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Long-term (12 to 18 months) functional voice assessment to detect voice alterations after thyroidectomy

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Abstract. – OBJECTIVES: Even when thyroidectomy preserves vocal cord motility it may leave patients with changes in voice quality. Although superior laryngeal nerve (LSN) damage after thyroidectomy manifests with aspecific symptoms, laryngoscopy discloses only slight morphological changes that are difficult to assess. We want to investigate the voice function in asymptomatic patients one year after thyroidectomy and to compare the obtained data against those of a healthy control group.

PATIENTS AND METHODS: Thirty adult patients who had undergone thyroidectomy, all of them euphonic before and after the operation, were submitted to a complete voice assessment including voice self-evaluation tools, videolaryngostroboscopy and spectrographic analysis of voice. Primary outcome measures were differences between surgical patients and control group in terms of microperturbation of voice intensity and amplitude as measured by spectrographic analysis.

RESULTS: In patients who had undergone thyroidectomy, acoustic parameters indicating amplitude microperturbations resulted slightly altered. All these values exceeded normal MDVP thresholds. Another interesting finding in our study sample concerns the lower F0 values we recorded in women patients after surgery than in healthy controls. Voice alterations may reflect prelaryngeal muscle scarring or fibrosis. Consider the possible alterations of vocal quality caused by scarring after surgery therefore strongly recommend surgery when the situation allows it, not to dissect the prelaryngeal muscles but only to spread apart.

CONCLUSIONS: Our study conducted at least one year after thyroid surgery underlines that surgery-related slight voice deficits can persist over time. More refined phoniatric testing discloses voice alterations that normalize without specific rehabilitation therapy, therefore confirming that certain acoustic changes are clinically unimportant.

Key Words:
Thyroidectomy, Vocal cord, Laryngeal nerve, Voice, Videolaryngostroboscopy.

Introduction

The most common complication after thyroid surgery is dysphonia caused by a recurrent laryngeal nerve paralysis, widely discussed in literature. An injury of the external branch of the superior laryngeal nerve (EBSLN) may be also responsible for subtle alterations of voice, very difficult to assess. In case of EBSLN deficit the alteration of the fundamental frequency (Fo) of the voice and the difficulties to produce the high-frequency vocal sounds, due to the cricothyroid muscle deficit, can damage the voice of the patient, resulting in handicap for professional voice users[1]. Only a few studies, however, have investigated voice alterations after thyroid surgery in patients with preserved vocal cord motility[2]. These postoperative voice disorders may result from several causes, including: transient neural conduction disorders involving the inferior laryngeal nerve (ILN) or the EBSLN; a cricothyroid muscle movement disorder; mucosal damage, hematoma, inflammation or vocal fold laryngeal edema induced by faulty venous or lymphatic drainage or both[3,4]; surgical trauma with prelaryngeal strap muscle fixation to the laryngotracheal axis, a maneuver that may alter the voice by reducing vertical movements[5]. Other potentially influential factors are gender[6], emotional and behavioral conditions[7] and mental stress.

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In our knowledge, no previous studies have described the natural history of post-thyroid surgery voice disorders in patients with preserved laryngeal nerve function, with no evident voice impairment, particularly in the long-term. This data could be useful in providing more detailed information about possible subtle voice alteration during preoperative informed consent, and in the postoperative follow-up to to require a correct speech therapy if necessary.

The aim of this study was to carefully investigate the voice function in asymptomatic patients one year after thyroidectomy and to compare the obtained data against those of a healthy control group.

Thirty adult patients who had undergone thyroidectomy, all of them euphonic before and after the operation, were submitted to a complete voice assessment including voice self-evaluation tools, videolaryngostroboscopy and spectrographic analysis of voice. Primary outcome measures were differences between surgical patients and control group in terms of microperturbation of voice intensity and amplitude as measured by spectrographic analysis. Secondary outcomes were differences in voice self-evaluation between patients who underwent thyroidectomy and healthy control patients.

