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ORIGINAL ARTICLE

Voice Examination in Patients with Decreased High Pitch after Thyroidectomy

Sung Won Kim · Seung Tae Kim · Hyo Sang Park · Hyoung Shin Lee · Jong Chul Hong · Soon Bok Kwon · Kang Dae Lee

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Abstract Decreased high pitch after thyroidectomy due to injury of the external branch of superior laryngeal nerve (EBSLN) may be a critical, especially to professional voice users. The author studied the usefulness of VRP (voice range profile) and MDVP (multi-dimensional voice program) to evaluate patients who have decreased high pitch after thyroidectomy. A study was performed with 58 females and 9 males who underwent voice assessment between January 2008 and June 2009. The patients were classified as the group of female with no decreased high pitch (group A, $n = 52$), decreased high pitch (group B, $n = 6$) and the group of male with no decreased high pitch (group C, $n = 9$). VRP and laryngeal electromyogram (EMG) was performed in group B. Results: The preoperative frequency range of group A and B were statistically not different. In Group B, the result of VRP showed that the frequency range was 443.11 ± 83.97, 246.67 ± 49.41, 181.37 ± 80.13 Hz showing significant decrease after the surgery compared to that of the preoperative result. ($P < 0.05$) In addition, the intensity range was 22.25 ± 2.87, 15.25 ± 2.22, 16.25 ± 2.63 dB respectively showing significant postoperative decrease. ($P < 0.05$) EMG of the cricothyroid muscle of group B showed decreased potential with 3 patients, normal potential in 2, and the other patient refused to take the examination. In group A and C, the result of VRP revealed no significant difference between the preoperative and postoperative result. VRP is a noninvasive, quick, and practical test to demonstrate decreased frequency range visually and helps to evaluate EBSLN injury in patient with thyroidectomy.

Keywords Thyroidectomy · Voice disorders · Superior laryngeal nerve

Introduction

Decreased high pitch after thyroidectomy may result from injury to the external branch of superior laryngeal nerve (EBSLN) or from causes other than nerve injury [1]. It may be a serious complication for professional voice users. Decreased high pitch may not be noticed during normal phonation because a significant change in voice quality, such as hoarseness, may not be present. Furthermore, if the surgeon does not evaluate the larynx before and after the surgery or has no interest in or knowledge of voice analysis, decreased high pitch may be overlooked or underestimated.

Most surgeons preserve the EBSLN without positive identification of the nerve by performing careful dissection and ligation of the superior thyroid vasculature adherent to the thyroid capsule [2]. While recurrent laryngeal nerve (RLN) injury may be easily detected through postoperative

S. W. Kim · S. T. Kim · H. S. Park · K. D. Lee
Department of Otolaryngology-Head and Neck Surgery, Kosin University College of Medicine, Busan, Korea

H. S. Lee
Department of Otolaryngology-Head and Neck Surgery, Graduate School, Kosin University, Busan, Korea

J. C. Hong
Department of Otolaryngology-Head and Neck Surgery, Dong-A University College of Medicine, Busan, Korea

S. B. Kwon
Department of Language and Information, College of Humanities, Pusan National University, Busan, Korea

K. D. Lee (✉)
Department of Otolaryngology, Kosin University Gospel Hospital, Am-Nam Dong 34, Seo-Gu, Busan 602-702, Korea
e-mail: kosinent@yahoo.co.kr

videostroboscopy, EBSLN injury may be difficult to evaluate. Laryngeal electromyography (EMG) has been accepted as an objective method for evaluation of nerve injury; however, it is invasive and relatively difficult to conduct. Voice analysis is a simple and non-invasive method that is useful for providing objective data in the form of a visual graphic regarding changes in voice quality and the frequency range. Although there are numerous studies documenting the complications of RLN injury and postoperative swallowing discomfort after thyroidectomy, studies rarely focus on superior laryngeal nerve (SLN) injury and decreased high pitch. The authors studied the usefulness of the voice range profile (VRP), multi-dimensional voice program (MDVP) and maximal phonation time (MPT) for evaluation of patients with decreased high pitch after thyroidectomy.

Materials and Methods

A prospective study was performed with 67 of the 156 patients who underwent thyroidectomy at our center between January 2008 and June 2009. The 67 patients were those who agreed to undergo voice assessment both prior to and at 1 week and 3 months after the surgery. The patients included 58 females and 9 males. Six female patients showed decreased high pitch. The extent of the surgery included 57 cases of total thyroidectomy and 10 cases of lobectomy. The patients were classified into three groups. Group A ($n = 52$) consisted of females without decreased high pitch, group B ($n = 6$) consisted of females who subjectively complained of decreased high pitch after the surgery, and group C ($n = 9$) consisted of males without decreased high pitch. Since males have a lower frequency range, group C was included as a separate group for comparison with group A. VRP was performed to identify the frequency range and the intensity range, and MDVP was performed to evaluate the jitter, shimmer, noise-to-harmonic ratio (NHR), and fundamental frequency (F_0). Maximal phonation time (MPT) was also obtained. Laryngeal EMG was performed in five of the six group B patients to detect any objective change. Patients with preoperative vocal cord paralysis or vocal lesions, such as nodules or polyps, and those with iatrogenic RLN injury that was definitely identified during surgery were excluded from the study. Patients without preoperative voice examination were also excluded. None of the subjects were trained vocalists with particular patterns of phonation compared to those of the general population. All of the patients underwent videostroboscopy and attention was paid to the patients in group B.

All surgical procedures were performed with the traditional open thyroidectomy technique. The superior thyroid pole was mobilized carefully to avoid injury to the EBSLN. The superior thyroid vessels were isolated and ligated individually, adhering closely to the thyroid capsule. When the EBSLN was not readily identifiable, no further dissection was pursued to avoid inadvertent nerve injury. In addition, surgeons avoided producing injury of the cricothyroid muscle secondary to electrocoagulation or manual retraction.

