

# Unilateral vocal fold paralysis post-thyroidectomy: does early intervention allow for better voice recovery?

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**Abstract.** – **OBJECTIVE:** Thyroidectomy is the primary cause of unilateral vocal fold paralysis (UVFP). A delay in rehabilitation may cause dysfunctional phenomena and worsen dysphonia. The main aim is to investigate the impact of early Speech Therapy (ST) on voice recovery in UVFP post-thyroidectomy and propose an appropriate treatment schedule.

**PATIENTS AND METHODS:** 93 patients with UVFP were analysed. 72 presented transient paralysis and 21 permanent ones. Individuals with permanent paralysis were retrospectively divided in two groups. Group A was composed of 11 patients (8 F, 3 M; mean age:  $50.5 \pm 8.6$ ) who received ST within 8 weeks; Group B comprised 10 patients (7 F, 3 M; mean age:  $57 \pm 11.5$ ) treated after more than 8 weeks. Videolaryngostroboscopy (VLS) was assessed and both objective and subjective voice parameters were collected. The non-parametric Wilcoxon test was applied to the sample.

**RESULTS:** The resolution of supraglottic compensations was observed in 91% of cases in Group A, whereas in only 40% of cases in Group B. A functional glottal closure occurred in 73% of patients in group A, while it was completely absent in group B. Group A showed a statistically significant difference between the values of Jitter, NHR, TMF and VHI collected pre-ST compared to that collected after 1 year. Conversely, a statistically significant difference was found only for VHI values in group B.

**CONCLUSIONS:** Early ST brings benefits to patients with permanent UVFP, both on voice recovery and on quality of life. A ST protocol should be applied both before and after thyroidectomy. The ST treatment should start early after surgery.

*Key Words:*

Unilateral vocal fold palsy, Thyroidectomy, Dysphonia, Voice, Early intervention.

## Introduction

Thyroid surgery is the major cause of unilateral vocal fold paralysis (UVFP). Currently, the percentage of postoperative recurrent laryngeal nerve (RLN) injuries is estimated between 1% to 30% for transient lesions and between 0.5% to 5% for permanent ones<sup>1</sup>. Thyroid surgery includes a wide range of surgical interventions. Although not investigated to date, the incidence of UVFP might be different when correlated with the type of procedure which is performed. Chen et al<sup>2</sup> on the risk factors associated with UVFP after thyroid surgery revealed that the incidence of UVFP was both higher in older patients and in patients with diabetes mellitus. Age in fact increases the risk of neoplasia and even of UVFP. Furthermore, total thyroidectomy with neck dissection was associated with the highest rate of UVFP<sup>2</sup>. On the contrary, another paper showed a considerable decrease in post-thyroidectomy UVFP events, with several cases occurring after thoracic surgery or for idiopathic causes<sup>3</sup>. This could be explained thanks to more accurate and conservative thyroidectomy techniques that prevent the incidence of iatrogenic RLN lesions. In addition, intraoperative neuromonitoring has demonstrated encouraging benefits in reducing the incidence of total and partial recurrent laryngeal nerve paralysis<sup>4</sup>. Nonetheless, UVFP remains a widespread complication after the current thyroidectomy procedures, since it is responsible for disabling dysphonia, low quality of life and medico-legal implications.

Patients who experience UVFP after thyroidectomy complains of dysphonia caused by incomplete glottal closure. Consequences are airflow leakage and inadequate vibration of the free

edges of the vocal folds. The patients' efforts to increase vocal intensity usually led to a strong contraction of the laryngeal muscles and can cause the involvement of supraglottic structures in phonation. The voice becomes rough and weak and the expiratory effort often interrupts speech. These changes can interfere with patients' daily life and cause a real handicap, especially for professional voice users.

