Montgomery thyroplasty. Case report focusing on endoscopic and functional findings

Case report di un paziente sottoposto ad intervento di Tiroplastica di I tipo con protesi di Montgomery: rilievi endoscopici e funzionali

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Key words

Vocal cord paralysis • Surgical treatment • Thyroplasty • Videoendoscopy

Parole chiave

Paralisi laringea • Trattamento chirurgico • Tiroplastica • Videolaringostroboscopia

Summary

The case is described of a 58-year-old male with cord paralysis submitted to Montgomery thyroplasty, attention being focused on the electro-acoustical findings. The usefulness is underlined of these indices which provide the opportunity to establish the phonatory advantages and results of this surgical procedure. Videolaryngostroboscopy and spectrographic analyses were carried out before and after surgery. Phonatory results were, in fact, evaluable 24 hours after surgery and found to be excellent whereas the perceptive evaluation and subjective symptoms were seen to be comparable to those in normal subjects one week after surgery.

Riassunto

Gli AA presentano una dettagliata analisi elettroacustica della voce di un paziente sottoposto ad intervento di tiroplastica di I tipo secondo Montgomery sottolineando l'importanza e l'utilità in particolare di alcuni indici che consentono di identificare in modo più specifico i vantaggi ed i risultati fonatori di tale tecnica chirurgica. In sede di intervento è stata valutata la posizione assunta dalla corda vocale al momento dell'innesto protesico; gli Autori sottolineano la facilità di esecuzione della tecnica chirurgica nonché la mancanza di complicanze. Il paziente è stato valutato, prima e dopo l'intervento, mediante una videolaringostroboscopia, un'analisi spettrografica con sistema MDVP (Kay) che prevedeva il rilevamento dei parametri di jitter (J), shimmer (Sh), NHR, VTI, DSH, DVB, DUV, una valutazione percettiva della voce secondo la scala GIRBAS, ed inoltre mediante un questionario di autovalutazione della propria voce per identificare il Voice Handicap Index (VHI). Dall'analisi di questi dati emerge che il risultato fonatorio è ottimale e valutabile oggettivamente già a 24 ore dall'intervento mentre la valutazione percettiva e la sintomatologia soggettiva sono assimilabili ai soggetti normali solo ad una settimana dall'intervento chirurgico.

Introduction

Unilateral paralysis in complete abduction causes severe glottic insufficiency that tends to show no spontaneous compensation in time (unlike unilateral paralysis in a paramedian position). The voice of these patients is typically low and breathy and due to the marked phonatory strain frequent inspiration is necessary.

Speech therapy alone cannot close the glottic gap; for this reason, various corrective techniques have been suggested, such as paraffin infiltration [1], homogenized cartilage [2], cartilage implant [3], the use of pulverized bone in suspension [4], Tantalium in suspension [5], Teflon [6], Silicone [7], Hydron Gel [8], Gelfoam paste [9], bovine collagen [10], autologous fat [11], autologous collagen [12], autologous fascia [13], autologous fascia implant [14], polydimethylsiloxane (PDMS-Bioplastique) [15]. However, the phonatory results achieved were not always maintained over time [16-20]. Type I Thyroplasty or medialisation of the vocal cord is currently the first choice surgery, with longer-lasting phonatory results, to recover glottic competence with passive correction of the cord position using implants of various materials. The sylastic implant designed by Montgomery has gained wide recognition by many Authors [21 22] as the most valid technique currently available to simultaneously medialise the cord and the arytenoid vocal process without severe complications. Its application is relatively simple and rapid, it requires local anaesthesia, and on account of the structure, no suture is required to keep it in place and it rarely becomes dislodged [20 21]. In addition, if necessary, the implant can be readily removed with-

out damaging the laryngeal tissue, and as the base of the implant is of standard size, it can be replaced by another of a different size without further intervening on the insertion window. Some Authors [20 23] have studied the phonatory results after this procedure, but only a few of the electroacoustical parameters have been assessed and no long-term follow-up results are available.

Aim of the study

The aim of the study was to evaluate a case of cord paralysis in complete abduction before and after Montgomery thyroplasty, using stroboscopy and spectroacoustical tests with MDVP to evaluate possible morphofunctional variations of the glottis and the trends in the acoustical parameters over time, as well as to identify the electroacoustical indices that provide the most useful information on the phonatory dynamics after surgery.

