Voice Changes after Thyroidectomy Without Recurrent Laryngeal Nerve Injury

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BACKGROUND: Injury of the inferior laryngeal nerve is not the only cause of voice alteration after thyroidectomy; many patients notice minimal changes immediately after operation, without evidence of inferior laryngeal nerve damage. We hypothesized that there may be other causes for voice modification, such as injuries of the superior laryngeal nerve, prethyroid strap muscles, and cricothyroid muscles. We describe voice changes after total thyroidectomy, without inferior laryngeal nerve injury, using a computer program to objectively compare different patterns of voice.

STUDY DESIGN: Forty-six consecutive patients who underwent total thyroidectomy were studied between March 1997 and December 1999. Acoustic voice analysis was performed preoperatively and at the second, fourth, and sixth postoperative months using a microphone adapted to a personal computer. Parameters measured were intensity of the voice (Shimmer) and fundamental frequency (Fo).

RESULTS: No complications occurred during operation or in the postoperative period. Voice fatigue during phonation was the most common symptom after thyroidectomy. Forty patients (87%) stated that their voices had changed since the operation, and common complaints were voice alteration while speaking loudly, changes in voice pitch, and voice disorder while singing. Changes in the Fo and Shimmer values in smokers versus nonsmokers were similar (Fo overall, $p = 0.56$; Shimmer overall, $p = 0.66$), as were the same parameters in benign and malignant pathologies (Fo overall, $p = 0.66$; Shimmer overall, $p = 0.67$).

CONCLUSIONS: Voice changes after uncomplicated thyroidectomy occur and can be objectively measured. This is important in the preoperative counseling of patients before thyroidectomy, for ethical and legal purposes. (J Am Coll Surg 2004;199:556–560. © 2004 by the American College of Surgeons)

A lesion of the recurrent or inferior laryngeal nerve (ILN), whether by section, elongation, or injury by electrocauterization, is considered the main cause of post-thyroidectomy phonatory changes.[1] Its reported frequency fluctuates between 5% and 10%, of which 5% are temporary and between 0.8% and 1.7% are permanent.[1-3] Dysfunction of the ILN causes a dysphony, the seriousness and duration of which vary with the degree of nerve injury.

Injury of the ILN is not the sole cause of voice alteration because many patients notice minimal changes immediately after operation, without evidence of ILN damage.[4,5] We hypothesized that there may be other causes for voice modification, such as injury of the superior laryngeal nerve (SLN), prethyroid strap muscles, and cricothyroid muscles. Computer programs that allow voice recording permit investigators to avoid subjective factors in the evaluation of voice alterations by the patient and the observer.[6,7]

The current study was designed to objectively measure the presence, dimension, and duration of voice changes in patients who underwent total thyroidectomy without injury of the ILN.

No competing interests declared.

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METHODS

Forty-six consecutive patients were studied between March 1997 and December 1999 at the Hospital de

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Abbreviations and Acronyms

Fo = fundamental frequency of voice
ILN = inferior laryngeal nerve
Shimmer = intensity of voice
SLN = superior laryngeal nerve

Clínicas of the University of Buenos Aires. Mean age was 43 years (range 20 to 70 years); 43 (93.5%) were women, and 13 (28.3%) were smokers. There were 10 patients (21.7%) with adenomatous goiter, 19 (41.3%) with bilateral adenoma, and 17 (37.0%) with differentiated carcinoma. Patients who had previous thyroid surgery were excluded.

The preoperative evaluation consisted of a fibrolaryngoscopy and a voice recording on the computer program. The same studies were repeated 2, 4, and 6 months after surgery. The anatomy of the larynx and the motility of the vocal folds (opening and closing) were observed by fibrolaryngoscopy. The phonatory evaluation consisted of recording the voice on a computer program (Anagraf.LIS.1992) with sound blaster and a high-fidelity microphone. Each patient's voice was recorded and charted, and its acoustic outlines and characteristics were measured.

Both the ILN and SLN were carefully dissected in their route toward the larynx with the parathyroids. The opening of the midline by retraction of the strap muscles was carried out without sectioning them; the cricothyroid muscle was not injured. Patients were asked about the presence and magnitude of voice changes after surgery.