Acoustic analysis was conducted by a speech pathologist using Computerized Speech Lab (CSL, KAY Electrics Corp, Model 4500, NJ, USA). The examiner conducted the modeling and calibration before the examination to prevent any instrumental bias and to obtain objective data.

After adequate inspiration, phonation from the lowest note to the highest note was performed, and the note was demonstrated on the piano keyboard of the software screen. Then the minimum frequency and the maximum frequency were measured.

This vocal range profile confirmed that the high frequency was decreased. Then we examined the following two tests.

The patient was comfortably seated on a chair and told to say/a/for 3 s with a comfortable level of effort that allowed the voice to be recorded with a microphone 10 cm away from the lips. F_0, jitter, shimmer, and NHR were analyzed by MDVP, which is software for acoustic analysis.

MPT is an aerodynamic test that was measured during phonation of/a/after full inspiration at a constant pitch and intensity. The examination was conducted 3 times consecutively, and the maximum was taken. The pitch and intensity of the phonation were measured at a natural state of 0.5 s.

Laryngeal EMG was conducted in the Department of Rehabilitation 3 months after thyroidectomy when the voice examination was performed. VikingSelect™ Neurodiagnositic System (Nicolet Biomedical, WA, USA) was used. The patient was placed in a supine position with a pillow below the shoulders with neck extended and chin raised upward. The ground electrode and the reference electrode were placed on the skin of the lateral neck. The needle was inserted below the upper surface of the cricoid cartilage, 0.5–1 cm lateral to the median line and directed superolaterally to the inferior thyroid tubercle. Penetration of the muscular fascia could be felt when the needle was inserted 1 cm into the skin. The resting state was examined initially to detect any abnormal spontaneous action potentials, and then we checked for the presence of complete recruitment of motor unit action potentials (MUAP) during volitional high pitch phonation.

All experiments were performed in triplicate. Data were analyzed by SPSS version 17.0 for Windows (SPSS, Chicago, IL, USA) and were expressed as the mean ± standard deviation. Statistical analyses were conducted using

analysis of variance (ANOVA–Tukey's test) between groups and statistical significance was set at $P < 0.05$.

Results

The incidence of decreased high pitch diagnosed as EBSLN injury using laryngeal EMG is presented in Table 1.

Two cases (3%) of permanent paralysis and one case (1.5%) of temporary paralysis after total thyroidectomy were identified. Considering the 124 nerves at risk, four cases (3.2%) of EBSLN paralysis occurred with total thyroidectomy.

The results of VRP before surgery and 1 week and 3 months after surgery are presented in Table 2.

The preoperative frequency ranges of groups A and B were not statistically different. The frequency ranges of group B preoperatively and at 1 week and 3 months after surgery were 443.11 ± 83.97, 246.67 ± 49.41, 181.37 ± 80.13 Hz, respectively, showing a significant decrease at 1 week and 3 months after the surgery as compared to the preoperative result. The intensity ranges preoperatively and at 1 week and 3 months after surgery were 22.25 ± 2.87, 15.25 ± 2.22, and 16.25 ± 2.63 dB, respectively, also showing a significant decrease after surgery ($P < 0.05$). Group A and C revealed no significant difference between the preoperative results and those at 1 week and 3 weeks after the operation. MDVP and MPT results before surgery and at 1 week and 3 months after surgery are presented in Tables 3 and 4.

F_0, jitter, shimmer, and NHR from MDVP showed no significant differences between the preoperative results and those at 1 week and 3 weeks after the operation.

The results of laryngeal EMG from Group B are presented in Table 5.

Five out of the six patients with decreased high pitch underwent laryngeal EMG, but one refused the examination. Three patients (cases 1, 2, 3) showed reduced recruitment of MUAP at one or both cricothyroid muscles. Case 3 showed reduced recruitment of MUAP; however, reinnervation was expected showing a polyphasic pattern. Two patients (cases 4 and 5) showed decreased high pitch even though they had normal EMG.

The results of VRP and laryngeal EMG from the five patients who underwent laryngeal EMG are described. VRP before surgery (A) and at 1 week (B) 3 months (C), and 6 months after (D) surgery and laryngeal EMG of right cricothyroid muscle (E) and left cricothyroid muscle (F) are presented.

The frequency ranges from the VRP of case 1 were (a) 155.3–415.3 Hz, (b) 146.83–329.63 Hz, and (c) 146.83–293.66 Hz, showing a marked postoperative decrease. The laryngeal EMG showed a significant decrease in recruitment of MUAP in the right cricothyroid muscle during high pitch phonation. The frequency range of (d) 155.56–293.66 Hz after 6 months showed no signs of recovery. Thus, this case had permanent injury of the right EBSLN (Fig. 1).

The frequency ranges from the VRP of case 2 were (a) 155.56–554.37 Hz, (b) 130.81–196 Hz, and (c) 116.54–185 Hz, showing a marked decrease after the surgery. The laryngeal EMG showed almost complete loss of recruitment of MUAP in both cricothyroid muscles during

Table 1 Incidence of decreased high pitch diagnosed as EBSLN injury

	EBSLN paralysis[a]		Total
	Permanent paralysis[a]	Temporary paralysis[b]	
Extent of thyroidectomy			
TT + CCND ($n = 57$)	2 (3%)	1 (1.5%)	3 (4.5%)
Lobectomy ($n = 10$)	–	–	–
Nerve at risk ($n = 124$)	3 (2.4%)	1 (0.8%)	4 (3.2%)

TT + CCND total thyroidectomy and central compartment neck dissection

[a] Permanent paralysis: paralysis with laryngeal EMG abnormality and irreversible for 6 months

[b] Temporary paralysis: paralysis reversible within 6 months

Table 2 Preoperative and postoperative VRP

	Preoperative	1 week after operation	3 months after operation
Group A			
Frequency range (Hz)	352.37 ± 138.57[NS]	331.53 ± 116.84	388.72 ± 142.97
Intensity range (dB)	17.14 ± 4.03[a]	14.10 ± 4.73[ab]	15.88 ± 5.73[ab]
Group B			
Frequency range (Hz)	443.11 ± 83.97[a]	248.67 ± 49.41[b]	181.37 ± 80.13[b]
Intensity range (dB)	22.25 ± 2.87[a]	15.25 ± 2.22[b]	16.25 ± 2.63[b]
Group C			
Frequency range (Hz)	176.50 ± 49.48[NS]	189.85 ± 44.76	190.58 ± 57.51
Intensity range (dB)	17.71 ± 4.31[NS]	15.43 ± 3.60	15.86 ± 5.34

