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Post-thyroidectomy superior laryngeal nerve injury

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Abstract Voice dysfunction after thyroidectomy may be caused by damage to laryngeal nerves or lesions to strap muscles with laryngo-tracheal movement impairment. Injury to an external branch of the superior laryngeal nerve (EBSLN) is sometimes difficult to recognize clinically and its electromyographic incidence ranges from 0% to 58%. In this study we evaluated, 12–18 months postoperatively, 45 patients who had undergone thyroid surgery (6 total lobectomy, 5 subtotal thyroidectomy, and 34 total thyroidectomy), using a subjective interview, laryngeal videostroboscopy and spectrographic analysis with a multidimensional voice program. Vocal parameters included fundamental frequency, jitter, shimmer, noise-to-harmonic-ratio (NHR) and degree of sub-harmonics. Laryngeal electromyography (LEMG) of the cricothyroid (CT) muscles was performed in 21 subjects with voice problems (35 EBSLNs) using a modified method for the CT recording. In 3 patients of this group (14%) LEMG documented a unilateral EBSLN injury. Easy voice fatigue and decreased pitch range were the most common symptoms after surgery. Average values of vocal parameters pre- and postoperatively in patients without neural damage (n = 42) were: jitter 0.64% and 0.78%, shimmer 3.25% and 3.54%, and NHR 0.12% and 0.13%, respectively (P > 0.05). Acoustic analysis revealed altered patterns in some patients with no objective evidence of damage to EBSLNs, suggesting an extralaryngeal cause of vocal dysfunction, such as laryngo-tracheal fixation or lesions to strap muscles. We conclude that laryngeal videostroboscopy and spectrographic analysis are very useful to assess voice problems after thyroidectomy, including in patients without LEMG-proven neural lesions, in order to suggest early speech rehabilitation, especially in professional voice users.

Keywords Thyroidectomy · Superior laryngeal nerve · Voice dysfunction

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Introduction

Voice dysfunction after thyroidectomy may be caused by surgical damage to laryngeal nerves or lesions to strap muscles with impairment of laryngo-tracheal movement.

Lesions to recurrent laryngeal nerve (RLN) usually are easy to recognise with traditional indirect laryngoscopy and fibre-optic examination. In contrast, injury to the external branch of the superior laryngeal nerve (EBSLN) is often under-diagnosed because of poor or absent clinical signs [4, 11, 20]. The incidence of damage to EBSLN after thyroid surgery reported in the literature varies with authors and surgical techniques. When laryngeal electromyography of cricothyroid (CT) muscles was employed, this complication was detected in a higher percentage of patients, ranging globally from 0 to 58% [1, 11, 19].

The extralaryngeal muscles contribute to vocal function in modulating pitch range, so that their action is important especially in professional singers [5, 7, 9, 18]. A conservative approach to the thyroid gland to preserve the integrity of the strap muscles may avoid vocal changes after thyroidectomy [14].

The purpose of this study was to assess the incidence of iatrogenic damage to EBSLNs by laryngeal videostroboscopy and electromyography (LEMG) and to evaluate voice dysfunction after thyroid surgery in patients with and without evidence of neural (RLN and EBSLN) lesions.

Materials and methods

Patients

In this study we evaluated vocal dysfunction 12–18 months postoperatively in 45 patients who had undergone thyroid surgery, us-

ing a subjective interview, laryngeal videostroboscopy and spectrographic analysis. There were 37 females and 8 males with a mean age of 52 years (range 33–76). In all patients a preoperative indirect laryngoscopy was normal and no other laryngeal diseases were observed. No subject of our series complained of vocal dysfunction preoperatively. Indications for surgery included all benign thyroid diseases (41 multinodular goitres, two follicular adenomas, one Hurtle's adenoma and one Plummer's adenoma). The types of surgical procedures performed were total thyroidectomy ($n = 34$), subtotal thyroidectomy ($n = 5$) and total lobectomy ($n = 6$).

In 21 of these patients (35 nerves at risk), an electromyography of the CT muscles was performed.