Voice analysis technique

The starting point of the method of voice analysis was the recording of an initial voice pattern. In the present study the vowel "a" was recorded taking into account the following conditions: the microphone was set at a distance of 30 cm from the oral cavity to avoid distortions or modifications in the recording; and the emission lasted for 2 seconds because a longer emission is considered singing voice.

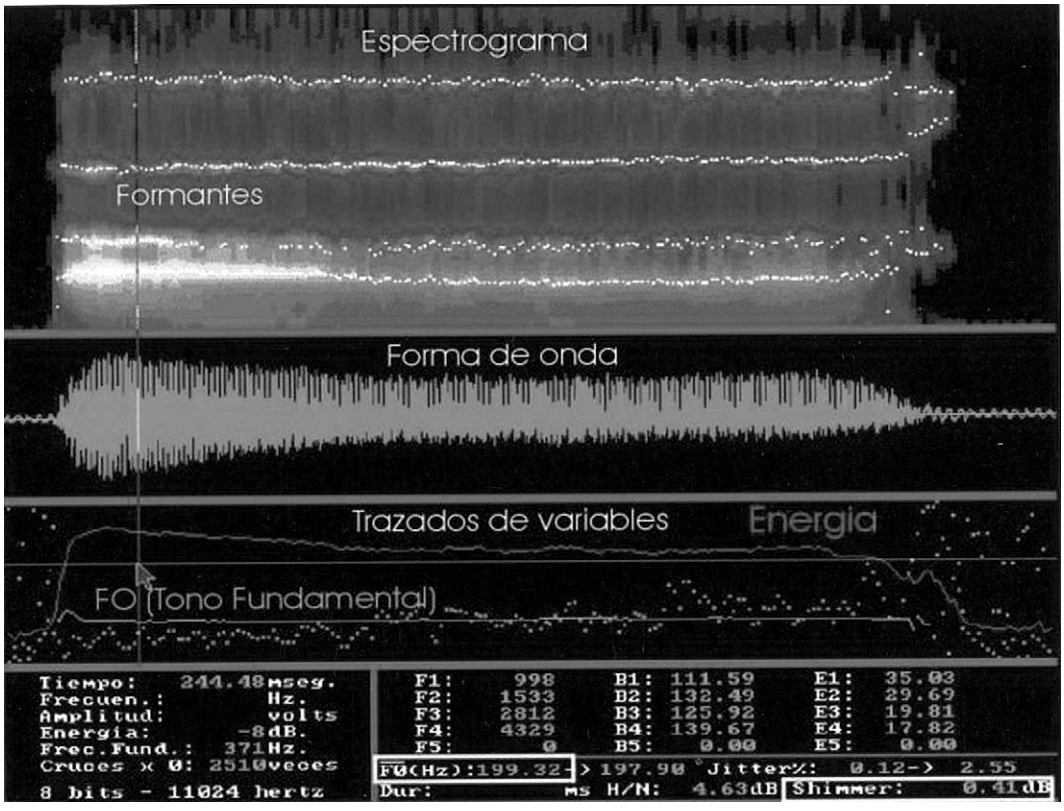

Figure 1. Spectogram of the parameters evaluated with a computer program.

Parameters evaluated

Once the recording was obtained, we graphed and measured the following parameters of voice production: speaking fundamental frequency (Fo) and its variation, the quantitative indicator of vocal cord vibration. Normal values are—men: 70 to 200 Hz; women: 150 to 300 Hz; and children: 200 to 400 Hz.

The Shimmer indicates total voice energy and its variation. Its curve consists of three parts: the attack, the body, and the end. It is expressed in decibels and its normal value must be less than 0 (Fig. 1).

Statistical analysis

For statistical analysis we used the program Statistica 5.0. Analysis of variance (ANOVA) for repeated measurements, multiple dependent measures of ANOVA (MANOVA), and Scheffé's posthoc tests for pairwise comparisons of means were used. Statistical significance was defined as $p < 0.05$.

RESULTS

No complications occurred during operation or in the postoperative period. Voice fatigue during phonation was the most common symptom after thyroidectomy. Forty patients (87%) stated that their voice had changed compared with what it was before surgery; the most common alterations were voice alteration while speaking loudly, changes in voice pitch, and voice disorder while singing.