Currently UVFP treatment options are both rehabilitative and surgical. Amongst the latter, different procedures are applied: transient or permanent vocal fold medialization, vocal fold injection<sup>5</sup> and reinnervation in case of a permanent lesion. Although various approaches have shown good results<sup>6</sup>, Speech Therapy (ST) is still the first treatment in UVFP patients, and several studies<sup>7-9</sup> have thus far demonstrated the role of early rehabilitation in the recovery of vocal function.

One of the major concerns in clinical practice is the delay in laryngological diagnosis. Sometimes the patient is reassured by the surgeon about the transient nature of the paralysis, thereby inducing a waiting behaviour. As a consequence, dysphonia can worsen and a supraglottic pathologic compensation can develop, with negative effects on voice recovery even in transient UVFP. Few studies have been conducted on the role of early rehabilitation in voice recovery after UVFP so far and none of them focus exclusively on UVFP after thyroid surgery. Analysing a sample of 171 patients with UVFP, Mattioli et al<sup>10</sup> demonstrated that receiving ST within 4 weeks from intervention resulted in better voice recovery and an increase in the patients' quality of life. Similarly, the researchers' results emphasized unsatisfactory vocal recovery in patients who were treated after more than 8 weeks from UVFP. On the other hand, Busto-Crespo et al<sup>11</sup> investigated the long-term efficacy of ST. They underlined an improvement in terms of quality of life also in patients who had received delayed voice therapy. Both studies analysed the effects of ST considering various aetiologies of UVFP<sup>10,11</sup>. In the present study, the differences between early ST (within 8 weeks) and late ST (more than 8 weeks) were instead studied focusing solely on thyroid surgery related UVFP. The development of a laryngeal compensation with complete glottic closure was carefully investigated through the use of Videolaryngostroboscopy (VLS). Voice parameters were analysed comparing their values before ST

and 1 year after thyroidectomy. Besides, differences in patients' self-perception of voice were studied through the use of the Voice Handicap Index (VHI)<sup>12</sup> questionnaire compiled before ST and after 1 year of follow-up.

## Patients and Methods

93 dysphonic patients were enrolled and prospectively analyzed between June 2017 and June 2020 at the Phoniatic Unit of Umberto I Hospital in Rome. They all received a thyroidectomy-related diagnosis of UVFP through VLS. The inclusion criteria of the study were: 20-75 years of age, clinical and instrumental diagnosis of UVFP after thyroidectomy and the presence of clinical signs of RLN injury. The exclusion criteria were vocal fold hypomotility already present before surgery, vocal fold paralysis lasting for more than 1 year and ST started before the enrolment phase. Besides, patients who were affected by other organic laryngeal diseases or who had undergone previous laryngeal treatments (surgery, chemoradiotherapy) were excluded. From the original sample, 21 patients with permanent UVFP were retrospectively collected and divided into two subgroups: group A composed of 11 subjects and group B of 10 subjects. The inclusion in a subgroup was determined considering the time elapsed between the onset of symptoms and the start of ST, evidently caused by a timely or delayed request of laryngological consultation. Group A received the ST treatment within 8 weeks (mean of  $41.6 \pm 14.4$  days; range of 21-56 days), while group B received it more than 8 weeks after (mean of  $132.2 \pm 51.6$  days; range 63-226 days). The ST started within 5 days from the laryngological consultation requested by the surgeon. A treatment with corticosteroids was administered to all the patients manifesting dysphonia after thyroidectomy. It was prescribed for 14 days before starting the ST, but it failed to improve vocal fold mobility. Each enrolled patient has been evaluated in 3 steps: before starting ST, immediately after finishing the ST cycle and 1 year after thyroidectomy. All patients received the same diagnostic assessment and the same voice therapy. The evaluation included a complete medical history, a laryngological examination and a voice analysis. VLS was performed by two experienced laryngologists of the Phoniatic Unit. A rigid 70° optics endoscope (Hopkins, 8700 CKA, Karl Storz, Germany) was used in a