Values are mean ± SD. Values with different *superscripts* in the same column are significantly different at $P < 0.05$

NS not significant

Table 3 Preoperative and postoperative MDVP

	Preoperative	1 week after operation	3 months after operation
Group A			
F_0 (Hz)	199.06 ± 18.38^{NS}	201.39 ± 22.19	198.21 ± 19.59
Jitter (%)	1.377 ± 0.978^{NS}	1.604 ± 1.110	1.450 ± 0.915
Shimmer (%)	3.714 ± 1.395^{NS}	3.855 ± 1.938	4.145 ± 1.466
NHR (%)	0.126 ± 0.018^{NS}	0.125 ± 0.027	0.128 ± 0.021
Group B			
F_0 (Hz)	191.73 ± 17.46^{NS}	184.84 ± 35.18	187.53 ± 38.04
Jitter (%)	0.779 ± 0.499^{NS}	1.450 ± 0.766	1.100 ± 0.730
Shimmer (%)	2.924 ± 0.537^{NS}	3.004 ± 1.237	3.131 ± 1.423
NHR (%)	0.129 ± 0.012^{NS}	0.138 ± 0.016	0.141 ± 0.018
Group C			
F_0 (Hz)	124.33 ± 11.95^{NS}	117.39 ± 6.71	118.13 ± 6.14
Jitter (%)	0.752 ± 0.460^{NS}	0.629 ± 0.366	0.713 ± 0.494
Shimmer (%)	3.317 ± 0.665^{NS}	3.775 ± 1.391	3.720 ± 1.488
NHR (%)	0.125 ± 0.007^{NS}	0.136 ± 0.005	0.136 ± 0.024

Values are mean ± SD. Values with different *superscripts* in the same column are significantly different at $P < 0.05$

NS not significant

Table 4 Preoperative and postoperative MPT

	Preoperative	1 week after operation	3 months after operation
Group A	15.25 ± 3.91^{NS}	14.05 ± 4.45	15.57 ± 5.05
Group B	14.50 ± 4.36^{NS}	14.00 ± 1.16	11.22 ± 2.80
Group C	17.57 ± 3.10^{NS}	16.00 ± 3.79	17.90 ± 2.26

Table 5 Results of laryngeal EMG from Group B

Case	Sex	Age	Diagnosis	Laryngeal EMG	Results
1	F	45	PTC	Examined	Complete denervation of right cricothyroid m.
2	F	58	PTC	Examined	Complete denervation of both cricothyroid m.
3	F	48	PTC	Examined	Partial denervation or reinnervation of left cricothyroid m.
4	F	47	PTC	Examined	Normal
5	F	42	PTC	Examined	Normal
6	F	33	PTC	Refused	

PTC papillary thyroid carcinoma

high pitch phonation. The frequency range of (d) 123.47–233.08 Hz 6 months after surgery showed no signs of recovery. Thus, this case had permanent injury of both EBSLNs (Fig. 2).

The frequency ranges from the VRP of case 3 were (a) 155.56–698.46 Hz, (b) 130.81–261.63 Hz, and (c) 116.54–233.08 Hz, showing a gradual decrease after the surgery. The laryngeal EMG showed great loss of recruitment of MUAP in the left cricothyroid muscle during high pitch phonation. However, the polyphasic pattern identified in this case indicated possible recovery and eventually showed recovery of (d) 164.81–622.25 Hz 6 months after the surgery. Thus, this case could be considered to have experienced temporary paralysis or a stage of reinnervation (Fig. 3).

The frequency ranges from the VRP of case 4 were (a) 207.65–554.37 Hz, (b) 174.61–466.16 Hz, and (c) 185–349.23 Hz, showing a mild decrease after the surgery. The laryngeal EMG was normal in both cricothyroid muscles during high pitch phonation. In this case, the patient complained of decreased high pitch and the frequency range decreased after the surgery. However, since the laryngeal EMG showed normal results, recovery was expected. The frequency range eventually recovered to (d) 196–440.25 Hz 6 months after the surgery. Thus, in this case causes other than injury of EBSLN were suspected (Fig. 4).

In case 5, the patient complained of decreased high pitch after the surgery. However, the frequency ranges from the VRP were (a) 185–698.46 Hz, (b) 196–695.26 Hz, and

