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MAIN ARTICLE

Lateral neck dissection affects the voice in thyroid cancer patients

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Abstract

Objective: This study aimed to identify the effect of lateral neck dissection on voice change in thyroidectomised patients.

Methods: Medical records from 264 patients who underwent thyroidectomy with ($n = 65$) or without ($n = 199$) lateral neck dissection were reviewed. Clinical and voice evaluation data were compared between the two groups.

Results: Patients who underwent surgery that included lateral neck dissection had lower fundamental frequencies and speaking fundamental frequencies. They also had a higher incidence of asymmetric mucosal wave and vocal fold oedema on videostroboscopy during the first month after surgery, with the incidence of vocal fold oedema remaining significantly higher at three months. Self-assessed voice quality scores were significantly higher in lateral neck dissection patients at both one and three months after surgery.

Conclusion: In thyroidectomised patients, lateral neck dissection lowers the vocal pitch in the initial period after surgery and induces vocal fold oedema that persists for several months. Although most objective parameters improved within a month, subjective symptoms lasted for longer.

Key words: Thyroidectomy; Neck Dissection; Voice

Introduction

Thyroid surgery is associated with a 25–84 per cent risk of voice alteration.[1–3] Injury or accidental damage of the recurrent laryngeal nerve resulting in vocal fold paralysis is the best-established cause of voice change after thyroidectomy; injury to the external branch of the superior laryngeal nerve was recently recognised as another important cause.[4,5] However, some patients experience voice change even without laryngeal nerve injury.[6] In such patients, objective measurements of acoustic parameters of vocal function changed significantly. Although the pathophysiology is not well understood, multiple causes have been hypothesised and objective outcomes and the natural course following surgery have been widely studied.[6–8]

The current authors previously reported that patients who underwent central neck dissection during uncomplicated thyroidectomy had a higher risk of developing globus symptoms and voice changes than those who did not.[9] Thus, voice implications following thyroidectomy and central neck dissection are well understood. However, no studies have focused on voice outcomes following lateral neck dissection in thyroid cancer patients. There is also little data on the natural course of voice change after lateral neck dissection. Reasons for this may include the low incidence of lateral neck dissection in thyroid cancer patients and indifference to the effect of lateral neck dissection on dysphonia. Therefore, the present study aimed to (1) investigate the additive effect of lateral neck dissection on subjective and objective voice change and (2) determine the natural course of any voice disturbance in thyroid cancer patients undergoing thyroidectomy.

Materials and methods

Study design

Medical records from 714 consecutive patients who underwent total thyroidectomy with bilateral central neck dissection with or without lateral neck dissection between January 2010 and December 2012 were evaluated. Patients with a history of head and neck surgery (including previous thyroid surgery) or of other disorders or conditions lasting for more than one month (at the time of the examination) that may have affected their voice quality (e.g. sinusitis, allergic rhinitis or recent upper respiratory infection) were excluded. Patients with vocal fold paralysis before or after

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surgery were also excluded. A total of 264 patients were enrolled in the study. All participants underwent perceptual voice analysis, computerised acoustic analysis and videostroboscopic examination, and completed a thyroidectomy-related voice questionnaire (developed at the present institution) prior to surgery and at one and three months after surgery.

All patients who undergo lateral neck dissection also undergo bilateral central neck dissection; therefore, all those who underwent total thyroidectomy and bilateral central neck dissection with or without lateral neck dissection were included to ensure comparative data. The 264 patients were classified into two groups according to whether they underwent lateral neck dissection: those who underwent total thyroidectomy with bilateral central neck dissection only were included in the control group and those who underwent simultaneous lateral neck dissection were included in the lateral neck dissection group ($n = 65$). Results of the perceptual and acoustic analysis and videostroboscopic examination (objective assessment) and questionnaires scores (subjective assessment) were compared between groups.

The institutional review board of Seoul St. Mary's Hospital approved the study design.