stroboscopic observation (Endo-Stroboscope L, Atmos, Germany). The morphology and motility of the vocal folds were recorded and classified according to the Protocol of the Committee on Phoniatics of the European Laryngological Society<sup>13</sup>. The motility of the vocal folds was then classified under one of the following behaviours: normal motility, hypomotility, hyperadduction during phonation, immobility (in median position, intermediate position or lateral position). The supraglottic framework behaviour was described as: normal behaviour during phonation; presence of anteroposterior hypercontraction; presence of hypercontraction of vestibular bands and complete hypercontraction of supraglottic structures. The level of immobile vocal fold was compared to the contralateral normomobile vocal fold by means of a flexible endoscope. The symmetry and periodicity of the glottic vibration were analysed. The glottic closure was classified as complete, slightly incomplete or very incomplete. The eventual glottic gap morphology could be: spindle-shaped, hour-glass shaped, posterior triangle, irregular or total. The amplitude of the vocal fold vibration was described as normal, small, large or absent and characteristics of the mucosal wave were analysed. These vibratory patterns were evaluated asking each patient to produce an /e/ and an /i/ vowel sound during the examination.

The Multidimensional Voice Program (MDVP) (Model 5105, Version 3.1.4<sup>©</sup> 2000-2006 KayPEN-TAX) was used to perform an objective voice evaluation. The voice was recorded with a Shure microphone (SM48 model) positioned at a 45° angle approximately 15 cm from the mouth and slightly below the chin; the environmental noise was inferior to 30 dB SPL. Patients were asked to produce the vowel /a/ at a comfortable loudness for at least 5<sup>2</sup>. The voice was recorded with a sampling rate of 50.000 Hz for MDVP analysis. An interval of 3<sup>2</sup> from the middle part of the voice sample was selected and the following parameters were evaluated: Jitter (Jitt %), Shimmer (Shimm %), Noise-to-Harmonics Ratio (NHR) and Soft Phonation Index (SPI). The Maximum Phonation Time (MPT) was determined asking the patient to produce the most prolonged /a/ vowel possible in a single inhalation while standing. The patient was asked to repeat the exercise three times and the best attempt was considered as the MPT. Then, each patient completed the Voice Handicap Index (VHI) questionnaire for self-assessment of the dysphonia severity. The VHI

consists of 30 questions regarding the effect and psychological impact of vocal problems on daily activities and the self-perception of voice quality. The objective voice parameters were collected by a speech therapist who was blinded for the purpose of the study and who had no knowledge as to which group the patient had been assigned to. All the subjects performed a total of 10 sessions of individual SP treatment. Each daily session lasted about 30' and was led by an experienced speech therapist. Although the speech therapist adopted an individual approach, the same procedure was applied to each participant.

The ST protocol focused on:

- The development and automatization of cos-to-diaphragmatic breathing.
- The recovery of the pneumo-phonetic coordination and reinforcement of the expiratory airflow. In the presence of a breathy voice, this was obtained through the production of vocalic syllables during phonatory tasks, by using central vowels (/i/, /e/), in a falsetto voice. If a patient pathologically displayed a falsetto voice, all the tasks were executed with a more low-pitched phonation and hard attack vocalizations.
- The elimination of any pathological or dysfunctional behaviours.
- The enhancement of the adduction of the vocal folds, based on vocal and non-vocal exercises and facilitating approaches. The vocal exercises comprise producing syllables containing unvoiced occlusive phonemes (/k/, /p/, /t/), produced singularly, in compound syllables (/kie/), in repetition (/papa/) and in consonant clusters (/kra/). Furthermore, a range of vowel sounds were used in isolation or together with voiced or unvoiced velar occlusive consonants (/aaaa/, /kaaaa/, /gaaaa/).
- The enhancement of the frequency and intensity of voice modulation.
- The correct use of the resonance system.
- The generalization of the acquired techniques.
- The study of the main standards for vocal hygiene and of the strategies for their application.