Patients and Methods

From a series of 110 adult patients who had undergone thyroidectomy for more than one year, preoperatively submitted to fiberoptic laryngoscopy and Voice Handicap Index (VHI) assessment, we identified by phone 30 consecutive patients whose VHI preoperative value was normal. All these patients voluntary attended our Department for a complete voice examination. Six patients were men, 24 women (mean age 62.22 yrs SD 12.76), the time elapsed from thyroidectomy ranged from 12 to 18 months (mean 16 months). All of them were found negative at the preoperative and postoperative laryngoscopic evaluation. Exclusion criteria were impaired laryngeal morphology or motility, preoperative functional voice disorders, history of smoke/alcohol abuse and previous head/neck surgery. In all patients the total thyroidectomy was performed for benign thyroid lesions or well-differentiated carcinomas. During surgery, prelaryngeal muscles (sternothyroideus and sternohyoideus) were dissected at the third superior segment, near the superior vascular thyroidal pedunculus. The control group (6 men and 9 women mean age 65.06 yrs, SD 8.10) comprised euphonic healthy patients comparable for age, gender, habits (non-smokers, non alcohol-users) and professional activities (this study did not recruit voice professionals). All of them had undergone Functional Endoscopic Sinus Surgery (FESS) between 12 and 24 months before (mean 18 months).

The voice assessment protocol included three procedures, performed in a single session lasting about 40 minutes:

1. Voice Handicap Index (VHI)[8]: patients were asked to answer 30 questions about the discomfort related to the use of their voice. The VHI includes 30 items, each scored on a 5-point scale ranging from "never" to "always", divided into three subscales including functional, emotional and physical features related to voice dysfunction. The normal limit and threshold for significant change were based on the values reported by Jacobson et al[8]. A difference of up to 8 points on the subscales and 18 points on the total score was considered to indicate significant discomfort.
2. Laryngo-stroboscopy: patients and control subjects underwent laryngeal examination using a 3.5 mm diameter fiberscope (Storz 11101RP) connected to a stroboscopic light source (ATMOS Endo-Stroboscope L) to assess the morphology and motility of the larynx and to evaluate vocal fold vibratory pattern (mucosal wave). The examination was video-recorded to assess symmetry and regularity of the vocal fold vibration as well as signs of functional dysphonia. Esophageal-laryngeal reflux (ELR) symptoms were reported according to the Reflux Finding Score[9].
3. Spettrographyc analysis: vocal quality was evaluated by means of a software tool for quantitative acoustic assessment of voice quality (MDVP KAYPENTAX Mod. 5101). The following acoustic parameters, Fo, Jitt (Jitter percent, the relative variability of the pitch in the short-term), sPPQ (smoothed Pitch Perturbation Quotient), Shim (Shimmer percent, the relative variability of the peak-to-peak amplitude in the short-term) and the sAPQ (smoothed Amplitude Perturbation Quotient) were measured in patients and control subjects.

Our study received approval from the Ethics Committee Azienda Policlinico Umberto I, Rome.

Statistical Analysis

Unless otherwise expressed, all values are means ± SD. One-way ANOVA *(Analysis of Variance)* were used to test the differences in the selected MDVP variables in four subgroups: men who had undergone surgery versus healthy control men and women who had undergone surgery versus healthy control women. *p* values less than or equal to 0.05 were considered to indicate significance. Data were analyzed with a PC version of the Statistical Package for Social Sciences 16.0 (SPSS, Chicago, IL, USA).

Results

In patients who had undergone thyroidectomy, acoustic parameters indicating amplitude microperturbations resulted slightly altered: shim: 5.43±1.87 (men) and 4.91±2.99 (women); sAPQ 5.75±0.84 (men) and 5.38±2.41 (women). All these values exceeded normal MDVP thresholds. Comparing the same acoustic parameters between women patients and healthy control women, the statistical analysis showed significant differences: shim 4.91 vs 2.18 ($p = 0.015$), sAPQ 5.38 vs 2.74 ($p = 0.05$). In the men's groups the difference in the shimmer percent was found close to being statistically significant: shim 5.43 vs 2.27 ($p = 0.07$), while sAPQ showed statically significant difference 5.75 vs 3.95 ($p = 0.012$). Jitt and sPPQ didn't show statistically significant differences between women patients and healthy control woman: Jitt 0.95 vs 0.50 ($p = 0.18$), sPPQ 0.73 vs 0.44 ($p = 0.13$) nor between men patients and healthy control men Jitt 0.66 vs 0.51 ($p = 0.13$), sPPQ 0.60 vs 0.51 ($p = 0.34$).

