excluded cases of papillary thyroid carcinoma with extensive extrathyroidal extensions, large multiple cervical lymph node metastases in the lateral or central compartment, or distant metastases. Patients with a history of neck or thyroid surgery or irradiation also were excluded.

The operating procedures for robotic thyroidectomy using the GUAB approach have been described previously [3, 5]. All robotic and open thyroidectomies were performed by one surgeon (K.T.). All patients provided informed consent for the voice and swallowing assessments. The Institutional Review Board of Hanyang University Hospital approved the study.

Voice and swallowing functions were assessed by subjective voice and swallowing evaluation, videolaryngostroboscopy or fiberoptic flexible laryngoscopy, objective acoustic voice analysis, and aerodynamic measurements. Using questionnaires that we specifically designed, the subjective voice and swallowing evaluation was performed the day before surgery and then 1 day, 1 week, 1 month, 3 months, and 6 months postoperatively. The voice questionnaire consists of five questions about changes in voice pitch, range, intensity, fatigability, and singing quality (Table 1). The swallowing questionnaire consists of three questions (Table 2).

Voice and swallowing symptoms were scaled as 0 (no symptom), 1 (mild), 2 (moderate), 3 (severe), or 4 (very severe). Voice and swallowing symptom scores were defined as the sums of the scores in the corresponding

Table 1 The subjective voice symptom score questionnaire

	0 None	1 Mild	2 Moderate	3 Severe	4 Very severe
1. Do you have vocal fatigue?					
2. Do you have a hoarse voice?					
3. Is it difficult to produce a high pitch?					
4. Is your voice weak or breathy?					
5. Do you have difficulty singing?					

Table 2 The subjective swallowing symptom score questionnaire

	0 None	1 Mild	2 Moderate	3 Severe	4 Very severe
1. Do you have pain or any difficulty swallowing?					
2. Do you feel a lump or foreign body sensation when swallowing?					
3. Do you cough or choke when swallowing?					

questionnaires. The maximum voice symptom score was 20, and the maximum swallowing symptom score was 12.

Videolaryngostroboscopy or fiberoptic flexible laryngoscopy was performed to assess motion of the vocal folds, vocal mucosal lesions, arytenoid asymmetry, vocal cord bowing, degree of glottis closure, and mucosal wave characteristics pre- and postoperatively. Objective acoustic voice analysis was performed using the Multidimensional Voice Program and the Voice Range Profile from the Computerized Speech Lab (Model 4150B; KayPENTAX, Lincoln Park, NJ, USA) the day before surgery and then 1 week, 1 month, 3 months, and 6 months postoperatively. Acoustic recordings were collected by an experienced speech-language pathologist with a microphone positioned 15 cm from the patient's mouth while the patient was in a comfortable sitting position.

For the Multidimensional Voice Program analysis, the patients were instructed to produce the sustained vowel "a" at a comfortable pitch and amplitude for at least 5 s. A period of steady-stable sound lasting 3 to 4 s for each vowel was used in the analysis. In the Multidimensional Voice Program analysis, fundamental frequency (F_0, Hz), jitter (%), shimmer (%), and noise-to-harmonic ratio (NHR, dB) were analyzed.

In the Voice Range Profile analysis, the patients were asked to phonate using a sustained vowel "a" as loudly and as softly as possible from the lowest to the highest frequency. The lowest (F-low) and highest (F-high) frequencies (Hz), the frequency range (number of semitones), and the intensity range (dB) were measured from the Voice Range Profile. Maximum phonation times (MPTs) were measured by having patients sustain the vowel "a" at the habitual amplitude and pitch for as long as possible in a single breath as an aerodynamic parameter.

All statistical analyses were performed using SPSS version 15.0 (SPSS, Chicago, IL, USA). A p value of 0.05 or less was considered statistically significant.

Results

During the study period, 205 patients with a thyroid nodule underwent open (141 cases) or robotic (64 cases) thyroidectomy. Of the 205 patients, 5 (7.8%) in the robotic group and 4 (2.8%) in the open group experienced postoperative transient or permanent (1 case in the open group) RLN paralysis and were excluded from this study. In addition, 85 patients were excluded from the study due to male gender, underlying vocal cord lesions, no informed consent, and the like. Of the 111 patients who finally participated in this study, 50 underwent robotic thyroidectomy using the GUAB approach, and 61 underwent open thyroidectomy.