Material and methods

G.C., a 58-year-old male, was admitted to our ward with marked dysphonia, not associated with dysphagia, caused by a left cord paralysis in complete abduction secondary to total thyroidectomy performed about 14 months earlier for multinodular goitre; the patient reported having had speech therapy twice weekly for 8 months with no improvement in the symptoms. Montgomery type I thyroplasty was planned. Before surgery and on the first, second, third and seventh day after surgery, the patient underwent a series of tests comprising:

- laryngostroboscopy with Atmos stroboscopic light with 90° rigid scope and a flexible fiberoptic scope. The latter was also used during surgery to check that the paralysed vocal cord reached the midline;
- spectrographic voice test, carried out with a Kay 4400 CSL system linked to a Personal Computer and input level at 6/9, environment noise less than 30 dB, microphone at 20 cm from the patient's mouth, at an angle of 45°.

During the test the following data were recorded:

- an /A/ sustained for at least 6 seconds at an intensity ranging between 55 and 65 dB, after at least 3 trial runs, testing the middle 2 seconds for the MDVP parameters applying a sampling rate at 50 kHz;
- the word "aiuole" with downsampling at 10 kHz;
- 10 seconds of spontaneous conversation.

On the basis of the spectrographic data, the following parameters were evaluated (upper normal values are given, in brackets, for each item):

- **Jitter** (1.04%) and **Shimmer** (3.81%), respectively, indicative of the average perturbations in frequency and intensity;
- **VAm** (Variation Amplitude = 8.20%): mean percent variation in peak amplitude and is indicative of voice intensity sustainment;
- **FTRI** (Frequency Tremor Intensity = 0.95%) and **ATRI** (Amplitude Tremor Intensity = 4.37%), indicating, respectively, the depth of frequency and amplitude tremors;
- **NHR** (Noise to Harmonics Ratio = 0.19), which expresses the ratio, in absolute numbers, between noise in the range 1500-4500 Hz and the harmonic energy in the range 70-4500 Hz (low frequency harmonics/noise ratio);
- **VTI** (Voice Turbulence Index = 0.06) ratio, in absolute terms, between noise in the range 2800-5800 Hz and the harmonic energy in the range 70-4500 Hz (harmonics/noise ratio on the high frequencies of the vocal spectrum);
- **DUV** (Degree of Unrecorded Voice = 0%), index of the degree of voicelessness (irregular and prolonged interruptions with no detection of the fundamental frequency);
- **DVB** (Degree of Voice Breaks = 0%), index of the degree of interruptions in sound;
- **DSH** (Degree of Subharmonics = 0%), index of the degree of diplophonia;
- questionnaire for subjective VHI voice evaluation (Jacobson modified by Luppi);
- in addition, 10 days after surgery, a CT scan of the neck and larynx, without contrast medium, to check that the implant was correctly positioned;
- four weeks after surgery a series of speech therapy sessions was carried out to maintain the good quality of the voice achieved with surgery. The aim of this therapy was to prolong the voice sustainment, by maintaing adduction and cord vibration. To combine phonation and articulation and to make the patient's voice more "natural" "linked diphthongs" were used in only one breath. Subsequently, vocal scales "with relaxed voice" were suggested to teach the tone and intensity variations used in everyday speech.

Finally, 3 months after speech therapy, another electroacoustical examination was carried out to assess any variations in voice performance.

Surgery was performed with the patient under local anaesthetic, induced by infiltration with 1% Xylocaine and Adrenaline, sedation with i.v. Propofol at a dose of 2 mg/kg/hour.

A horizontal skin incision was made on the neck starting 2 cm from the midline to the anterior margin of the sternocleidomastoid muscle, about 0.5 cm above the lower margin of the thyroid cartilage, followed by an incision on the platysma, diastasis of the sternohyoid muscles, exposure of the thyroid carti-

lage, without cutting the sternohyoid and omohyoid muscles. Identification of the *Key Point* (reference point on the thyroid cartilage that marks the position of the implant insertion window), marking of the four corners with the window outline instrument, cutting of the window and removal of the cartilage leaving the inner perichondrium intact. After carefully stripping the intralaryngeal perichondrium, the implant was selected with the use of a specific measuring calliper and inserted; no further dose of anaesthetic had to be administered when the implant was inserted. The correct positioning of the implant, the degree of cord medialisation and the immediate phonatory results achieved were assessed during surgery using a flexible fiberoptic laryngoscope. Suture of the deep layers was carried out bringing the sternohyoid muscles together, on the midline, with single catgut stitches, suction drainage was applied and the skin was sutured.