### **Statistical Analysis**

A statistical analysis was performed using SOFA Statistics version 1.4.6. The inter-rater reliability between the evaluations of the motility of the vocal folds was determined by calculating Cohen's kappa coefficient. MPT, Jitt %, Shimm %, NHR, SPI and VHI values were comput-

ed in group A and in group B separately. The post-treatment values, collected after 1 year, were compared to the corresponding pre-treatment values. The non-parametric Wilcoxon test was used to analyse the differences between the values in order to establish if they were significantly different in statistical terms. A *p*-value of less than 0.05 was considered as statistically significant. The present study was approved by the Institutional Review Board and was conducted according to the principles and rules presented in the Declaration of Helsinki and its subsequent amendments.

### Results

The study enrolled 93 patients: 72/93 (77%) showed transient paralysis of RLN, while 21/93 (23%) permanent ones. Patients diagnosed with permanent lesions were retrospectively divided in two groups. Group A received an early diagnosis and was composed of 11 patients (8 females, 3 males; mean age:  $50.5 \pm 8.6$ ; range 33-68). Group B patients were given a late diagnosis and consisted of 10 subjects (7 females, 3 males; mean age:  $57 \pm 11.5$ ; range 28-73). All patients completed all therapy sessions. The videolaryngostroboscopic observations were the

following: Group A patients were diagnosed with 8 left and 3 right vocal fold paralyses in total, while Group B patients showed 6 left and 4 right vocal fold paralyses. The paralysed vocal fold was immobile in a paramedian position in all the patients. At the end of the 1 year of follow-up, a complete glottal closure was achieved in 8 cases for Group A; glottal closure was slightly incomplete in 2 cases and very incomplete in only 1 patient. Conversely, the glottal closure of Group B patients resulted slightly incomplete in 3 cases and very incomplete in 7 cases (Figure 1). Regarding the supraglottic framework behaviour, 6 patients in Group A presented hypercontraction of vestibular bands and 1 patient manifested anteroposterior supraglottic hypercontraction. Nevertheless, 10/11 (91%) of Group A patients resolved these dysfunctional behaviours at the follow-up after 1 year. In group B, 8 patients presented hypercontraction of vestibular bands and 2 patients presented anteroposterior supraglottic hypercontraction. In this group, on the contrary, only 4/10 (40%) patients after 1 year restored a normal behaviour of supraglottic structures during phonation (Figure 2). The Cohen's kappa coefficient measured the agreement between two independent rates in evaluating the morphology and motility of the vocal folds and the resulting value was 0.92.