Perceptual voice analysis

Participants were instructed to read the short story 'Sanchaek' [A walk] at a comfortable volume and rate, and voice samples were recorded on audiotape. Each patient's voice was also evaluated perceptually during conversation. Patients provided a voice history and basic demographic data. At the end of the evaluation session, a grade-roughness-breathiness-asthenia-strain scale score was given: grade (overall degree of deviance of voice); roughness (irregular fluctuation of the fundamental frequency); breathiness (turbulent noise produced by air leakage); asthenia (overall weakness of the voice); and strain (an impression of tenseness or excess effort). The audiotapes were replayed after the evaluation session for reviewing the score. Where the scores for reading and conversation differed, the score for conversation was used. Each of the five scale parameters was scored on a 0–3 scale: 0, normal; 1, slight disturbance; 2, moderate disturbance; and 3, severe disturbance. Consensus among two speech therapists and one otolaryngologist was obtained for all voice assessment scores.

Acoustic analysis

Digital recordings were made of each patient pronouncing the vowel 'a' for at least 3 seconds at a comfortable volume and constant pitch at a constant mouth-to-microphone distance of 5 cm using a Computerised Speech Lab (Model 4150B; KayPENTAX, Lincoln Park, New Jersey, USA). All digital recordings were made in a quiet room. The task was repeated at least four times, and the fourth trial was usually taken as the recorded sample. Recordings were analysed using a Multi-Dimensional Voice Program (Model 5105, version 3.1.7; KayPENTAX) and to obtain data on the following parameters: fundamental frequency, perturbations of fundamental frequency (i.e. jitter), amplitude (i.e. shimmer), glottal noise (i.e. noise-to-harmonic ratio) and speaking fundamental frequency.

Videostroboscopic examination

The whole larynx was examined by videolaryngostroboscopy (Model 9200C; KayPENTAX) to obtain data on the following parameters: symmetry and regularity of the wave of the vocal fold mucosa; vocal fold gap during phonation; vocal fold oedema; subglottic oedema; vocal fold tension; and the colour of the vocal folds.

Thyroidectomy-related voice questionnaire

The questionnaire was developed at the Department of Otorhinolaryngology – Head and Neck Surgery, The Catholic University of Korea, as a self-assessment tool to measure voice quality.[10] It consists of 20 questions about general voice complaints, representative symptoms related to laryngopharyngeal reflux and vocal fold palsy, and swallowing-related symptoms associated with thyroidectomy. Responses are on a scale from 0 (no voice alterations or symptoms) to 80 (highest voice impairment and multiple vocal symptoms).

Operative technique

All patients were operated on by the same surgeon using the same surgical technique and under the same conditions. During total thyroidectomy with bilateral central neck dissection, the strap musculature was retracted laterally from the midline but was not completely divided. Thyroidectomy was performed by extracapsular dissection to remove total thyroid tissue. Recurrent laryngeal nerves were identified and followed both caudally to the mediastinum and cranially to the cricothyroid junction. All vessels were ligated close to the thyroid gland. The superior thyroid artery and vein were individually ligated on the thyroid capsule to avoid damaging the external branch of the superior laryngeal nerve. Dissection was halted when the external branch of the superior laryngeal nerve could not be readily identified. The parathyroid glands were identified and preserved. The cricothyroid muscle was protected from injury by electrocoagulation or manual retraction, even when the pyramidal lobe was dissected.

In patients clinically suspected of having or pathologically proven by fine-needle aspiration cytology to have a metastatic lateral lymph node, modified radical neck dissection was limited to the involved side, according to the prescribed extent of dissection for papillary thyroid cancer (selective neck dissection at sublevels IIa, IIb, III, IV, Va and Vb).

Continuous recurrent laryngeal nerve monitoring was not performed during surgery and steroid was not administered before or during surgery.

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Statistical analyses

Statistical analyses were performed using IBM SPSS Statistics software version 18.0 (Chicago, Illinois, USA). Individual clinical features and values from the perceptual and acoustic analyses were compared between the two groups using the χ^2 square test, Fisher's exact test and Student's *t*-tests, as appropriate. A p value of less than 0.05 was considered significant.

Results

Of the 264 patients enrolled, only 65 underwent lateral neck dissection concomitantly with total thyroidectomy and bilateral central neck dissection. The mean age (± standard deviation) was 45.3 ± 10.2 years for the control group and 41.4 ± 10.8 years for the lateral neck dissection group (no significant difference). The female-to-male ratio was 6.1 in the control group (171 women, 28 men) and 1.7 in the lateral neck dissection group (41 women, 24 men; $p < 0.01$). Patient demographics and clinical data are summarised in Table I.