Results

Preoperative tests

Preoperative tests showed:

- at laryngostroboscopy (Fig. 1), a severe glottic gap with attempted adductory compensation, by the other vocal cord: in particular, the fixed vocal cord appeared hypotonic and atrophic and even below the glottic level. The right arytenoid presented slight luxation;
- Spectrographic test with MDVP parameters (Fig. 2A, B) showed the following phonatory assessment: F 0 = not assessable, Jitter 7.2%, Shimmer 13.5%, NHR 3.5, VAm 28.5%, VTI 3.2%, FTRI 2.3%, ATRI 5.2%, DSH 2% DVB 2%, DUV 1.2%.

Fig. 1. Pre-operative laryngostroboscopy: severe glottic gap caused by paralysis of left vocal cord, which apeared hypotonic, atrophic and even below glottic level. Right arytenoid presented slight luxation.

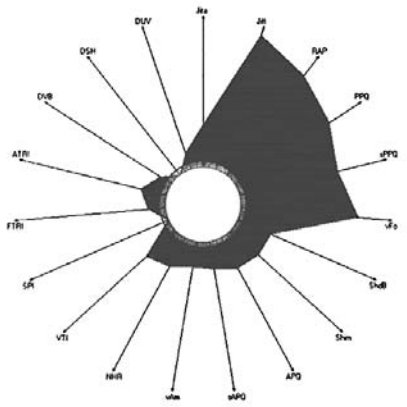

Fig. 2A. Pre-operative MDVP evaluation: Parameter values - F0 = not determinable; Jitter = 7.2%; Shimmer = 13.5%; NHR = 3.5%; Vam = 28.5%; VTI = 3.2%; FTRI = 2.3%; ATRI = 5.2%; DSH = 2%; DVB = 2%; DUV = 1.2%

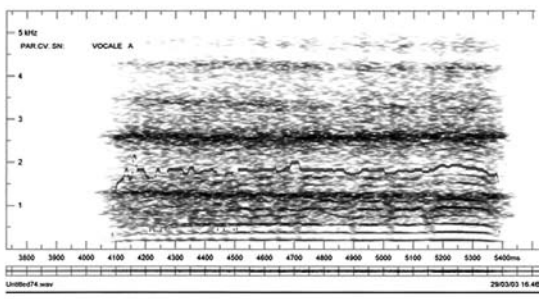

Fig. 2B. Pre-operative spectrography: noise overlaps signal. Sustained phonation is very short.

Perceptual voice assessment (GIRBAS) showed level 3 for all parameters.

The VHI questionnaire showed a particularly high score of 100, reflecting a clear difficulty in voice emission.

Post-operative examination at 24 hours

Laryngostroboscopy showed complete glottic closure with cord and arytenoid oedema (Fig. 4). This confirmed the intra-operative findings with the flexible fiberoptic scope that demonstrated the favourable outcome of surgery (Fig. 3), with no physical pain or discomfort for the patient.

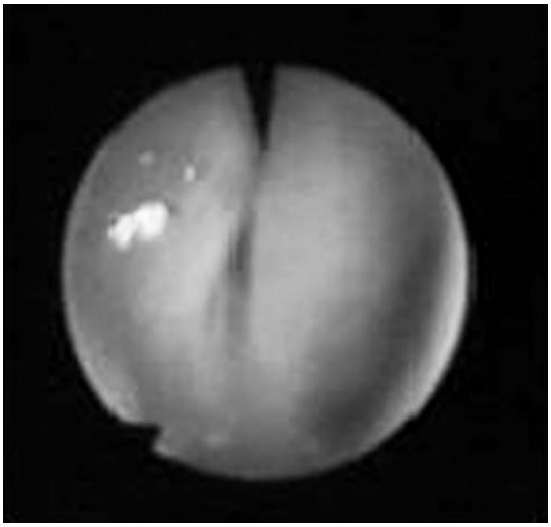

Fig. 3. Intra-operative evaluation by flexible endoscope: complete glottic closure.

Fig. 4. Laryngostroboscopy 24 hours after surgery: complete glottic closure; oedema of left vocal cord and arytenoid.