The questionnaire was completed by all 111 patients preoperatively, then 1 day and 1 week after the operation, by 105 patients after 1 month, by 97 patients after 3 months, and by 92 patients after 6 months. The acoustic voice analysis was completed by all 111 patients preoperatively and 1 week after operation, by 102 patients after 1 month, by 92 patients after 3 months, and by 85 patients after 6 months.

Table 3 presents the clinicopathologic characteristics of the two groups. All the patients were females, and the mean age was significantly younger in the robotic group than in the open group. The distribution of pathologies, mean tumor sizes, types of thyroidectomy, and rates of central compartment neck dissection did not differ between the two groups. The operation times were significantly longer

Table 3 Clinicopathologic characteristics of the robotic and conventional open thyroidectomy groups

Characteristics	Robotic group ($n = 50$)	Open group ($n = 61$)	p Value
Gender (female:male)	50:0	61:0	
Age (years)	40.78 ± 9.618	54.36 ± 10.566	<0.001
Pathologic tumor type			0.275
Benign	6	12	
Malignant	44	49	
Size of tumor (mm)	12.52 ± 9.075	13.74 ± 12.136	0.555
Type of thyroidectomy			0.214
Lobectomy	13	10	
Total thyroidectomy	37	51	
CCND: n (%)	44/50 (88)	53/61 (86.9)	0.860
Operation time (min)	181.1 ± 39.0	147.3 ± 43.9	<0.001
Vocal risk factors: n (%)			
Smoking	1/50 (2)	2/61 (3)	0.679
Alcohol drinking	6/50 (12)	5/61 (8.2)	0.505
Laryngopharyngeal reflux: n (%)	31/50 (62)	34/61 (55.7)	0.505

CCND central compartment neck dissection

Table 4 Comparison of voice symptom scores (VSS) between the robotic and conventional open thyroidectomy groups

VSS	Robotic group ($n = 50$)	Open group ($n = 61$)	p Value
Preop	1.69 ± 3.67	1.58 ± 2.74	0.826
1 Day postop	3.79 ± 3.59	5.90 ± 5.24	0.008
	$p < 0.001$	$p < 0.001$	
1 Week postop	3.60 ± 3.74	4.71 ± 4.75	0.106
	$p < 0.001$	$p < 0.001$	
1 Month postop	4.61 ± 4.42	6.17 ± 5.71	0.049
	$p < 0.001$	$p < 0.001$	
3 Months postop	3.96 ± 4.37	5.60 ± 5.32	0.043
	$p = 0.001$	$p < 0.001$	
6 Months postop	3.52 ± 3.79	4.51 ± 4.55	0.182
	$p = 0.004$	$p < 0.001$	

Preop preoperative; *postop* postoperative

Table 5 Comparison of swallowing symptom scores (SSS) between the robotic and conventional open thyroidectomy groups

SSS	Robotic group ($n = 50$)	Open group ($n = 61$)	p Value
Preop	0.85 ± 1.39	0.62 ± 1.53	0.473
1 Day postop	2.46 ± 2.07	3.11 ± 2.85	0.142
	$p < 0.001$	$p < 0.001$	
1 Week postop	1.63 ± 1.86	1.82 ± 2.18	0.557
	$p = 0.001$	$p < 0.001$	
1 Month postop	1.94 ± 2.43	1.91 ± 2.72	0.933
	$p < 0.001$	$p < 0.001$	
3 Months postop	1.57 ± 1.99	1.83 ± 2.53	0.477
	$p = 0.004$	$p < 0.001$	
6 Months postop	0.75 ± 1.30	1.02 ± 2.02	0.372
	$p = 0.832$	$p = 0.234$	

Preop preoperative; *postop* postoperative

in the robotic group than in the open group. The voice risk factors including smoking, alcohol, and laryngopharyngeal reflux did not differ between the two groups.

None of the patients evidenced any paralysis of the RLN or the external branch of the superior laryngeal nerve at the pre- or postoperative videolaryngostroboscopic or flexible laryngoscopic examination. The changes in voice symptom scores are shown in Table 4. The mean voice symptom scores were significantly elevated 1 day after surgery and did not return to preoperative levels until 6 months postoperatively in either group. Comparison of the two groups showed that voice symptom scores were significantly lower in the robotic group 1 day, 1 month, and 3 months after surgery.

The mean swallowing symptom scores also were significantly elevated 1 day, 1 week, 1 month, and 3 months after surgery but had returned to preoperative levels by 6 months postoperatively in both groups. Comparison of the two groups showed that pre- and postoperative swallowing symptom scores did not differ between the two groups (Table 5).