Voice analysis and questionnaire results

Differences in all acoustic parameters and questionnaire scores before and after surgery were calculated. At month one after surgery, changes in the fundamental frequency and speaking fundamental frequency were significantly different between groups ($p = 0.01$ and $p = 0.02$, respectively). The mean change in fundamental frequency was −3.83 Hz in the control group and −10.80 Hz in the lateral neck dissection group, and the mean change in speaking fundamental frequency was −2.59 Hz in the control group and −10.21 Hz in the lateral neck dissection group. Negative values indicate lowering of the fundamental and speaking pitch. The decrease in fundamental frequency and speaking fundamental frequency was significantly greater in lateral neck dissection patients than in the control group. The increase in overall questionnaire score and in the voice- and throat-related subscores after surgery was significantly higher in lateral neck dissection patients ($p < 0.01$).

At three months after surgery, none of the acoustic parameters differed significantly between the two groups. Although the increase in questionnaire scores was not very prominent in either group at three months after surgery, it was significantly higher in lateral neck dissection patients ($p < 0.01$). Results of the acoustic analysis at one and three months after surgery are summarised in Table II.

Videostroboscopic results

At one month after surgery, asymmetric mucosal wave of the vocal fold and vocal fold oedema were more common in lateral neck dissection patients ($p = 0.03$ and $p = 0.04$, respectively). However, at three months after surgery, only vocal fold oedema was more common in the lateral neck dissection group ($p = 0.02$). Examples of videostroboscopy findings are shown in Figure 1 and all results are summarised in Table III.

Discussion

The principal focus of this study was to determine whether lateral neck dissection affects the voice of thyroidectomy patients. Clinical observations indicated that patients who undergo concomitant lateral neck dissection and thyroidectomy (with or without central neck dissection) are prone to more severe voice changes compared with those who undergo thyroidectomy only. Thus, the acoustic vocal parameters were compared in groups who underwent thyroidectomy with and without lateral neck dissection. To exclude an effect of central neck dissection, only patients who underwent total thyroidectomy with bilateral central neck dissection were included. As bilateral central neck dissection is mandatory for patients requiring lateral neck dissection, this allowed the specific effect of lateral neck dissection on thyroidectomised patients to be assessed.

At one month after surgery, the decrease in vocal pitch (fundamental frequency and speaking fundamental frequency values) and increase in questionnaire score were significantly greater in the lateral neck dissection group. At three months after surgery, vocal fold oedema evident on videostroboscopy was more common in the lateral neck dissection group. These results indicate that lateral neck dissection is associated with voice changes, the most prominent of which were decreases in fundamental frequency and speaking fundamental frequency. Although deterioration in other acoustic parameters was also observed, the differences were not statistically significant. A previous study by

TABLE I
PATIENT DEMOGRAPHICS AND CLINICOPATHOLOGICAL DATA

Parameters	Control group ($n = 199$)	LND group ($n = 65$)	p value
Age (y)	45.3 ± 10.2	41.4 ± 10.8	0.135
Sex (female)	171 (86)	41 (63)	<0.01*
Diabetes	31 (15.6)	9 (13.8)	0.425
Hypertension	34 (16.9)	9 (13.8)	0.309
Smoker	23 (11.7)	8 (12.5)	0.876
Operative time (min)	134.3 ± 13.3	271.2 ± 14.1	<0.01*

Data are n (%) or mean ± standard deviation. *$p < 0.05$. LND = lateral neck dissection; y = years; min = minutes

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TABLE II
ACOUSTIC ANALYSIS AFTER SURGERY

Parameter	Month 1			Month 3		
	Control group	LND group	*p* value	Control group	LND group	*p* value
GRBAS	0.45 ± 1.32	0.55 ± 1.46	0.21	0.25 ± 0.22	0.58 ± 0.96	0.66
Jitter	1.22 ± 0.96	1.55 ± 1.03	0.23	1.20 ± 0.69	1.42 ± 1.21	0.51
Shimmer	4.51 ± 1.71	5.10 ± 2.02	0.15	4.21 ± 1.84	4.53 ± 1.97	0.26
NHR	0.13 ± 0.03	0.24 ± 0.03	0.16	0.12 ± 0.04	0.16 ± 0.02	0.25
Fo	−3.83 ± 1.52	−10.80 ± 2.21	0.01*	−1.72 ± 1.62	−3.58 ± 2.18	0.13
SFF	−2.59 ± 1.45	−10.21 ± 1.76	0.02*	−1.48 ± 0.99	−3.02 ± 1.12	0.19
Questionnaire						
– Total	3.05 ± 4.60	23.73 ± 14.50	<0.01*	2.57 ± 2.02	19.45 ± 10.58	<0.01*
– Voice	2.81 ± 3.58	15.14 ± 9.78	<0.01*	2.14 ± 3.01	14.50 ± 7.88	<0.01*
– Throat	0.23 ± 2.65	7.91 ± 6.14	<0.01*	0.21 ± 2.11	5.04 ± 4.85	0.02*