F_0, was on average lower in women patients than in healthy control women (F_0: 197 vs 239 Hz, $p = 0.007$).

VHI *p* scale scores (measuring self-perception of voice emission characteristics) differed significantly between women and patients healthy control women: 4.43 vs 0.00 ($p = 0.03$). The difference between men patients and healthy control men was close to significance: 3.67 vs 00.00 ($p = 0.06$). No statistically significant differences were detected between patients and healthy controls for VHI f (impact in the daily activities) and VHI e (psychological impact), neither in women or men. VHI f (woman) 1.10 vs 0.00 ($p = 0,17$), VHI e (women) 0.95 vs 0,00 ($p = 0.28$), VHI f (men) 0.50 vs 0.00 ($p = 0.23$), VHI e (men) 0.17 vs 0.00 ($p = 0.23$) (Tables I, II.

The laryngo-stroboscopic examination showed normal laryngeal morphology and motility in all the patients, except for a woman patient who had

Table I. One way Anova analysis. Patient women vs healthy control women.

	Mean score	p
Shim	Patients 4.91 Controls 2.18	0.015
sAPQ	Patients 5.38 Controls 2.74	0.05
Jitt	Patients 0.95 Controls 0.50	0.18
sPPQ	Patients 0.74 Controls 0.44	0.13
F0	Patients 197 Controls 239	0.007
VHI p (perception of vocal emission characteristics)	Patients 4.43 Controls 0.00	0.03
VHI f (daily activities impact)	Patients 1.10 Controls 0.00	0.17
VHI e (psychological impact)	Patients 0.95 Controls 0.00	0.28

Shim: absolute shimmer, sAPQ: smotted amplitude perturbation quotient, jitter: irregularity index of vibration glottic, sPPQ: Smotted Pitch Period Perturbation Quotient, F0: fundamental frequency, vAm: peak to peak amplitude variation, VHI: Voice Handicap Index

Table II. One way Anova analysis. Patient men vs healthy control men.

	Mean score	p
Shim	Patients 5.43 Controls 2.27	0.07
sAPQ	Patients 5.73 Controls 4.95	0.012
Jitt	Patients 0.66 Controls 0.51	0.13
sPPQ	Patients 0.60 Controls 0.51	0.34
VHI p (perception of vocal emission characteristics	Patients 3.67 Controls 0.00	0.06
VHI f (daily activities impact)	Patients 0.50 Controls 0.00	0.23
VHI e (psychological impact)	Patients 0.17 Controls 0.00	0.23

Shim: absolute shimmer, sAPQ: smotted amplitude perturbation quotient, jitter: irregularity index of vibration glottic, sPPQ: Smotted Pitch Period Perturbation Quotient, F0: fundamental frequency, vAm: peak to peak amplitude variation, VHI: Voice Handicap Index

a vocal cord cyst. In eleven patients, out of the 30 examined, hyperkinetic features involving the supraglottic larynx were found. As many as 10 of 11 subjects with laryngeal hyperkinesia had acoustic alterations on spectrographic evaluation.

Sixteen patients reported minor ELR symptoms (Grade 1). Vocal fold vibration was regular and symmetric in all the patients, a slight adduction deficit was found in 6 of the 15 patients suffering from supraglottic hyperkinesia.

Discussion

In our group of 30 euphonic patients who had undergone thyroidectomy at least one year previously, the quantitative acoustic assessment of voice quality disclosed mild alterations in several parameters, more evident in those concerning the variability of loudness than pitch. To perform a more reliable acoustic evaluation we have associated to the generally used relative variability of the pitch (Jitt) and of the peak-to-peak amplitude (Shim) in the short-term, the smoothed corresponding parameters (sPPQ and sAPQ). When we compared self-perception of voice (VHI) in patients who had undergone thyroidectomy and healthy control subjects we found many patients who complained changes in their voice perception, despite experiencing no voice problems in their daily activities. Furthermore, in about one third of our patients who reported experiencing no problems related to vocal cord motility, videolaryngostroboscopy showed vocal cord hyperkinesia.