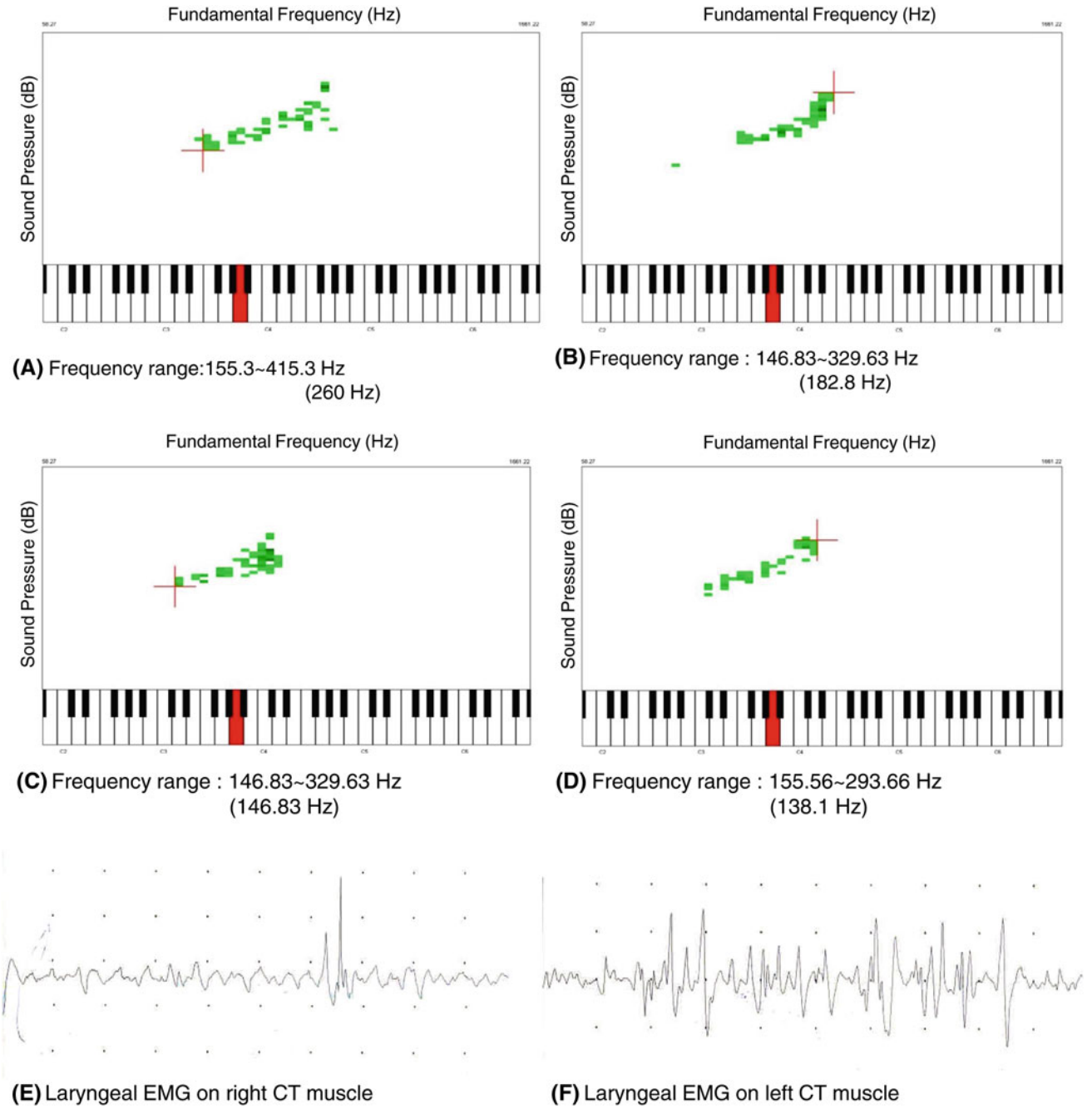

Fig. 1 Results of VRP and EMG in case 1. The frequency ranges were **a** 155.3–415.3 Hz before surgery, **b** 146.83–329.63 Hz 1 week after surgery, **c** 146.83–293.66 Hz 3 months after surgery, and **d** 155.56–293.66 Hz 6 months after surgery. The laryngeal EMG showed significantly decreased recruitment of MUAP in the right cricothyroid muscle during high pitch phonation

(c) 185–659.26 Hz, showing no significant changes after the surgery. The laryngeal EMG also showed normal findings in both cricothyroid muscles during high pitch phonation. In this case, the patient had subjectively decreased high pitch after the surgery, but showed normal results on VRP and laryngeal EMG, excluding the possibility of EBSLN injury (Fig. 5).

Discussion

Thyroidectomy has been reported as the most frequent cause of EBSLN injury. Diagnosis of EBSLN injury may be difficult because the symptoms are nonspecific in many cases. However, advanced diagnostic techniques have revealed the incidence to be relatively high, ranging from 5 to 28% [3–5].