Data are mean ± standard deviation of the differences after surgery (i.e. value before surgery minus value after surgery). *$p < 0.05$. LND = lateral neck dissection; GRBAS = grade-roughness-breathiness-asthenia-strain scale; NHR = noise-to-harmonic ratio; Fo = fundamental frequency; SFF = speech fundamental frequency

the current authors found that patients who underwent thyroidectomy without laryngeal nerve injury also had lower-pitched voices.[7] However, the current study revealed greater decreases in fundamental frequency and speaking fundamental frequency after thyroidectomy with lateral neck dissection. Videostroboscopy examination showed that lateral neck dissection patients had a higher incidence of vocal fold oedema and asymmetric mucosal wave of the vocal folds, which may explain the lowered vocal pitch. Vocal pitch is determined by vocal fold tension and mass. Therefore, an increase in vocal fold mass (due to vocal fold oedema) probably results in decreased pitch. A subjective analysis using the questionnaire had similar results: questionnaire scores were significantly higher after surgery in the lateral neck dissection group than in the control group.

One drawback of the study is that the lateral neck dissection group included a significantly higher proportion of men because lateral lymph node metastasis is more common in men. The different sex ratio between groups may have biased the results. However, a previous study comparing voice change after thyroidectomy in men and women found a greater pitch reduction in speaking and singing voice in women.[1] In the present study, pitch lowering was significantly more common in lateral neck dissection patients, despite this group containing more men. These results suggest that the effect of lateral neck dissection overcame the effect of sex on pitch lowering.

Lateral neck dissection probably affects the voice through one of the mechanisms underlying dysphonia that presents after thyroidectomy without laryngeal nerve injury, such as inflammation after surgery, laryngeal oedema due to vascular and/or lymphatic change, surgical trauma to the cricothyroid muscle or cricoarytenoid joint, endotracheal intubation-related trauma, and laryngotracheal fixation by fibrosis around the thyroid bed after surgery.[11–16] Of these, laryngeal oedema due to vascular and/or lymphatic change is the more likely cause of voice change induced by lateral neck dissection. Thyroidectomy (with or without central neck dissection) can induce laryngeal oedema by removing and changing venous and/or lymphatic channels, and lateral neck dissection can have a similar or more robust effect. Several studies have indicated that thyroidectomy extent is significantly associated with the degree of voice change. For example, recent studies demonstrated a significant difference in acoustic vocal parameter changes after surgery between total thyroidectomy and partial thyroidectomy patients.[17–19] Therefore, patients in the lateral neck dissection group may have experienced more severe voice change than those in the control group owing to the greater surgical extent and more severe venous and/or lymphatic changes.

The current authors previously reported a higher incidence of specific videostroboscopic findings suggestive of a worse laryngeal condition (including a severe decrease in vocal fold tension, severe vocal fold oedema, the presence of subglottic oedema and mucus in the larynx, and decreased vocal fold regularity and symmetry) in patients with the greatest degree of voice pitch lowering after thyroidectomy.[7] These findings may result from laryngeal mucosal changes due to modified vascular supply and/or venous drainage of the larynx. The present study found a higher incidence of vocal fold oedema in videostroboscopic examinations in lateral neck dissection patients at both one and three months after surgery. These results suggest that lateral neck dissection leads to more severe laryngeal oedema due to severe venous and/or lymphatic changes.