Voice alterations after thyroid surgery preserving laryngeal function[5,10,11] can have numerous causes including vocal cord edema, inflammation caused by orotracheal intubation, prelaryngeal strap muscle dysfunction, laryngotracheal fixity and scars which impair laryngeal elevation[6,12]. Some investigators suggest that a strap muscle contraction affects the external laryngeal structure thus elongating the vocal cords[5,13]. After thyroidectomy, the laryngotracheal unit is supported only by the prelaryngeal muscles. Hence abnormal scarring after dissection and suturing or even simple manipulation during surgery may engender a functional deficit[2]. These alterations may constitute a moderate or severe handicap to an individual's voice requirements in their professional and social life.

Our data, particularly the alterations found in the acoustic parameters related to peak-to-peak amplitude variability, suggest that in many patients we examined after thyroidectomy, the muscles of larynx were unable to maintain a stable voice emission. Although we cannot directly attribute these findings to thyroidectomy, we can assume that, despite the preservation of the EBSLN, the surgical maneuvers we used for sectioning and resuturing the sternothyroid muscles could have induced fibrosis, thus, altering our patients' laryngeal muscle balance. We also conjecture that surgically-related fibrosis might explain why[14], whereas in other series mild vocal changes reportedly reversed with a month, in our patients vocal alterations persisted for one year or more[15].

The more severe changes in voice quality we found in women patients than in men after thyroidectomy suggest that the lower ossification of the thyroid cartilage in the female sex makes them more prone to postoperative laryngeal muscle scarring or fibrosis[6].

Another finding in our study sample concerns the lower F_0 values (reflecting an individual's basic quality of tone) we recorded in women patients after surgery than in healthy controls. We tentatively attribute these decreased F_0 values to decreased vocal cord tension due to cricothyroid muscle dysfunction[16].

Although the difficulty to diagnose a SLN lesion by means the current standard equipment, our complete voice testing, including laryngostroboscopy and performed by an experienced ear-nose-and-throat specialist, make us confident in the accuracy of our assessment that excluded in all the patients a monolateral cricothyroid muscle damage[17].

In our evaluation we did not include methods based on the air flow rate during phonation, both based on indirect assessment (maximum phonation time) and direct (mean flow rate) because these methods yield poor diagnostic accuracy and the normal range is difficult to define[6]. Furthermore, we didn't seek to correlate SLN impairment with electromyographic (EMG) findings[18]. Even though cricothyroid muscle EMG accurately assesses SLN impairment, given that none of our patients complained of severe voice alterations we could hardly expect them to undergo this invasive procedure[19].

Conclusions

Our study conducted at least one year after thyroid surgery underlines that surgery-related slight voice deficits can persist over time. A complete pre and postoperative voice assessment should always include laryngostroboscopy[20] and spectrog-

raphy to document damage for possible litigations. Not the least, in our study the data regarding the voice self-perception suggest the importance of considering the patients' point of view and their expectations. A standardized voice self-evaluation should also become part of a standard pre and postoperative evaluation in patients who have to undergo thyroid surgery.

Even when thyroidectomy preserves vocal cord motility it may leave patients with changes in voice quality[21]. These changes may reflect prelaryngeal muscle scarring or fibrosis. Consider the possible alterations of vocal quality caused by scarring after surgery therefore strongly recommend surgery when the situation allows it, not to dissect the prelaryngeal muscles but only to spread apart.

Videolaryngostroboscopy is a reliable diagnostic procedure that can evaluate signs of cricothyroid muscle impairment. More refined phoniatric testing discloses voice alterations that normalize without specific rehabilitation therapy, therefore confirming that certain acoustic changes are clinically unimportant. Preoperative and postoperative acoustic tests may be helpful in detecting voice alterations already present before surgery and possible postsurgical alterations. Postoperative follow-up after thyroidectomy should include voice assessment to detect voice alterations early and start timely multidisciplinary treatment.

Conflict of Interest

The Authors declare that there are no conflicts of interest.

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