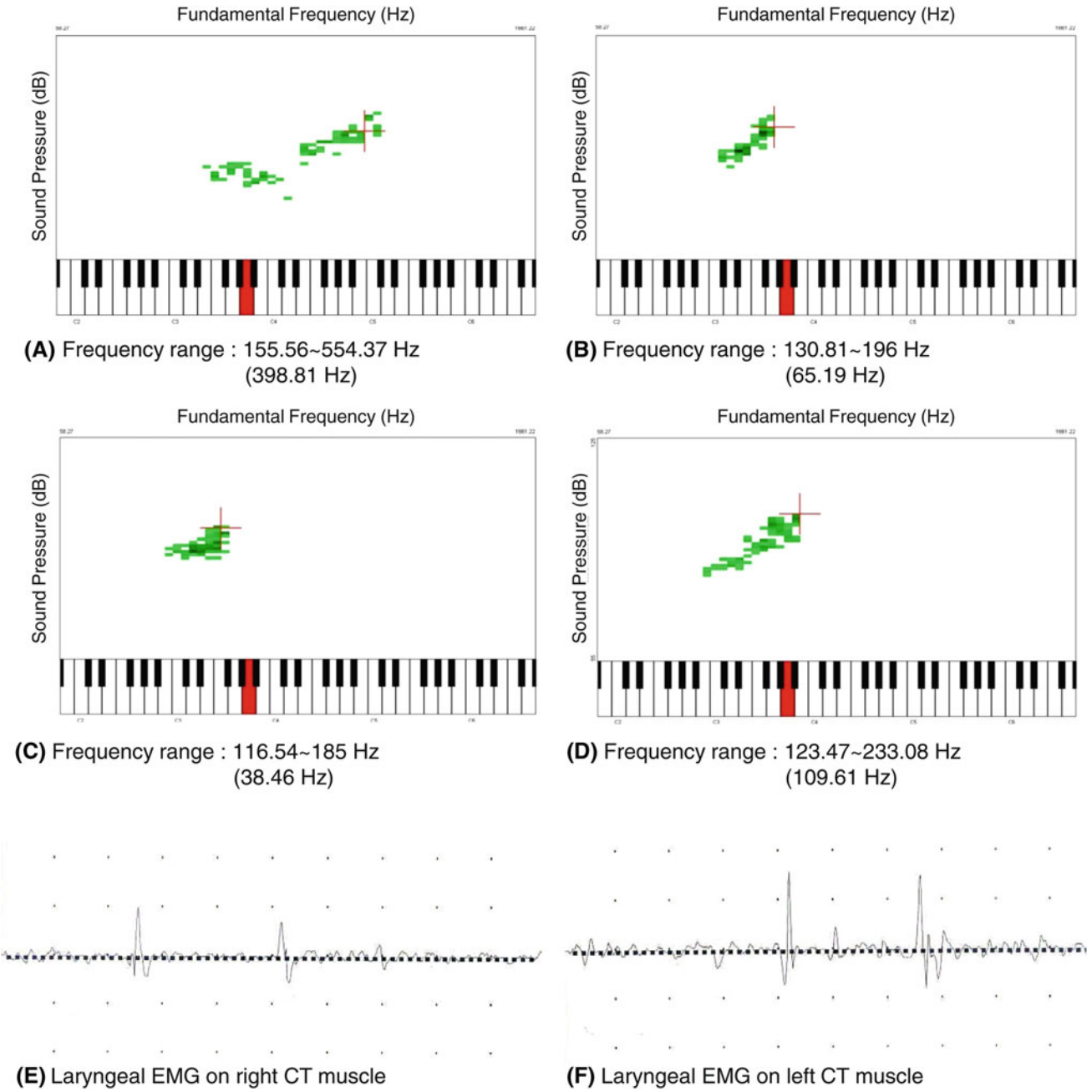

Fig. 2 Results of VRP and EMG in case 2. The frequency ranges were **a** 155.56–554.37 Hz before surgery, **b** 130.81–196 Hz 1 week after surgery, **c** 116.54–185 Hz 3 months after surgery, and **d** 123.47–233.08 Hz 6 months after surgery. The laryngeal EMG showed almost complete loss of recruitment of MUAP in both cricothyroid muscles during high pitch phonation

Paralysis of the EBSLN causes difficulty with high pitch phonation and decreased pitch range secondary to failure of cricothyroid muscle stimulation and lack of tension in the vocal cord. This symptom may be extremely serious for professional voice users. EBSLN injury can also cause vocal fatigue, hoarseness, breathy sounding voice, and vocal nodules, resulting in loud speech that results in an ability to produce high pitch phonation. However, not all cases of post-thyroidectomy dysphonia are related to nerve injury, and there are patients who complain of postoperative dysphonia when the nerve is preserved [6]. Therefore, objective methods for evaluation of patients are needed in order to provide patients with an explanation of the status of any potential injury and to plan for further management according to the expected prognosis.

There are important clinical findings on laryngeal videostroboscopy that suggest EBSLN injury. The paretic or paralytic vocal cord shortens with lack of tension, and the