Fibrolaryngoscopy showed no changes in the 46 patients, including those 40 who presented subjective changes, in whom the motility of the vocal folds in the immediate postoperative period was normal. The Fo measurements showed an initial decrease in the recorded parameters postoperatively, and progressive recovery by the sixth month (Table 1). Global statistically significant differences across the 4 time points were found ($p < 0.0001$) using the ANOVA test for repeated measurements of the Fo values. The Scheffé posthoc tests showed statistically significant differences between pre-and postoperative values (see Table 1). Comparison of values from preoperative and 6-month measurements indicated that a complete recovery was not achieved.

Table 1. Values of the Fundamental Frequency of the Voice in 46 Patients Who Underwent Total Thyroidectomy

Measurement time	Mean ± SD
Preoperative (a)	211 ± 17
2 mo (b)	176 ± 19
4 mo (c)	185 ± 12
6 mo (d)	199 ± 15

Probabilities for Scheffé posthoc test: (a) versus (b), $p < 0.0001$; (b) versus (c), $p < 0.0001$; (c) versus (d), $p < 0.0001$; (a) versus (c), $p < 0.0001$; (a) versus (d), $p < 0.0001$.

Table 2. Values of Total Voice Energy (Shimmer) of 46 Patients Who Underwent Total Thyroidectomy

Measurement time	Mean ± SD
Preoperative (a)	0.444 ± 0.18
2 mo (b)	0.819 ± 0.31
4 mo (c)	0.664 ± 0.32
6 mo (d)	0.449 ± 0.18

Probabilities for Scheffé posthoc test: (a) versus (b), $p < 0.0001$; (b) versus (c), $p < 0.04$; (c) versus (d), $p < 0.0013$; (a) versus (c), $p < 0.0009$; (a) versus (d), $p > 0.99$.

In contrast to Fo, Shimmer is inversely proportional to voice intensity. An initial Shimmer increase was observed, with a progressive lessening of Shimmer values indicating an increase in intensity in the following postoperative months (Table 2). Global statistically significant differences across time points were found ($p < 0.0003$) for the Shimmer values also. The Scheffé posthoc tests showed significant differences between preoperative, and 2- and 4-month postoperative values, but no differences were found between preoperative and 6-month postoperative values (see Table 2).

So although total recovery in the Fo recording was absent, a recovery in the Shimmer recording was observed.

Changes in the Fo and Shimmer values in postoperative recordings in smokers (n = 13) and nonsmokers (n = 33) were similar (Tables 3 and 4), as they were in patients with benign (n = 29) versus malignant (n = 17) pathologies (Tables 5 and 6).

DISCUSSION

The acoustic parameters affected in this study were the mean speaking fundamental frequency (Fo) and the mean

Table 3. Values of the Fundamental Frequency of the Voice in Smokers and Nonsmokers

Measurement time	Smokers (n = 13)	Nonsmokers (n = 33)
Preoperative	210 ± 16	210 ± 17
2 mo	177 ± 18	176 ± 20
4 mo	185 ± 12	186 ± 12
6 mo	197 ± 14	199 ± 15

F (MANOVA) = 0.346, $p = 0.56$.
Measurements are reported as mean ± SD.

Table 4. Values of Total Voice Energy (Shimmer) in Smokers and Nonsmokers

Measurement time	Smoker (n = 13)	Nonsmoker (n = 33)
Preoperative	0.450 ± 0.17	0.443 ± 0.18
2 mo	0.820 ± 0.30	0.820 ± 0.31
4 mo	0.638 ± 0.31	0.670 ± 0.33
6 mo	0.463 ± 0.18	0.450 ± 0.19

F (MANOVA) = 0.192, p = 0.66.
Values are mean ± SD.