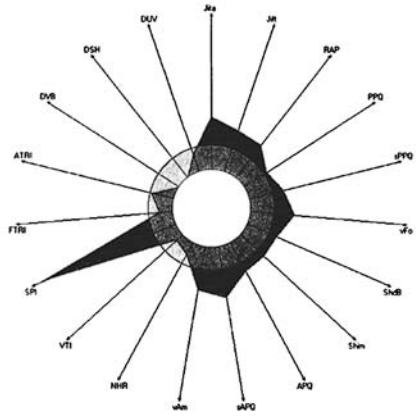

Fig. 5. MDVP assessment 24 hours after surgery: Parameter values.

F0 = 140 Hz; Jitter = 3.5%; Shimmer = 10.2%; NHR = 0.17%; VAm = 17.2%; VTI = 0.15%; FTRI = 0.49%; ATRI = 4.01%; DSH = 0%; DVB = 0%; DUV = 0%.

Spectrographic tests showed the following already good phonatory results (Fig. 5): F0 = 140 Hz, Jitter 3.5%, Shimmer 10.2%, NHR 0.17, VAm 17.2%,VTI 0.15%, FTRI 0.49%, ATRI 4.01%, DSH 0%, DVB 0%, DUV 0%.

The electro-acoustical parameters, one day after surgery, confirmed the absence of diplophonia (DSH) although the indices regarding disturbances in frequency and intensity and the harmonics/noise ratio remained above normal threshold values.

The perceptual voice evaluation showed a clear reduction in the grade of dysphonia (G) from 3 to 1, as also in the breathiness value (B), Instability (I) strain (S); roughness (R) remained at score 3.

The VHI questionnaire confirmed a marked reduction in phonation difficulty, although some psychophysical difficulty persisted (score = 80) (lowest scores were obtained for questions 11 to 20).

Assessment at 48 and 72 hours

Laryngostroboscopy: findings at 48 (Fig. 6) and 72 hours (Fig. 7) were comparable; cord oedema had disappeared, but the arytenoid oedema remained;

Spectrographic tests: at 48 hours, the MDVP values (Fig. 8) were as follows: F0 = 149 Hz, Jitter 2.5%, Shimmer 8.5%, NHR 0.13, VAm 16.8%, VTI 0.11%, FTRI 0.41%, ATRI 3.9%, DSH 0% DVB 0%, DUV0%.

At 72 hours, the electro-acoustical parameters showed further modifications (Fig. 9): F0 = 149 Hz, Jitter 2.1%, Shimmer 7.5%, NHR 0.11, VAm 10.5.%, VTI 0.04%, FTRI 0.38%, ATRI 3.1%, DSH 0% DVB 0%, DUV 0%. Briefly, the fundamental frequency remained unchanged, while the other values showed slight improvements, the most significant changes being found for VAm and VTI.

Perceptual voice evaluation showed a score of 0 (normal) for G, I, B, A and S, and 1 for R.

VHI questionnaire still showed a score of 70, being far from normal; in particular, the answers relating to voice satisfaction were still negative, despite normal spectrographic results.

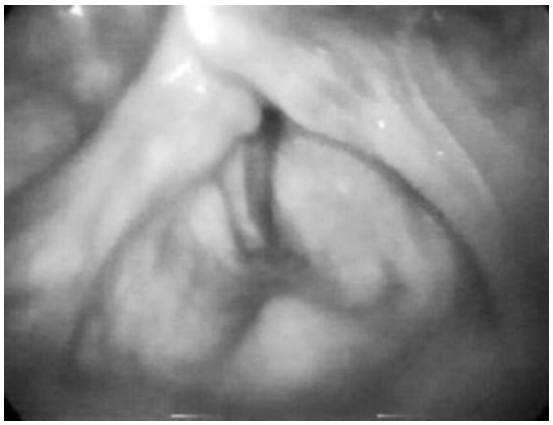

Fig. 6. Laryngostroboscopy 48 hours after surgery.

Fig. 7. Laryngostroboscopy 72 hours after surgery. Values are comparable: complete glottic closure; no oedema of left vocal cord but persistence of left arytenoid oedema.

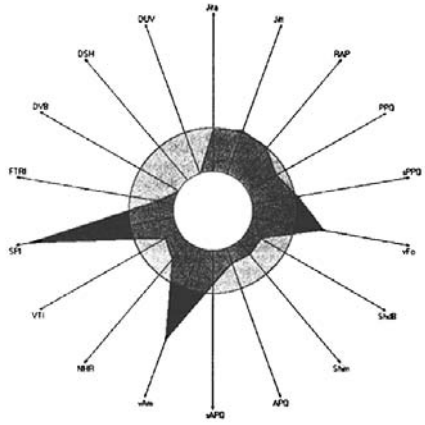

Fig. 8. MDVP evaluation 48 hours after surgery: parameter values.