Surgical technique

In the multinodular diffuse goitres, the strap muscles were usually cut in their inferior third. The RLN was routinely identified and isolated in the inferior retro-thyroid space, where it crosses the inferior thyroid artery. When the superior thyroid pole was gently mobilised, the superior thyroid vessels were isolated and separately ligated as near as possible to the gland, without positive searching for the EBSLN, and avoiding dangerous coagulation in the area of cricothyroid muscle. An extracapsular dissection was systematically employed. Finally an accurate stratified reconstruction of strap muscles was routinely performed.

Subjective voice evaluation

All patients were subjectively interviewed postoperatively about the presence of vocal symptoms: hoarseness and voice changes in pitch, range, intensity and fatigability. Changes in singing performances, also in non-professional singers, were especially sought.

Videostroboscopic analysis

Laryngeal videostroboscopy was performed in all subjects in a 12- to 18-month follow-up. A basic fibreoptic and a stroboscopic examination was routinely performed in the sitting position with a rigid 70° telescope, recording images with a colour camera in a professional videocassette recorder. Patients were asked to phonate /i/ using high pitches. Bowing and inferior displacement of the vocal cord and rotation of the posterior glottis toward the paralytic side were considered abnormal findings that suggest EBSLN lesions. Other characteristics evaluated were the regularity and symmetry of the mucosal travelling wave and the degree of glottic closure [17].

Laryngeal electromyography

LEMG was performed in 21 patients (35 EBSLNs), 16 females and 5 males (mean age 56 years, range 41–76) complaining of postoperative vocal changes or with a suspected EBSLN injury. LEMGs of the CT muscles were performed using a modified method for the CT recording, consisting of needle insertion at the lateral one-third portion to the midline [22]. Verifying features for needle insertion included increased activity during high pitch vocalization or pitch change, but no activity during low-pitch phonation or head-raising procedure. In patients who underwent total lobectomy this procedure was previously performed on the normal side in order to compare bilateral EMG findings.

Acoustic analysis

In all patients, an objective preoperative and postoperative voice assessment was performed using a spectrographic analysis with a multidimensional voice program (MDVP), model 4305 (Kay Elemetrics, Lincoln Park, N.J., USA). Vocal parameters evaluated included fundamental frequency (F0), jitter for fundamental frequency microperturbation, shimmer for amplitude microperturbation, noise-to-harmonic ratio (NHR) and degree of sub-harmonics (DSH).

Statistical analysis of pre- and post-operative acoustic data was performed using paired and non-paired Student's *t*-test.

Results

Overall, 21 of 45 (47%) patients had subjective postoperative voice changes of various degrees. The most common symptoms complained of after thyroid surgery were easy voice fatigue (38% of subjects) and decreased pitch range (33%). Hoarseness was noticed in three cases (6.5%) and dysphonia in one patient (2%). Two other dysphonic patients were excluded from this study at follow-up because of an inflammatory glottic oedema or a severe retractive cervical scar. In our series of studies, no professional singers were observed.

A preoperative indirect laryngoscopy was normal in all patients. The postoperative laryngo-stroboscopic examination showed bowing of a vocal cord in two cases (4%), rotation of the posterior glottis of various degree in three cases (7%) and asymmetry of the travelling mucosal wave, slight to severe, in four subjects (9%). An incomplete glottic closure was observed in three cases (7%).

In 3 of 21 (14%) symptomatic patients, the laryngeal electromyography documented an unilateral EBSLN injury, occurring in two cases after a total thyroidectomy for multinodular goitre and in one patient after a completion surgery for recurrent goitre. In other subjects showing a mild impairment in the glottic closure or a slight asymmetry of the mucosal wave, we did not find any EMG evidence of superior laryngeal nerve (SLN) damage. LEMG findings suggesting a SLN paralysis included an absence of interference patterns during high pitch vocalisation and electrical silence (Fig. 1). SLN neuropathy was identified in 3 of 35 nerves at risk (8.6%).