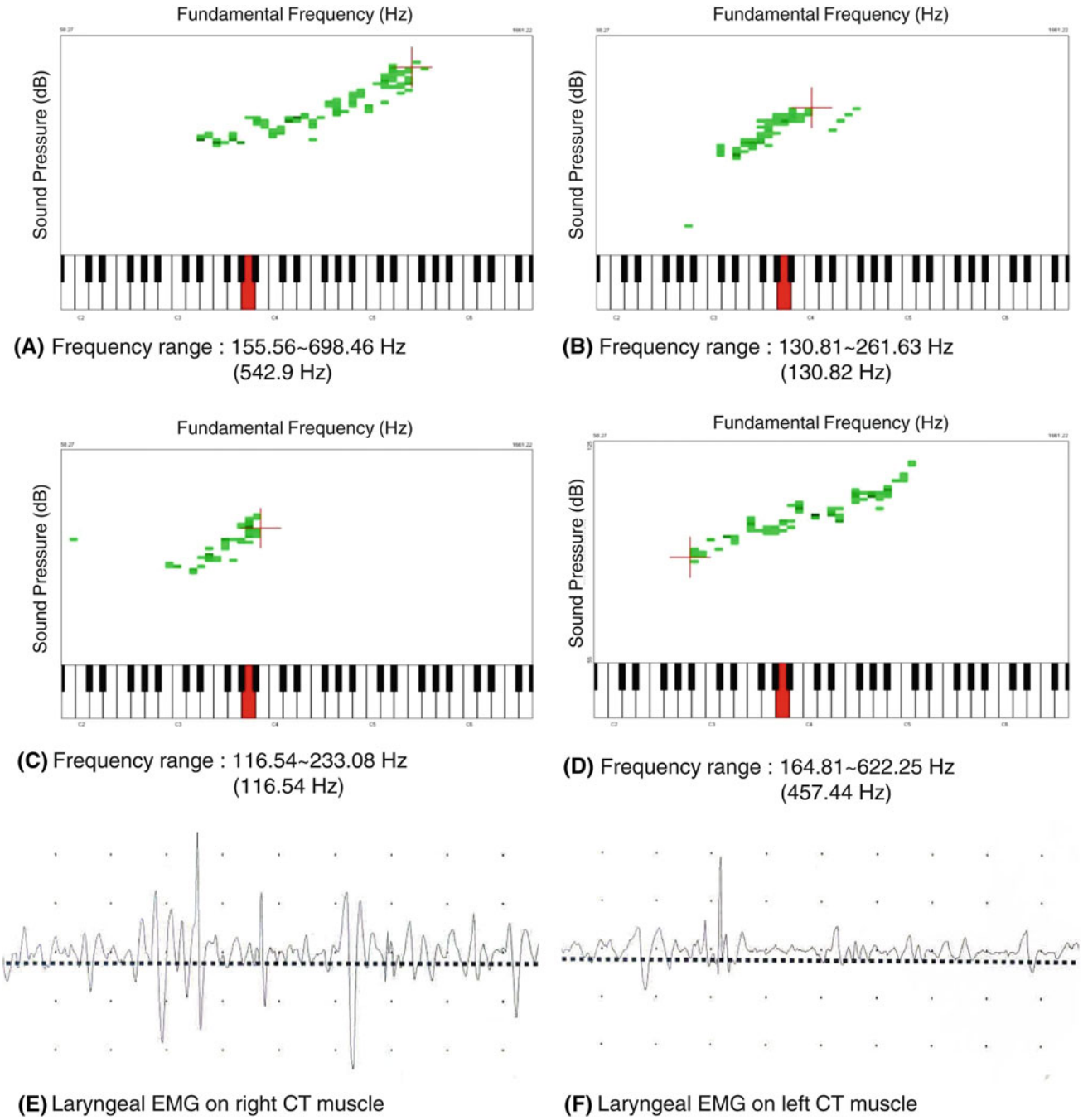

Fig. 3 Results of VRP and EMG in case 3. The frequency ranges were **a** 155.56–698.46 Hz before surgery, **b** 130.81–261.63 Hz 1 week after surgery, **c** 116.54–233.08 Hz 3 months after surgery, and **d** 164.81–622.25 Hz 6 months after surgery. The laryngeal EMG showed substantial loss of recruitment of MUAP along with a polyphasic pattern in the left cricothyroid muscle during high pitch phonation

weak vocal cord is located at a lower vertical level than the normal cord so that the normal cord overlaps the weak cord. The vocal cord may also move in the vertical direction during high pitch phonation. Bowing of the vocal cord may lead to incomplete glottis closure. In cases of severe paralysis, the larynx may be tilted to the paralytic side due to overstimulation of the normal cricothyroid muscle [5, 7, 8]. However, such findings were not identified in patients in group B of this study. These findings are demonstrated in severe paralysis of the cricothyroid muscle, paralysis of the recurrent laryngeal nerve, and also in the elderly or other neurologic diseases. Thus it may be difficult to use the findings of laryngeal videostroboscopy to differentiate EBSLN injury from other causes [7, 9].

Acoustic analysis in EBSLN injury may be helpful to provide analysis of the regularity of vocal phonation and also

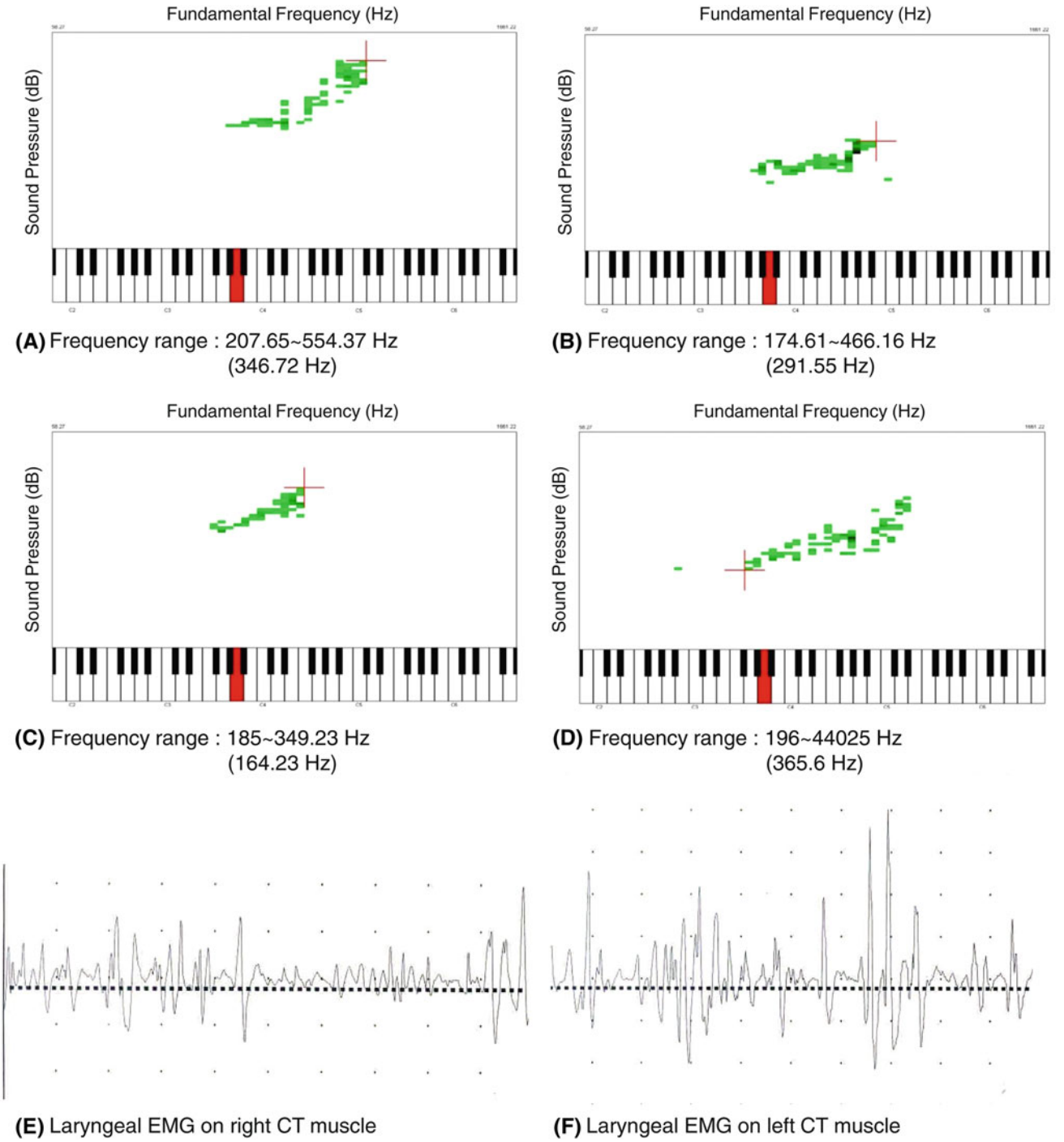

Fig. 4 Results of VRP and EMG in case 4. The frequency ranges were **a** 207.65–554.37 Hz before surgery, **b** 174.61–466.16 Hz 1 month after surgery, **c** 185–349.23 Hz 3 months after surgery, and **d** 196–440.25 Hz 6 months after surgery. The laryngeal EMG was normal in both cricothyroid muscles during high pitch phonation

to visually demonstrate the vocal change in the form of graphs [10, 11]. MDVP includes jitter, which indicates the pitch variation, and shimmer, which indicates the amplitude variation. Alterations of regularity in the normal individual are very small but substantial enough to characterize one's voice, and excessive irregularity may indicate a pathologic state. NHR is a representative index that indicates the noise degree in a vocal wave. NHR is measured by categorizing and evaluating each sound wave in terms of regular components and irregular components. It is known that NHR increases as a lesion gets more severe. In this study, jitter, shimmer, NHR, and F_0 showed no significant difference