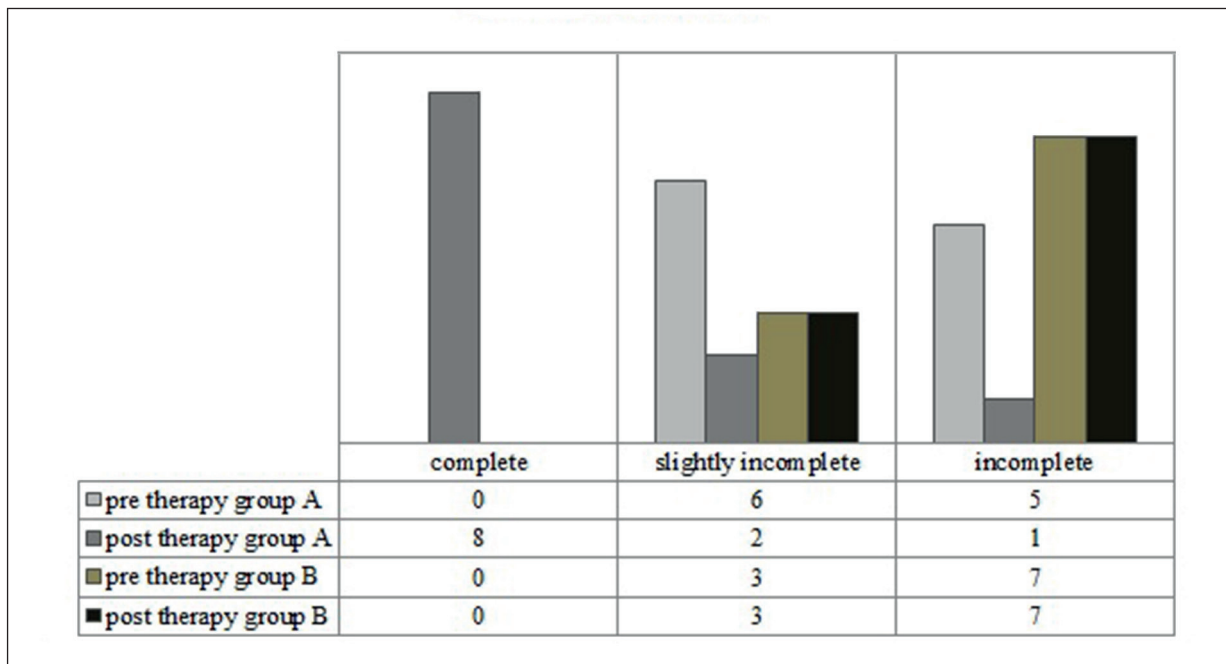


Figure 1. Glottic closure.

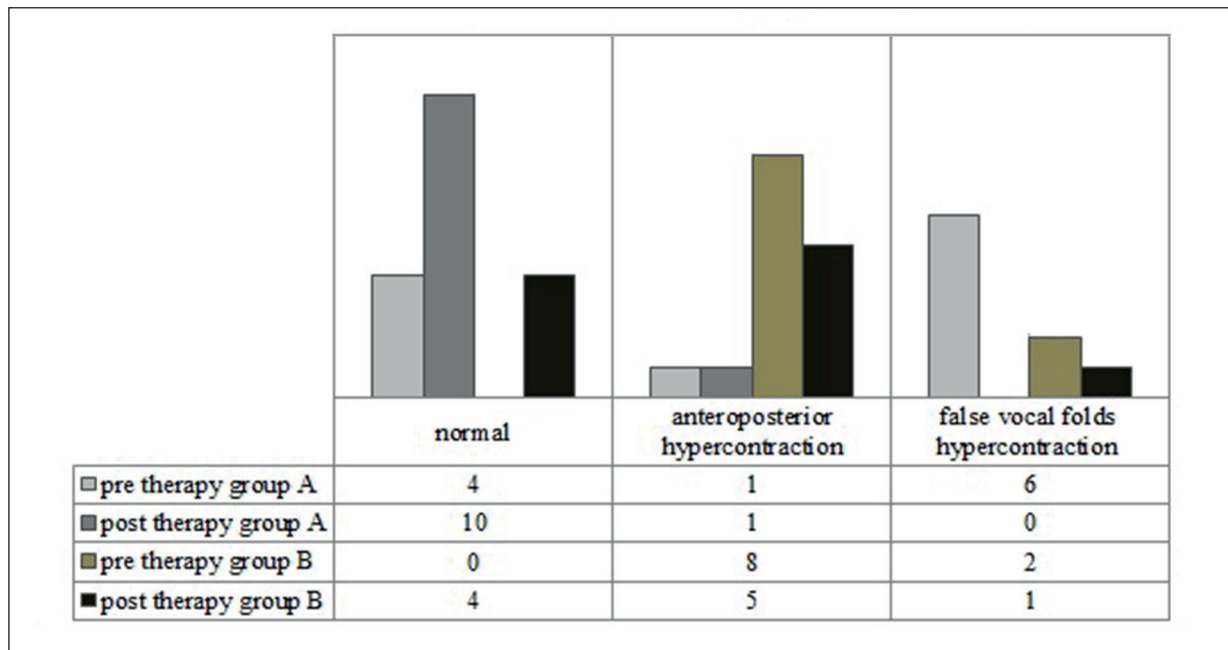


Figure 2. Supraglottic structures.