The results of the objective acoustic voice analysis are presented in Table 6. No significant differences between the two groups were found in terms of mean F_0, jitter, shimmer, or NHR. The mean F-high was significantly reduced 1 week ($p = 0.024$), 1 month ($p = 0.021$), and 3 months ($p = 0.033$) after surgery in the open group, whereas the robotic group showed no significant effect. In addition, the mean F-high was significantly lower 3 months postoperatively in the open group than in the robotic group. The mean frequency range was significantly reduced 1 week ($p = 0.020$) after surgery in the robotic group, and 1 week ($p = 0.010$) and 3 months ($p = 0.002$) after surgery in the open group. The frequency range was significantly lower 3 months postoperatively in the open group than in the robotic group. The pre- and postoperative intensity ranges did not differ between the two groups. The mean MPT was reduced 1 week ($p < 0.001$) and 1 month ($p < 0.001$) after surgery in both groups and had returned to preoperative levels at 3 months postoperatively. The pre- and postoperative MPT did not differ between the two groups.

Discussion

Recurrent laryngeal nerve injury is the main cause of voice alteration after thyroidectomy. However, effects on the voice and swallowing are common complaints after thyroidectomy, even in the absence of impaired RLN function [18–30]. Voice alteration after uncomplicated thyroidectomy usually is temporary and includes various changes such as voice fatigue, roughness, low voice pitch, and volume reduction. Subjective voice symptoms increase immediately after thyroidectomy and gradually decrease to the preoperative level 3 or 6 months postoperatively [18, 20, 21, 25–28, 30]. Generally, subjective voice symptoms are more common than objective voice alterations. However, several authors have reported objective changes in acoustic parameters including F_0, shimmer, highest frequency, frequency range, highest intensity, and dysphonia severity index in the absence of laryngeal nerve injury after thyroidectomy [20, 21, 24, 30].

The mechanism of postthyroidectomy voice alteration without injury to the laryngeal nerve is not well understood. Possible causative factors include laryngotracheal fixation with impairment of vertical movement, cricothyroid muscle dysfunction, operative injury or temporary dysfunction of extralaryngeal strap muscles, orotracheal intubation trauma and laryngeal edema, severe retractile cervical scar, local neck pain, and psychological factors [20–22, 27, 28].

Table 6 Comparison of objective acoustic parameters between the robotic and conventional open thyroidectomy groups