Table 5. Values of the Fundamental Frequency of the Voice in Patients with Benign and Malignant Pathology

Measurement time	Benign (n = 29)	Malignant (n = 17)
Preoperative	211 ± 17	211 ± 17
2 mo	180 ± 20	177 ± 19
4 mo	185 ± 12	185 ± 12
6 mo	199 ± 15	199 ± 19

F (MANOVA) = 0.201, p = 0.66.
Values are mean ± SD.

voice intensity (Shimmer). Mean Fo values were different at 2 months after surgery compared with preoperative values, and they gradually recovered in the fourth and sixth postoperative months, although they didn't reach preoperative values. This may be attributed to a decrease in the cordal tension by alteration in the functional character of the cricothyroid muscle or the SLN.[7,8]

The Shimmer was also affected in the first postoperative recording (2 months), but a recovery was observed in later recordings. Intensity of the voice depends on the closing of the vocal folds, the cordal tension, and the breathing puff.[7,8]

Neither of these changes is compatible with ILN injury, but rather with alterations of the SLN or some temporary distortion of the laryngeal skeleton that produces a degree of temporary dysphony. In this study, no alterations in vocal fold motility were found by fibrolaryngoscopy, concluding that no ILN injury had occurred.

Other possible causes of postthyroidectomy voice alteration, besides ILN injury, have been described. Some authors[9-13] pointed out the importance of the strap muscles in phonation and described the external laryngeal structure that should contribute to the length of the vocal folds after muscular contraction. During some thyroidectomies in which the gland is very big, the strap muscles must be sectioned in order to obtain a good exposition. If this occurs, it is advisable to suture them to keep part of the larynx skeleton unaltered. After thyroidectomy, these muscles, in the absence of the thyroid gland, will be the sole support of the laryngotracheal unit, which will join the muscles through formation of a scar. In this series, the strap muscles were not sectioned, but we do not rule out that their elongation and retraction could produce a certain functional deficit.

Another possible cause of phonatory dysfunction may be the alteration of the SLN. The path of this nerve is variable; it accompanies the superior laryngeal pedicle and runs across the vessels of the superior thyroid pedicle. During its ligature, it can be sectioned if the nerve is not carefully individualized. An injury to the internal sensorial branch that is purely sensitive causes loss of sensitivity of the homolateral half of the larynx and piriform sinus. Injury of the external branch of the SLN affects the cricothyroid muscle.

Signs of cricothyroid dysfunction, whether by nervous or direct muscular injury, are subtle and variable. Normally, the cricothyroid muscle actively tightens during phonation to increase the tension in the vocal folds. When this function is lost, pitch decrease, fatigue during phonation, hoarseness, and loss of voice projection become apparent. Fatigue during phonation may be caused by the additional effort needed to increase voice pitch to compensate for the aforementioned deficit. So we cannot ignore the fact that a certain degree of nerve injury might have occurred in this series. These slight anatomic changes are usually unnoticed during operation, but they produce phonatory changes perceived by the patients during the postoperative period.

In conclusion, taking into account the results obtained, we conclude that:

1. Objective changes in the voice characteristics of patients with a total thyroidectomy are noticed even though the ILN was not damaged.
2. These changes are temporary for the Shimmer and more lasting for the Fo, although there is tendency toward recovery.

Table 6. Values of Total Voice Energy (Shimmer) in Patients with Benign and Malignant Pathology

Measurement time	Benign (n = 29)	Malignant (n = 17)
Preoperative	0.445 ± 0.18	0.432 ± 0.18
2 mo	0.819 ± 0.31	0.804 ± 0.32
4 mo	0.664 ± 0.32	0.656 ± 0.33
6 mo	0.449 ± 0.18	0.450 ± 0.19

F (MANOVA) = 0.181, p = 0.67.
Values are mean ± SD.

3. Both changes and recovery are subjectively noticed by 87% of patients.
4. Differences from smoking habits or thyroid pathology could not be proved.

Possible causes for these alterations may be from SLN injury, injury of the strap muscles of the larynx, or injury of the cricothyroid muscle. So we believe it is important to warn patients about these changes and, for ethical and legal purposes, to include this statement in the consent form, and advise patients to follow an early phonatory treatment to speed up recovery.

Author Contributions

Study conception and design: Sinagra
Acquisition of data: Tacchi, Moreno
Analysis and interpretation of data: Sinagra, Montesinos
Drafting of manuscript: Sinagra
Critical revision: Falco
Statistical expertise: Montesinos
Obtaining funding: Sinagra
Supervision: Debonis, Curutchet

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