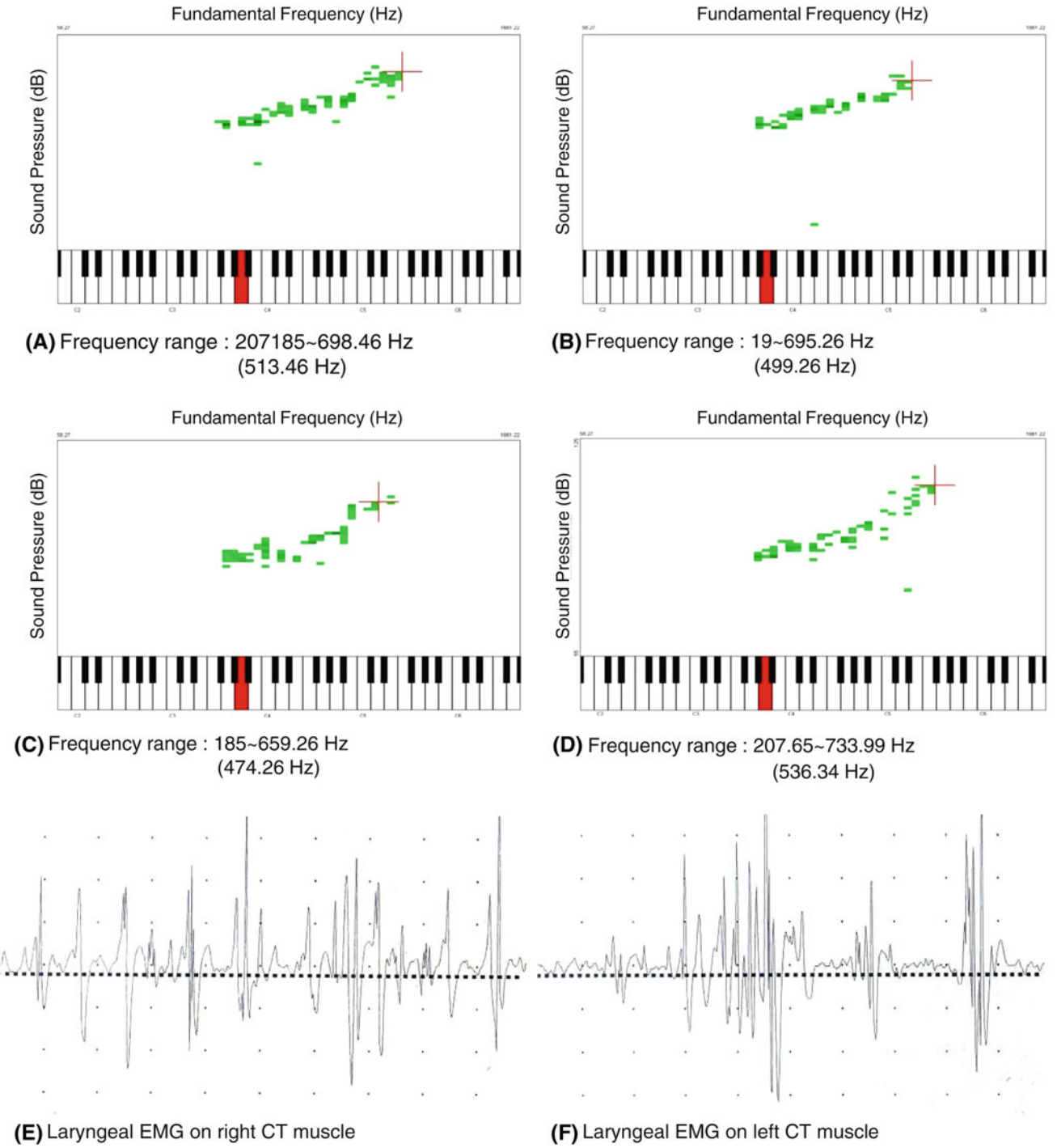

Fig. 5 Results of VRP and EMG in case 5. The frequency ranges were **a** 185–698.46 before surgery, **b** 196–695.26 Hz 1 week after surgery, **c** 185–659.26 Hz 3 months after surgery, and **d** 207.65–733.99 Hz 6 months after surgery. The laryngeal EMG showed normal findings in both cricothyroid muscles during high pitch phonation

between the preoperative and postoperative results. The results indicated that patients with minor injury of the EBSLN showed good vocal cord adduction and regular phonation. This may be related to the normal findings of the laryngeal videostroboscopy. In clinical situations, EBSLN injury could easily be neglected by both the patient and the surgeon since the voice change may not be as prominent as the hoarseness observed in RLN injury. If the surgeon does not pay attention to the findings of laryngeal videostroboscopy both before and after the surgery or does not have interest in or knowledge of voice analysis, EBSLN injury could easily be overlooked or underestimated.