	Robotic group ($n = 50$)	Open group ($n = 61$)	p Value
F_0 (Hz)			
Preop	216.4 ± 40.4	207.9 ± 37.0	0.694
1 Week postop	207.3 ± 28.2	201.4 ± 34.9	0.787
1 Month postop	206.5 ± 49.7	198. 6 ± 37.7	0.344
3 Months postop	211.5 ± 29.9	200.1 ± 29.2	0.254
6 Months postop	215.5 ± 27.3	204.2 ± 36.2	0.477
Jitter (%)			
Preop	0.97 ± 0.87	1.31 ± 0.89	0.254
1 Week postop	1.22 ± 0.89	1.10 ± 0.70	0.176
1 Month postop	1.05 ± 0.86	1.18 ± 1.13	0.423
3 Months postop	1.50 ± 3.46	0.98 ± 0.85	0.229
6 Months postop	1.12 ± 0.98	1.27 ± 2.04	0.634
Shimmer (%)			
Preop	3.59 ± 2.33	3.98 ± 2.51	0.296
1 Week postop	4.12 ± 2.47	3.80 ± 2.17	0.322
1 Month postop	3.06 ± 2.01	3.52 ± 3.05	0.284
3 Months postop	2.91 ± 1.38	3.49 ± 2.89	0.179
6 Months postop	3.16 ± 2.08	3.25 ± 2.30	0.832
NHR (dB)			
Preop	0.14 ± 0.05	0.14 ± 0.04	0.501
1 Week postop	0.15 ± 0.05	0.23 ± 0.97	0.451
1 Month postop	0.28 ± 1.23	0.21 ± 0.66	0.636
3 Months postop	0.13 ± 0.03	0.13 ± 0.03	0.377
6 Months postop	0.13 ± 0.05	0.13 ± 0.04	0.712
F-high (Hz)			
Preop	552.4 ± 254.6	534.8 ± 252.3	0.765
1 Week postop	479.3 ± 250.5	412.3 ± 225.9*	0.223
1 Month postop	504.7 ± 136.5	430.6 ± 165.3*	0.111
3 Months postop	519.7 ± 141.7	416.2 ± 123.8*	0.001
6 Months postop	513.5 ± 126.9	457.8 ± 134.5	0.077
F-low (Hz)			
Preop	127.1 ± 38.4	122.6 ± 33.1	0.603
1 Week postop	134.5 ± 39.1	117.5 ± 31.5	0.052
1 Month postop	119.1 ± 30.9	121.8 ± 57.2	0.824
3 Months postop	125.4 ± 32.7	121.7 ± 27.1	0.639
6 Months postop	132.9 ± 33.1	128.1 ± 29.0	0.594
Frequency range (no. of semitones)			
Preop	27.62 ± 9.27	26.85 ± 8.11	0.715
1 Week postop	22.21 ± 8.63*	21.3 ± 8.15*	0.658
1 Month postop	24.15 ± 8.14	24.79 ± 14.92	0.844
3 Months postop	26.04 ± 9.27	21.29 ± 7.35*	0.034
6 Months postop	24.08 ± 6.36	22.91 ± 7.18	0.550
Intensity range (dB)			
Preop	32.71 ± 11.37	33.60 ± 13.87	0.721
1 Week postop	27.71 ± 16.45	31.24 ± 13.94	0.212
1 Month postop	31.18 ± 15.53	32.56 ± 15.38	0.654
3 Months postop	28.48 ± 12.28	27.81 ± 12.81	0.820
6 Months postop	29.71 ± 14.16	26.75 ± 8.36	0.394
MPT (s)			
Preop	12.15 ± 5.54	12.91 ± 3.91	0.509
1 Week postop	10.58 ± 4.56*	11.39 ± 4.06*	0.439
1 Month postop	11.31 ± 4.68*	11.87 ± 4.25*	0.621
3 Months postop	12.54 ± 5.88	12.43 ± 4.63	0.943
6 Months postop	11.67 ± 3.67	12.43 ± 3.76	0.662

Preop preoperative; *postop* postoperative; F_0 fundamental frequency; *NHR* noise-to-harmonic ratio; *F-high* the highest frequency; *F-low* the lowest frequency; *MPT* maximum phonation time

* $p < 0.05$

The results of this study confirmed that thyroidectomy frequently results in subjective and objective vocal alterations, even in the absence of laryngeal nerve injury. To our knowledge, this is the first study that analyzed objective acoustic parameters after robotic thyroidectomy as well as subjective voice and swallowing symptoms. In this study, subjective voice function was significantly better in the robotic group than in the open group 1 day, 1 month, and 3 months after surgery. Moreover, in the objective acoustic voice analysis, the mean F-high was significantly higher and the frequency range significantly broader in the robotic group than in the open group at 3 months postoperatively.

The loss of frequency range may be associated with unilateral vocal fold paralysis [20]. The reductions in F_0, F-high, and frequency range also could be associated with an injury to the external branch of the superior laryngeal nerve [31]. Paralysis of the external branch of the superior laryngeal nerve may result in a low-pitched and monotonous voice, voice fatigue, hoarseness, and breathiness, although its effects are vague and nonspecific in some cases.

Videolaryngostroboscopy is an important diagnostic tool for evaluating the signs indicating paralysis of the external branch of the superior laryngeal nerve. The affected vocal fold seems to loosen and shorten and is at a lower level than the normal vocal fold. Laryngeal electromyography permits a definitive diagnosis of paralysis of the external branch of the superior laryngeal nerve. In laryngeal electromyography, fibrillation potentials and absence of recruitment point to paralysis of the external branch of the superior laryngeal nerve [32].

Because RLN and paralysis of the external branch of the superior laryngeal nerve were excluded in this study, we suppose that the subjective and objective voice alterations after robotic and open thyroidectomy were associated mainly with laryngotracheal fixation and impaired vertical movement of the larynx due to scar contracture or temporary malfunction of the strap muscles after surgery, as suggested previously [20].

It is known that the strap muscles have a positive relation to pitch elevation [33]. After thyroidectomy, the larynx and trachea adhere to the strap muscles because of scar formation, and the strap muscle and subcutaneous soft tissue also adhere to each other. Therefore, movement of the larynx and trachea during speech is impaired, resulting in defective pitch control during speech or singing.