F0 = 149 Hz; Jitter = 2.5%; Shimmer = 8.5%; NHR = 0.13%; VAm = 16.8%; VTI = 0.11%; FTRI = 0.41%; ATRI = 3.9%; DSH = 0%; DVB = 0%; DUV = 0%.

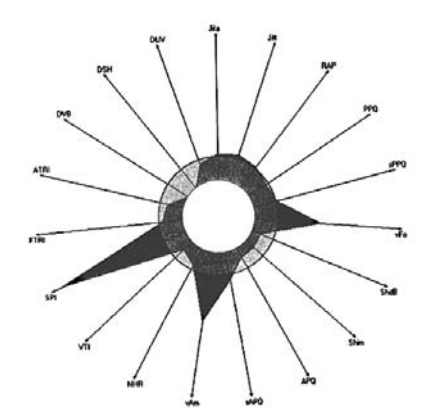

Fig. 9. MDVP evaluation 72 hours after surgery: parameter values.

F0 = 140 Hz; Jitter = 2.1%; Shimmer = 7.5%; NHR = 0.11%; VAm = 10.5%; VTI = 0.04%; FTRI = 0.38%; ATRI = 3.1%; DSH = 0%; DVB = 0%; DUV = 0%.

At 7 days after surgery

Findings were as follows.

Laryngostroboscopy (Fig. 10): normal glottic closure, with no sign of laryngeal trauma or voice strain.

MDVP spectrographic tests: electro-acoustical values (Figs. 11A-B) showed no further changes: the VAm and VTI values remained within the normal range, whereas NHR, Jitter and Shimmer as well as FTRI and ATRI still persisted above default values, 7 days after surgery, and did not present significant differences – GIRBAS values were all normal. VHI scores were similar to those in normal subjects (58).

CT scan of the neck and larynx, without contrast medium, 10 days after surgery (Fig. 12), confirmed that the implant was correctly positioned.

The stroboscopic and electro-acoustical tests, carried out 3 months later, showed no substantial variations, thus confirming a satisfactory voice sustainment.

Discussion

The data emerging from our study offer some interesting considerations. The voice recovery achieved with type I thyroplasty was immediate and satisfac-

Fig. 10. Laryngostroboscopy 7 days after surgery: normal glottic closure, with no sign of laryngeal trauma or voice strain.

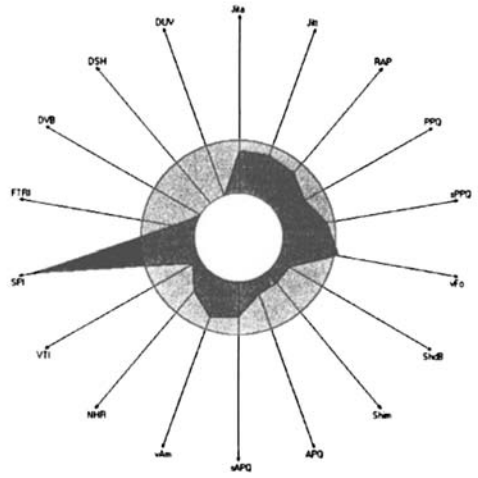

Fig. 11A. MDVP evaluation 7 days after surgery: there were no further changes in electroacoustical values.

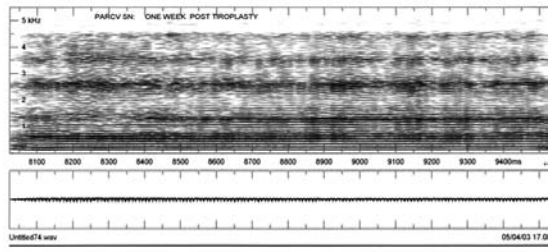

Fig. 11B. Spectrographic evaluation 7 days after surgery: harmonics are more clearly observed.