VRP is widely used to check the frequency range of phonation since the test is simple and quick and demonstrates the results visually. However, it is seldom used to demonstrate difficulty with high pitch phonation after thyroidectomy. In this study, decreased high pitch after surgery was easily detected as a decrease in high pitch in the frequency range of VRP in cases 1, 2, 3, and 4. In case 5, the patient complained of subjective discomfort; however, an objective difference in preoperative and postoperative frequency ranges was not identified. When laryngeal EMG is performed together with VRP we can differentiate between neurogenic and non-neurogenic changes, and also assess the clinical prognosis. In group B, the result of VRP also showed a postoperative decrease in intensity range, a measurement reflecting the loudness of phonation. It is believed that changes in the position of the vocal cords, as well as changes in the vibration phases during phonation, affect the intensity range of phonation in these patients. Although further research is needed that provides exact measures of the loudness of phonation and further examination of variables that may confound study results, including the appropriate distance for microphone placement, EBSLN damage should be considered in post-thyroidectomy patients with intensity range changes. Thus VRP could be considered a screening test for evaluation of decreased high pitch in patients who have undergone thyroidectomy. However, we were unable to conduct laryngeal EMG, which is needed to verify the sensitivity and specificity of VRP, in all of the patients. This remains a limitation of this study. According to the post-surgery VRP examination, the patients in groups A and C did not have significant decreases in high pitch. However, it is possible for patients to be unaware of decreased high pitch if they are not professional vocalists.

It has been reported that MPT decreases and the mean airflow rate increases in patients with EBSLN injury. However, there was no significant difference between the three groups in our study before and after the surgery. A decrease of phonation time may be related to glottic incompetence in many cases, such as in cases of paralysis of the recurrent laryngeal nerve, sulcus vocalis, and large vocal polyp. In this study, the decrease in vocal cord tension from cricothyroid muscle dysfunction due to EBSLN injury did not lead to glottic incompetence, which may be the reason for the absence of a significant decrease in MPT. Robinson et al. [12] reported that MPT and frequency range decreased and jitter, shimmer, and NHR increased in patients with EBSLN paresis; they concluded that acoustic analysis is useful for evaluation of EBSLN paresis. Another study reported that difficulty with high pitch phonation occurred and speaking F_0 changed after severe damage of the EBSLN in female patients and professional voice users, such as singers or teachers [13].

Laryngeal EMG of the cricothyroid muscle is a mandatory examination for confirmation of EBSLN paralysis in patients with decreased high pitch after thyroidectomy. Paresis of the EBSLN reveals polyphasic units with decreased recruitment of MUAP, while paralysis results in fibrillation and the absence of recruitment of MUAP. Among six patients who had subjective symptoms, three patients showed decreased recruitment of MUAP. Their symptoms may be related injury of the nerve. Two patients showed normal findings. The laryngeal EMG was performed 3 months after the surgery. However, taking temporary paralysis into consideration, follow-up out to 12 months and an additional examination would be required to evaluate the possibility of future recovery. Some authors do not recommend laryngeal EMG since it is invasive. However, the discomfort and morbidity of the examination are acceptable and could be conducted, after obtaining informed consent, in patients with decreased high pitch.

It seems that decreased high pitch after thyroidectomy may be due to permanent or temporary paralysis from direct nerve injury or due to causes other than nerve injury. In our study, cases 1 and 2 showed decreased frequency range in the VRP and were confirmed as nerve injury through laryngeal EMG. Although it was a single case, case 2 had bilateral degeneration of the EBSLNs and more severe postoperative discomfort and a larger decrease in frequency range than case 1. To confirm this association, comparative study with more cases should be conducted. Case 3 showed a polyphasic pattern on laryngeal EMG, although somewhat atypical, and showed recovery to normal frequency range by 6 months after the surgery. This indicates the paralysis was temporary. Preservation of the RLN and EBSLN is important for maintaining vocal function; however, not all post-thyroidectomy voice changes are related to nerve injury. The mechanism of voice change after thyroidectomy with preservation of the nerve is not fully understood. Possible causes include damage to the extralaryngeal muscles, such as the strap muscles; laryngotracheal fixation of the strap muscles during the healing process; postoperative fibrosis; laryngeal edema; effects of endotracheal intubation for general anesthesia; and injury of the arytenoids [1, 14, 15]. We assume that the decreased high pitch in cases 4 and 5, which had normal findings on laryngeal EMG, could be attributed to such causes. Unless the nerve is directly injured, these causes should be prevented. The surgeon should consult with the anesthesiologist to prevent trauma to the arytenoid during endotracheal intubation, and factors such as arytenoid swelling should be fully explained. Cosmetic factors should be considered because small incisions require heavy retraction, which could damage the skin or the muscles. However, an appropriate incision

should be performed so that the retractor or the electrocautery do not damage the cricothyroid muscles during upper pole dissection. Suture closure should be conducted layer by layer to avoid adhesion of strap muscles or subcutaneous tissues to the larynx and trachea.

There are many cases of phonetic changes, such as hoarseness, vocal fatigue, and decreased high pitch, after thyroidectomy. To verify these changes, we have to confirm the normal movement of larynx, the changes of vocal cord shape, and the tension of the vocal cord by videostroboscopy. However, it is difficult in clinical practice for physicians other than otolaryngologists, who perform neck surgery, to evaluate voice disorders by videostroboscopy because the procedure is time consuming and involves specific instruments and extra costs. Additionally, it is unpleasant for patients [14].

The vocal examination is a noninvasive, quick, and easy-to-use examination that provides a sum of vocal parameters that is useful in discriminating different voice disturbances. It is a more comfortable, easier, subjective and objective postoperative voice assessment, and it is, therefore, an efficient tool for assessing vocal cord changes before and after thyroid surgery. The VRP test is an easy and practical test that gives a visual representation of the frequency range and helps to evaluate EBSLN injury in patients with decreased high pitch after thyroidectomy.

One of the limitations of this study was the small sample size, which was due to the low incidence of injury to the external branch of superior laryngeal nerve (EBSLN) that is due to physicians working hard to save the EBSLN during surgery. In spite of efforts to avoid EBSLN injury, it occurs in some cases and the injury rate in this study was 3.8%.

Conclusions

In patients with decreased high pitch after thyroidectomy, EBSLN injury should be prominent in the differential diagnosis. VRP is a noninvasive, simple, easy, and practical method that is useful for identifying decreases in the frequency range and provides objective data regarding dysphonia. Laryngeal EMG could be added to evaluate whether there is a definite nerve injury and also to assess the prognosis of the dysphonia.

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