Concerning the objective voice parameters collected before ST treatment, none of the average values showed a statistically significant difference between the two groups (Table I). The Wilcoxon test showed a statistically significant difference between the pre-therapy values and the 1-year follow-up values in Group A. In particular, this was true considering the *p*-values of the following parameters: 0.003 for Jitt %, 0.01 for VHI, 0.02 for NHR, and 0.03 for TMF. Conversely, a statistically significant difference was found only for VHI (*p*-value: 0.002) in Group B. The objective voice parameters collected from the 2 groups both pre-ST and post-ST are reported in Table II.

### Discussion

To our knowledge, this is the only study that focuses on voice quality after ST treatment in the case of UVFP after thyroidectomy. Several authors underlined that early ST might enhance glottic closure and then improve voice quality avoiding the development of hyperfunctional compensatory behaviours<sup>8,10,11,13</sup>. Nevertheless, there are still grey areas that need to be clarified, e.g., the best time to start ST, what factors predict better outcomes<sup>14,15</sup> and the best timing for evaluating outcomes<sup>16</sup>. The time expected for UVFP recovery seems to depend on the portion of the RLN which is injured<sup>17</sup>. The mean recovery time

Table I. Pre-therapy values

Pre-treatment values	Group A		Group B		<i>p</i> -value
	Σ	STDEV	Mean	STDEV	
Jitter %	3.983	1.675	3.791	3.075	0.89
Shimmer %	11.075	4.627	11.673	6.687	0.86
NHR Hz	0.276	0.111	0.316	0.214	0.70
SPI Hz	4.486	1.622	4.932	2.879	0.75
VHI	59.2	27.3	67	17.3	0.50
TMF sec	6.2	2.3	6.1	1.9	0.93

NHR, noise-to-harmonic ratio; SPI, soft phonation index; VHI, voice handicap index; MPT, maximum phonation time; STDEV, standard deviation; Hz, hertz; sec, seconds.

**Table II.** Pre-therapy and post-therapy outcomes.

Group A = N 11 Early Rehabilitation	I		II		III		<i>p</i> -value
	Mean	STDEV	Mean	STDEV	Mean	STDEV	
Jitter %	3.983	1.675	1.338	1.087	0.873	0.308	0.003
Shimmer %	11.075	4.627	6.034	4.095	6.345	2.103	0.07
NHR Hz	0.276	0.111	0.162	0.055	0.141	0.019	0.02
SPI Hz	4.486	1.622	5.347	2.721	6.351	2.532	0.20
VHI	59.2	27.3	24.4	16	18	9.21	0.01
TMF sec	6.2	2.3	12	4.8	12.4	4.8	0.03
Group B = N 10 Late Rehabilitation	I		II		III		<i>p</i> -value
	Mean	STDEV	Mean	STDEV	Mean	STDEV	
Jitter %	3.791	3.075	2.614	2.625	2.185	2.753	0.23
Shimmer %	11.673	6.687	9.184	7.633	9.461	9.497	0.55
NHR Hz	0.316	0.214	0.227	0.171	0.239	0.206	0.42
SPI Hz	4.932	2.879	4.087	1.446	4.804	2.316	0.91
VHI	67	17.3	48.6	17.5	38.9	18.4	0.002
TMF sec	6.1	1.9	8.9	4.3	10.7	6.8	0.05

NHR, noise-to-harmonic ratio; SPI, soft phonation index; VHI, voice handicap index; MPT, maximum phonation time; STDEV, standard deviation; Hz, hertz; sec, seconds. I = pre-therapy; II = post-therapy; III = 1 year follow up.