Fig. 12. CT scan of neck without contrast medium during breathing: intrarotation of arytenoid and correct position of implant are observed.

tory: in the case described here, use of a flexible endoscope, during surgery, showed the immediate voice improvement achieved with the introduction of the implant and the absence of any compensatory mechanism. Laryngostroboscopy, with a fixed endoscope, confirmed the recovery of glottic efficiency and showed a slight oedema of the relative arytenoids, the first two days after surgery. Noteworthy, in this case, was atrophy of the paralysed vocal cord and luxation of the opposite arytenoid: this was due, in our opinion, to the continuous and prolonged attempts, by the organ, to compensate for the glottic gap, thus creating an obstacle to complete recovery following thyroplasty. In short, permanent alterations occur, due to strain, compromising perfect voice recovery. Data from the electro-acoustical voice tests confirm the endoscopic findings and also provide more useful information on voice dynamics. In particular, unlike our expectations, not all the acoustic parameters allow adequate monitoring of voice recovery. The Jitter and Shimmer values, in particular, as well as the NHR values, remain impaired even when objective and subjective assessments indicate voice recovery. Numerous Authors [24-27] have reported that the Jitter and Shimmer values are often highly dependent upon muscle tension and on the frequency and intensity of the voice, and cannot be considered a reliable means of evaluation that offers statistically significant values denoting voice improvement. On the contrary, a more evident voice recovery can be seen from other parameters which

have been recently introduced in quantitative voice studies. A brief outline of their characteristics is given:

- **VTI**, expressing the harmonics/noise ratio, with particular regard to the high frequencies (noise ranging between 2800 and 5800 Hz and harmonic energy between 70 and 4500 Hz) of the vocal spectrum, better reveals the reduction in the glottic gap; this appears to be higher, the greater the adductory deficit and provides useful information on the degree of voice efficiency reached.
- **NHR** (noise ranging between 1500 and 4500 Hz and the harmonic energy distributed between 70 and 4500 Hz) did not show any substantial changes during the study: it should be pointed out that this index evaluates the inharmonic energy located on low frequencies.
- **DSH** assesses diplophonia and is often difficult to determine only from the sonagram, where it corresponds to the presence of one or more subharmonics among the true harmonics. It confirms the reduction in diplophonia and allows evaluation over time. In this study, normal values were observed, the day after surgery.
- **DVB** and **DUV** show the segments of voicelessness better as well as their reduction: these values had already reached normal threshold levels, the day after surgery.
- **Shimmer** presents a trend that directly correlates with Jitter, and does not offer any specific information: both remained impaired after surgical recovery and after the patient reported complete voice recovery.
- **VAm**, instead, shows the clearest changes as far as concerns voice improvement. This value is inversely correlated to the stability of voice intensity, and is particularly indicative of voice sustainment.
- **FTRI** and **ATRI** show a reduction directly related to a reduction in the glottic gap and consequent voice improvement.

Conclusions

The present investigation is limited to only one case and, therefore, does not allow generalisation; however, the evolution in the electro-acoustical voice parameters, during follow-up provides useful information on glottic status after type I thyroplasty. First of all, we confirm the need for quantitative and multiparametric electro-acoustical tests, in this type of surgery, which are still not widespread in clinical practice, in order to reliably assess voice improvement and to provide a useful legal medicine aid for the operating surgeon. Many of the cases of cord paralysis found in clinical practice are the outcome of previous surgery (17-46%) [28]. No detailed voice studies are available, as yet, on the results achieved with Montgomery thyroplasty; in a very recent study [20], Peretti et al. refer only to TMF, J and Sh. Our data show that the J and Sh values are extremely non-specific and of little significance, while VAm and VTI allow good monitoring of voice recovery, as seen in Table I (comparative assessment of the changes in J, Sh and Vam, in the pre-operative evaluation, and at 24, 48, and 72 hours, respectively, after surgery). Data from the questionnaire, completed by the patient, are interesting: up to three days after surgery, the VHI data did not correspond with the good recovery indicated by the electro-acoustical data and evident at endoscopy; the data are indicative of the patent's social discomfort caused by the psychological impact of his own voice. Only 7 days after surgery were the VHI values within normal limits and in keeping with the data from the subjective evaluation. It appears that the rapid voice recovery, perceived by the physicians during and immediately after surgery, as confirmed by the spectrographic data, does not meet with a correct perception of his voice, by the patient. A few days are necessary for the patient to adapt to the new, more efficient voice tone. We suggest speech therapy in order to maintain the voice recovery achieved, above all to prevent compensatory voice mechanisms that the patient might instinctively adopt even with the new and more efficient glottic closure.

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