Prolonged intubation is another possible cause of more severe laryngeal oedema in lateral neck dissection patients. The operative time was significantly longer and consequently intubation was longer in this group than in the control group. Longer intubation may damage the microstructure of vocal fold and consequently worsen oedema. Therefore, the greater voice change observed in the lateral neck dissection group might result from prolonged intubation instead of

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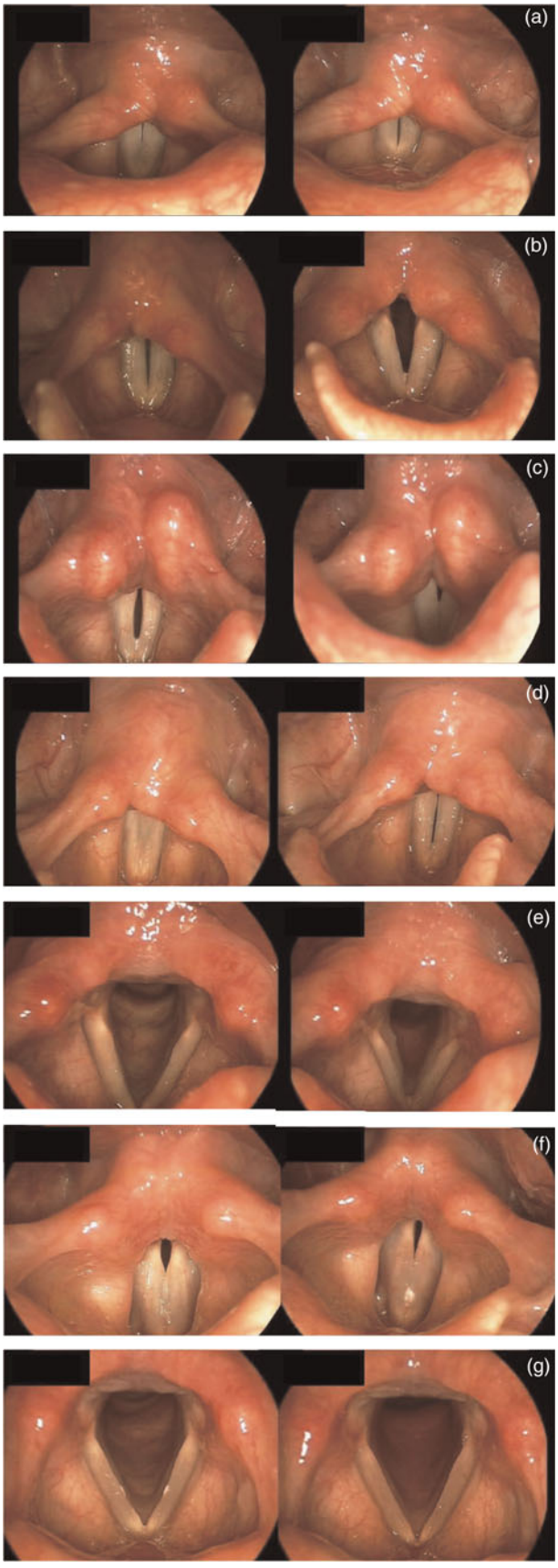

FIG. 1

Examples of videostroboscopic findings before (left) and after (right) surgery: (a) decreased vocal fold tension; (b) asymmetric mucosal wave of vocal fold; (c) decreased regularity; (d) glottic gap; (e) subglottic oedema; (f) mucus in the larynx; and (g) change in vocal fold colour.

lateral neck dissection. However, although patients who underwent general anaesthesia with endotracheal intubation had poorer outcomes for acoustic parameters compared with those given laryngeal masks, normal acoustic parameters in the former group were restored within two weeks after surgery. These observations are consistent with those of a previous study comparing the effects of endotracheal intubation and laryngeal masking on voice changes after thyroidectomy.[20] Therefore, even if a prolonged operative time (owing to lateral neck dissection) induces additional laryngeal irritation and vocal fold oedema, any effects should disappear within two weeks of surgery. On this basis, it is reasonable to suggest that persistent vocal fold oedema at three months after surgery is caused by reduced lymphatic or venous drainage after lateral neck dissection and not by prolonged intubation.

The results of this study support previous findings that voice change is common at an early stage after thyroid surgery, even when concomitant lateral neck dissection is performed. On acoustic analysis at one month after surgery, decreases in fundamental frequency and speaking fundamental frequency were greater in the lateral neck dissection group than in the control group. However, this difference lost statistical significance at three months after surgery. Videostroboscopy examination showed that asymmetric mucosal wave of the vocal fold was more common in lateral neck dissection patients at one month after surgery (but not at three months). However, vocal fold oedema was more common in the lateral neck dissection group at both time points, and might be caused by more severe and prolonged venous and/or lymphatic changes compared with the control group.