for transient RLN injuries seems to be equal to 8 weeks after intervention<sup>1</sup>, confirming the nerve has great potential to regenerate. Surgical treatment is then currently not recommended until 6 months after a thyroid surgical procedure<sup>18</sup>. In the present study, voice therapy was started for each diagnosed UVFP. Subsequently, only cases of permanent paralysis were analyzed, splitting the sample in patients who received ST before 8 weeks and after 8 weeks. Outcomes were assessed 12 months after thyroidectomy. Less hyperfunctional compensatory behaviors and better glottal closure were expected in patients who started therapy sooner rather than patients who started therapy later. The hypothesis was confirmed by the post-treatment VLS evidence that showed a clear reduction or elimination of supraglottic dysfunctional compensations associated with early voice therapy in all the patients. A normal supraglottic framework behaviour was observed in 10/11 cases (91%) of Group A after ST, whereas only in 4/10 cases (40%) of Group B. Furthermore, the most relevant result was that a compensatory behaviour aimed at reaching glottal closure occurred in 73% of patients belonging to group A. Conversely, this functional behaviour did not develop in any patients within group B. Regarding the analysis of objective voice parameters, Jitt % values improved after ST in both

groups; nevertheless, in group A Jitt % values reached statistical significance. As regards the Shimm % values, improvements were observed in both groups without reaching statistical significance. The values of Jitt % and Shimm % indicate the irregularity of glottic vibration and they are respectively correlated to rough voice and to breathy voice; higher values are usually associated with UVFP<sup>19</sup>. NHR provides an overall quantification of the presence of noise in the range of middle to low frequency. Its values improved more consistently after ST in group A. Besides, SPI is an objective measure of the degree of the vocal fold adduction during phonation. Its values evidently improved in group A as opposed to in group B. The improvement of TMF was evident in both groups, but Group A values reached statistical significance. The subjective voice parameters were obtained by administering the VHI test to all the patients. The scores between the two groups were not radically different. An important decrease in the VHI mean scores was evident in all patients after ST. This result underlines the role of ST in terms of improving the perception of good vocal health after the rehabilitation treatment.

The results presented in the study confirm the crucial role of early voice rehabilitation in achieving better outcomes in the case of UVFP

post-thyroidectomy. The Group A patients who underwent early ST developed compensatory behaviours whereby a voice of good quality was restored. They also achieved benefits in terms of voice-related quality of life and avoided surgical treatments. Nonetheless, a delayed ST could be also recommended as it is shown to improve patients' quality of life. It is noteworthy that ST resulted in a VHI score improvements in both groups, even if functional laryngeal behaviours were significantly improved only in the Group which had received early ST. According to literature<sup>1,14</sup>, the results confirmed that the position of the vocal folds was paramedian in most UVFP thyroidectomy-related, allowing for better vocal recovery. This can reasonably happen when the external branch of the superior laryngeal nerve is spared from the injury and the cricothyroid muscle can perform its motion. In UVFP caused by thoracic surgery, the paralysed vocal fold usually assumes a lateral position. For this reason, the recovery from vocal folds paralysis should be considered more difficult after thoracic surgery rather than in post-thyroidectomy. Moreover, there is another important element to consider. The number of people under 50 years of age is much higher in the case of thyroidectomy as oppose to that of thoracic surgery. Therefore, patients of this age group in general have greater motivation to receive ST treatment and more often get results, especially if they are professional voice users. The results presented are developed after 1 year of follow-up. It was therefore possible to define the nature of RLN paralysis, whether transient or permanent, and assist the patient during the entire rehabilitation process. The aim is to raise awareness in the medical community about UVFP in a way that allows patients an easy access to the vocal care they need. This would enable them to more easily recover a satisfactory quality of voice and avoid surgical treatments unless strictly needed.

### Conclusions

In the clinical management of patients who undergo thyroid surgery, it would always be appropriate to examine the patient through VLS not only before the surgical intervention, but also shortly after it. If examined within a week from surgery, it would be possible to assess any consequent laryngeal deficit. In the case of UVFP, clinicians should establish an appropriate medi-

cal treatment and assist the patient during the 14 days after surgery. In persisting UVFP, ST should be started as soon as possible, at least within 8 weeks from surgery.

### Conflict of Interest

The Authors declare that there is no conflict of interests. The authors alone are responsible for the content and for the writing of the paper.

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