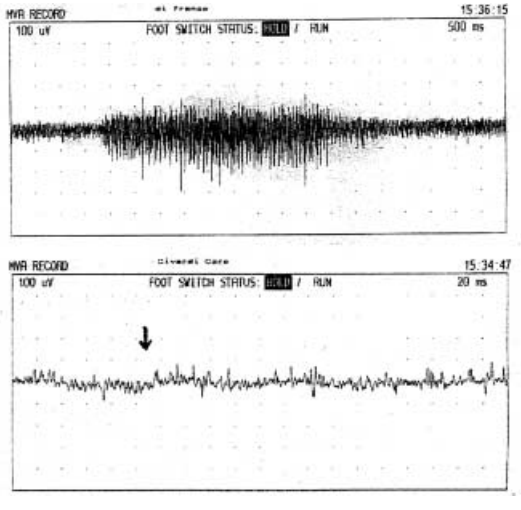

Fig. 1 Laryngeal electromyographic (LEMG) findings in a patient with a 1-year history of voice fatigability and decreased pitch range after total thyroidectomy. The bilateral samples show a decreased interference pattern from the left cricothyroid muscle (*bottom*) with normal pattern on the right (*top*)

Table 1 Acoustic objective data in patients *without* laryngeal nerves injury ($n = 42$)

Acoustic parameter	Preoperative mean	Postoperative mean	% Increase
Jitter (%)	0.64	0.78*	22%
Shimmer (%)	3.25	3.54*	27%
Noise-to-harmonic ratio	0.12	0.13*	14%

*The mean value before thyroidectomy was not significantly changed after surgery (paired and non-paired Student's *t*-test, $P > 0.05$)

Table 2 Acoustic objective data in patients *with* EBSLN unilateral injury ($n = 3$)

Acoustic parameter	Preoperative mean	Postoperative mean
Jitter (%)	0.64	1.6
Shimmer (%)	3.30	6.3
Noise-to-harmonic ratio	0.13	0.19

In the group of patients with no injury to laryngeal nerves ($n = 42$), the mean F0 during phonation of the sustained vowel /i/ after surgery was 216 s (SD = 48) in females and 131 s (SD = 37) in males. The pre- and post-operative acoustic results obtained with MDVP are given in Table 1. The mean value of these parameters before thyroidectomy was not significantly changed after surgery (paired and non-paired Student's *t*-test, $P > 0.05$). Only DSH significantly changed after thyroid surgery ($P < 0.05$).

The postoperative acoustic values of patients with a EBSLN unilateral damage ($n = 3$) were markedly increased (Table 2; Fig. 2).

Discussion

Iatrogenic damage to EBSLN is a well-known complication of thyroid surgery and can be confirmed by LEMG of cricothyroid muscles. Vocal changes after surgical injury to EBSLN may be explained also by the contribution of EBSLN to innervation of the internal thyroarytenoid muscle [16, 21]. The incidence of post-thyroidectomy EBSLN injury observed in our series was 14%, not dissimilar to values reported in literature [1, 11, 19]. Although LEMG is sometimes difficult to execute technically and to evaluate, it seems to be a useful tool to confirm objectively neural laryngeal damage [8, 13, 15].

As described by Lorè et al., a careful mobilisation of the superior thyroid pole and a selective dissection and ligation of the superior vascular pedicle strictly adherent to the gland, without a systematic positive identification of the EBSLN, may prevent injuries to the EBSLNs [6, 12, 14]. It is also useful to avoid blind coagulation or dangerous manoeuvres in the so-called critical area, where superior thyroid vessels proximate to the thyroid capsule [14].

Nevertheless, many patients complain of vocal change after thyroid surgery even with a normal laryngeal neuromuscular function. Some reports have demonstrated that the extrinsic laryngeal muscles participate indirectly or directly in the vocal function, showing pronounced activity