Generally MPT and perturbations are affected by the status of the RLN. When the RLN is injured, the MPT decreases, and jitter and shimmer increase. In our study, MPT declined immediately after thyroidectomy in both groups. Because RLN paralysis was excluded, the reduction of MPT may have been related to the early postoperative neck pain or discomfort.

Less attention has been paid to functional swallowing outcomes after thyroidectomy [18, 19, 23, 27]. However, swallowing symptoms including painful swallowing, swallowing difficulty, and sensation of a lump or coughing during swallowing are common after thyroidectomy. These symptoms usually resolve after a short period but may persist longer as the voice changes in some circumstances [27].

In this study, subjective swallowing function did not differ between the two groups. However, there was a trend toward slightly better postoperative swallowing function in the robotic group, although the difference did not reach statistical significance. A previous study that evaluated voice and swallowing functions after robotic thyroidectomy using the gasless transaxillary approach also showed better subjective swallowing outcomes in the robotic group than in the open group [19]. Further studies with a larger number of cases are warranted to validate swallowing outcomes after robotic thyroidectomy.

Postthyroidectomy voice and swallowing alterations in the absence of laryngeal nerve palsy seem to be associated mainly with the routine healing process. Therefore, it is thought that less invasive techniques such as smaller incisions, limited dissection, and fewer traumas to the strap muscles could prevent this postthyroidectomy syndrome. In a study of voice and swallowing outcomes after minimally invasive video-assisted thyroidectomy (MIVAT), MIVAT caused fewer postthyroidectomy voice and swallowing alterations than open thyroidectomy. The authors suggested that reduced risk of injury to the perivisceral neural plexus, formed by small branches connecting the RLN and the external branch of the superior laryngeal nerve, due to the less extensive and finer dissection of the thyroid bed, could be responsible for the reduction in voice and swallowing changes after thyroidectomy [18].

In this study, the postoperatively subjective voice function and objective acoustic parameters were significantly better in the robotic group than in the open group. Based on these findings, it appears that robotic thyroidectomy using the GUAB approach may have a role in minimizing postthyroidectomy voice impairment, although the dissected area of skin flap is larger than in open thyroidectomy. Robotic thyroidectomy using the GUAB approach is characterized by the absence of cervical skin incision and limited dissection of the strap muscles without cutting. The absence of cervical skin incision, the limited dissection of the strap muscles, and the reduced adhesion between the strap muscles, subcutaneous tissues, and skin in robotic thyroidectomy using the GUAB approach may be the key factors responsible for the better voice outcomes in this study.

Several comparative studies have already shown that robotic thyroidectomy has significant advantages in terms of postoperative cosmesis and neck paresthesia, resulting in early surgical outcomes comparable with those after conventional open thyroidectomy, whereas surgical completeness and complication rates are similar [1–3, 5, 19]. Our study showed a further advantage in terms of better voice function after robotic thyroidectomy using the GUAB approach.

This study had some limitations. First, although videolaryngostroboscopic examination provided no evidence of paralysis of the external branch of the superior laryngeal nerve in any of the patients, we cannot exclude palsy of this branch because confirmatory laryngeal electromyographic examination was not performed. However, the results of this study can be trusted because paralysis of the external branch of the superior laryngeal nerve in most cases is shown by videolaryngostroboscopic examination or by clinical symptoms.

Second, age, gender, extent of surgery, smoking, alcohol, and laryngopharyngeal reflux can affect voice outcomes. The mean age differed in the two groups and may have influenced the results of the acoustic voice analysis. However, the effect of age on acoustic parameters was probably limited because we excluded very young and very old patients.

Third, we used relatively simple questionnaires that we developed to evaluate subjective voice and swallowing functions. These questionnaires may have limitations in that they were not validated with normal control groups, nor have they been validated in other studies. However, we think they are appropriate tools for assessing postthyroidectomy voice and swallowing alterations because they include questions about the typical symptoms of voice and swallowing after thyroidectomy. Moreover, their use by patients is easy and quick.

In conclusion, postoperative voice function is better with robotic thyroidectomy using the GUAB approach than with conventional open thyroidectomy. This is an additional advantage of robotic thyroidectomy using the GUAB approach in addition to the excellent cosmesis.

Disclosures Kyung Tae, Ki Yong Kim, Yong Bae Ji, Chul Won Park, Dong Sun Kim, Tae Wha Kim, and Bo Ram Yun have no conflicts of interest or financial ties to disclose.

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