Subjective symptoms appeared to last longer than the objective outcomes: the increase in questionnaire scores was greater in the lateral neck dissection group than the control group at three months after surgery. Persistent vocal fold oedema on videostroboscopy might cause prolonged voice- and throat-related discomfort. Therefore, patients should be informed that subjective voice changes might last longer than three months, although objective outcomes might resolve within that time. Therefore, proper counselling before surgery may reassure patients and decrease the number of patient complaints following surgery.

The findings of this study provide supportive evidence for early intervention with voice therapy. Patients with dysphonia after thyroidectomy with or without lateral neck dissection can develop maladaptive compensatory mechanisms during the recovery period.[11,12] Such vocal behaviours can persist after the underlying vocal pathology is resolved. Early identification of voice dysfunction and early initiation of vocal rehabilitation in these patients may help to optimise vocal function before maladaptive compensations can develop. The timely recognition of dysphonia and intervention after surgery can help to improve patient quality of life after treatment for thyroid cancer.

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TABLE III
VIDEOSTROBOSCOPY ANALYSIS AFTER SURGERY

Parameter	Month 1			Month 3		
	Control group	LND group	*p* value	Control group	LND group	*p* value
Asymmetric mucosal wave	47 (23.5)	44 (67.7)	0.03*	25 (12.5)	10 (15.1)	0.09
Decreased regularity	19 (9.8)	18 (27.7)	0.14	18 (9.0)	9 (13.9)	0.51
Vocal fold oedema	59 (29.4)	50 (76.9)	0.04*	42 (21.1)	47 (72.3)	0.02*
Subglottic oedema	24 (11.8)	30 (46.2)	0.09	19 (9.5)	25 (38.1)	0.12
Decreased vocal fold tension	90 (45.1)	39 (60.0)	0.31	86 (43.2)	37 (56.9)	0.37
Vocal fold colour change	39 (19.6)	29 (44.6)	0.17	30 (15.1)	16 (25.0)	0.35
Vocal fold gap during phonation	24 (11.8)	23 (35.4)	0.56	25 (12.6)	21 (32.3)	0.30

Data are *n* (%). *$p < 0.05$. LND = lateral neck dissection

This study had several limitations. First, the work was retrospective; therefore, the observed effects of lateral neck dissection on the voice require confirmation. Moreover, only 65 of the 264 enrolled patients were eligible for inclusion in the lateral neck dissection group, which may weaken the statistical power of this study. However, as the need for lateral neck dissection in thyroid cancer patients is infrequent and patients were enrolled consecutively, an imbalance in number between the study and control groups was inevitable.

A second limitation was the absence of steroid treatment. Steroid administration before surgery can significantly improve voice function after thyroidectomy.[21] Therefore, had voice quality improved in lateral neck dissection patients after steroid administration, the effect of lateral neck dissection on voice (and on the associated pathophysiology) could have been more precisely defined. However, steroids are not routinely prescribed in the host institution, so their influence on outcome could not be assessed.

- **Thyroid surgery carries a high risk of voice alteration, even without nerve injury**
- **The effect of lateral neck dissection in thyroidectomy on the voice has not been studied**
- **Lateral neck dissection affects voice outcomes in thyroidectomised patients**
- **Lateral neck dissection patients had lower fundamental and speaking fundamental frequencies and a higher incidence of asymmetric mucosal wave and vocal fold oedema**
- **Subjective questionnaire scores were significantly higher in lateral neck dissection patients**
- **Objective voice parameters improved more quickly than subjective symptoms**

Another limitation is the possibility of damage to the superior and recurrent laryngeal nerves as continuous recurrent laryngeal nerve monitoring was not performed during surgery and electromyography was not performed after surgery. Although patients with evident vocal fold paralysis either before or after surgery were excluded and a standard thyroidectomy procedure was performed (to minimise the possibility of superior laryngeal nerve damage), it is still possible that microscopic nerve injury may have affected the voice analysis.

Despite these limitations, this is the first study to show that lateral neck dissection affects the voice in thyroidectomised patients. Further studies addressing the limitations of this study might provide more details about the effects of lateral neck dissection on the voice.

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