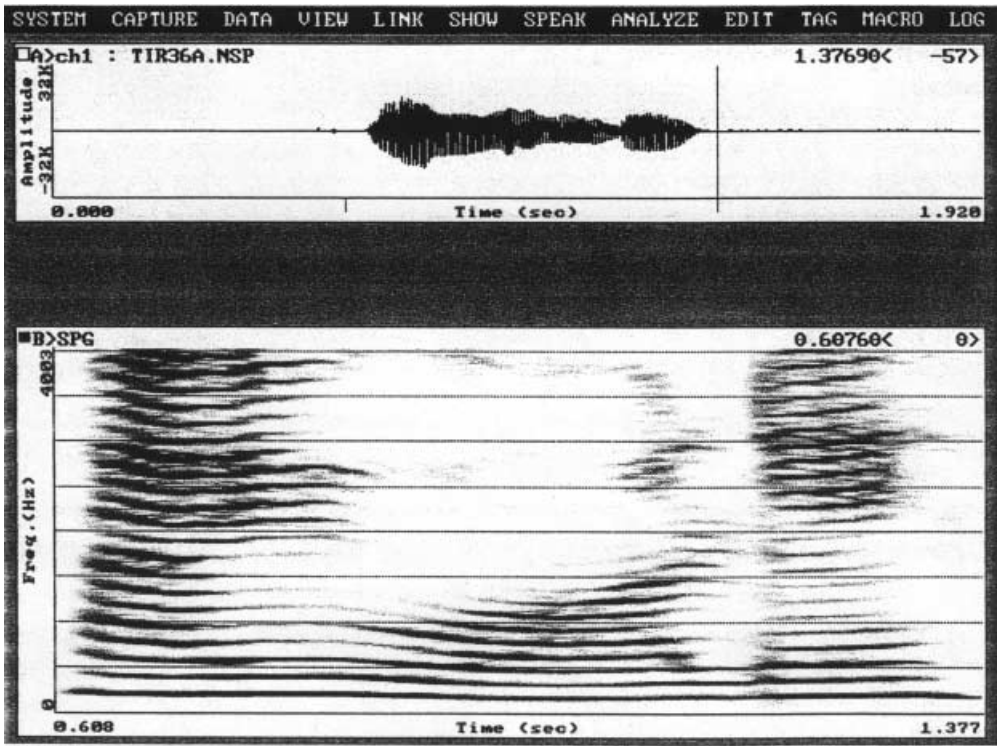

Fig. 2 Laryngeal spectrographic sample from one patient, a 56-year-old woman, with a unilateral EBSLN injury that shows the presence of airflow rates and turbulent noise in the frequency range 1500–4500 Hz of the harmonic spectral energy

at low pitch and decreased activity at high pitch [5, 7, 9]. Hong et al. demonstrated in a canine laryngeal model that the contraction of sternohyoid and sternothyroid muscles caused lengthening of vocal cords and a rise in pitch [10]. Iatrogenic damage to strap muscles, cervical scar shrinkage with reduction in vertical movements of laryngo-tracheal axis, may cause subtle voice dysfunction, also in the absence of laryngoscopic signs of glottic movement impairment. An accurate suture of strap muscles and repair of muscular planes, when transected, may prevent iatrogenic damage to neuromuscular structures during thyroid surgery.

Hong and Kim reported that the speaking fundamental frequency (SF0) and range of SF0 were significantly decreased 1 and 3 months after thyroid surgery, but not at 6 months [9]. These authors emphasise the importance of the extralaryngeal mechanism for pitch control and conclude that the vocal changes that are not due to nerve damage are usually temporary. Debruyne et al. compared some acoustic parameters pre- and post-thyroidectomy in 47 females and observed a progressive normalisation of jitter and other spectral values in a few months postoperatively [2, 3]. Our post-operative acoustic analysis revealed altered patterns in some patients with subjective voice disturbances, but no objective evidence of damage to laryngeal nerves (RLN, EBSLN), suggesting an extralaryngeal cause of vocal dysfunction such as laryngo-tracheal fixation or iatrogenic lesions to strap muscles. Because our examination was obtained > 12 months postoperatively, we believe that in a few cases the vocal dysfunction after thyroid surgery may be persistent. This can be explained by wound retractions or cervical scars that limit contraction of the neck muscles and oppose the vertical movements of the laryngeal skeleton. The relatively high incidence of persistent vocal dysfunction detected in our series is probably due to the surgical technique usually adopted, which consists of cutting strap muscles in their inferior third, so causing damage to the muscular innervation. The wound retraction and the functional reduction in muscular contraction may cause an impairment in the extralaryngeal mechanism of vocal function. According to many authors, it would be preferable, whenever possible, to dissect and laterally dislocate the strap muscles in order to maintain their structural and functional integrity. Postoperatively, appropriate speech rehabilitation may achieve a neuromuscular adaptation and a voice improvement in many patients.

Conclusions

We conclude that laryngeal videostroboscopy and spectrographic analysis are very useful to assess voice problems after thyroid surgery, including patients without LEMG-documented neural lesions, in order to suggest early speech rehabilitation, especially in professional voice users. A proper diagnosis and a specific voice rehabilitation may avoid the negative effects of voice problems on professional and quality of life.

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