Managing Voice-Related Issues in Laryngectomized Patients With Voice Prosthesis: A Troubleshooting Algorithm for Rehabilitation

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SUMMARY: Objectives. To analyze the voice-related issues in laryngectomized patients with voice prosthesis (VP) and to evaluate the effectiveness of voice therapy (VT) in their management.

Materials and methods. The retrospective analysis included 194 patients (170 M, 24 F; mean age 64.86 ± 10.09 years) who underwent total laryngectomy (TL) with VP placement and subsequent VT between May 2010 and May 2024. In this study, patients were categorized based on vocal symptoms and underlying causes. To investigate issue resolution solving and outcomes, post-TV outcomes were analyzed using patient-reported outcome measures (PROMs) and auditory-perceptual assessments. Specifically, the Italian Self-Evaluation of Communication Experiences After Laryngeal Cancer (I-SECEL) and University of Washington Quality of Life (UWQoL-v4) Questionnaires, and the INFVo scale.

Results. 100 out of 194 patients (51.55%) presented a voice-related issue (82 M, 18 F; mean age 67 ± 9.35 years). The age over 65 years and female sex increased the incidence of voice-related complications. Hypertonic voice was the most frequent issue (40%) and was resolved in 72% of cases through ~20 sessions of VT. This resolution rate increased to 95% when combined with botulinum toxin injections. No results were recorded in cases of hypertonic voice associated with post-radiation fibrosis. Problems related to the stoma, anatomical abnormalities, interference between esophageal and tracheoesophageal (TE) voice, and radiotherapy, as well as hypotonic and poor-quality voices, achieved a 100% resolution rate after 5–15 sessions of VT. Issues related to breathing, coordination and posture achieved a resolution rate of 92%, with lower-quality vocal outcomes. The implementation of specific VT allowed for an overall resolution of 92% of treated cases, reaching a success rate of 95% in the entire cohort of patients (N = 194).

Conclusions. In the treatment of TE voice, identifying voice-related issues through patient assessment and symptoms analysis allows for targeted VT, leading to higher success rate.

Key Words: Total laryngectomy–Tracheoesophageal voice–Voice prosthesis–Voice therapy–Patient-reported outcome measures (PROMs).

INTRODUCTION

The therapeutic approach to laryngeal carcinoma is multidisciplinary and encompasses various treatment modalities, including surgery, radiotherapy, chemotherapy, and immunotherapy, administered alone or in combination depending on the tumor stage. In advanced stages, total laryngectomy (TL) is often necessary.[1,2] Despite advances in organ-preserving treatments, TL remains the standard of care for T3 and T4 laryngeal tumors, as well as a salvage procedure after failure of conservative treatments.[3] Total Laryngectomy is a radical and mutilating surgery with significant functional consequences, including loss of voice, swallowing disorders, loss of nasal function with impaired smell and taste, altered pulmonary function, the need for a permanent tracheostomy. These changes also have major social and psychological repercussions.[4,5] Among these, the most impactful consequence is voice loss. Currently, three main methods of voice rehabilitation after TL are available: esophageal voice, electrolarynx, and tracheoesophageal (TE) voice through implantation of a voice prosthesis (VP).[3,6] Over the past 30 years, the VP has become the gold standard, as it enables more natural-sounding speech, better acoustic and aerodynamic parameters, shorter rehabilitation times, and a higher success rate (60% to 90%) compared with alternative methods.[2,7–10]

However, despite its advantages, VP use is associated with complications and sequelae related to the presence of a foreign body. The most frequently reported issues are device-related, intra- or periprosthetic leakage and granulation tissue formation.[7,9,11] Less extensively described are voice-related complications that may significantly impair outcomes and require specific voice therapy (VT).[12] These include alterations in muscle tone, particularly hypertonicity – reported as cause of rehabilitation failure in

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10%–12% of patients[13] - and hypotonicity of the cervical musculature, constrictor muscles, and pharyngoesophageal segment.[13,14] A functional neopharynx and pharyngoesophageal segment require adequate flexibility and tone to enable fluent and effortless speech.[15] Hypotonia may impair vibration and bolus transit, whereas hypertonicity may airflow, requiring increased intratracheal pressures and resulting in a strained, spasmodic voice.[14] These alterations are often secondary to postural changes such as forward head posture and thoracic kyphosis, which increase tension in accessory respiratory muscles. Additional voice-related complications include stoma difficulties, arising from tracheostoma irregularities or inadequate digital occlusion, impaired respiratory-phonatory coordination and structural abnormalities of the residual vocal tract. Further factors affecting vocal quality include the confusion between prosthetic and esophageal speech mechanism -particularly in cases of delayed prosthesis placement difficulties in controlling parameters such as intensity, pitch, and modulation, as well as the long-term effects of radiotherapy.[16] Specifically, post-radiation fibrosis, tissue necrosis, scar-related myalgia, and vascular damage may significantly alter the flexibility of the pharyngoesophageal mucosa. Given the limited evidence in the literature regarding the voice-related issues, it is clinically essential to recognize their signs, symptoms, and underlying causes to identify the most appropriate solutions and propose targeted VT.

The aim of this paper was to retrospectively analyze a large cohort of laryngectomized patients rehabilitated with a VP, in order to describe for the first time in the literature the incidence of each voice-related complication, and to propose a systematic and standardized algorithm of therapeutic solutions and training strategies that can be easily applied by SLPs specialized in this field of rehabilitation.

MATERIALS AND METHODS

Setting and participants

In this retrospective study, the medical records of 194 patients (170 M, 24 F; mean age 64.86 ± 10.09 years) who underwent TL and VP implantation were analyzed. Patients were followed at the Otolaryngology and Phoniatrics outpatient clinics of the Agostino Gemelli University Hospital-IRCCS in Rome, from May 2010 to May 2024.

A total of 171/194 patients (88.14%) underwent TL with bilateral neck dissection and primary pharyngeal closure. The remaining 23/194 patients (11.86%) underwent reconstruction with free flaps (9 ALT, 9 IMAP, 3 radial, 1 double IMAP, and 1 SCAIF).

Overall, 120 patients underwent radiotherapy, either as primary treatment (n = 36/30%) or as adjuvant treatment (n = 84/70%). Eighteen patients received radio chemotherapy, either primary (n = 6/33.33%) or adjuvant (n = 12/66.66%), while five patients received chemotherapy alone, either primary (n = 2/40%) or adjuvant (n = 3/60%).

Forty-four of 194 patients (22.68%) underwent sequential/delayed prosthetic rehabilitation, with a mean interval of 28.3 ± 18.6 months (range 2–129 months) between TL and VP implantation.

After placement of a low-resistance indwelling VP (Provox Vega, Atos Medical AB, Hörby, Sweden), all patients underwent VT. This included instruction on the use and maintenance of the prosthesis, as well as structured voice rehabilitation sessions. Depending on the primary or secondary surgical setting, VT began on the ward on the 10th-12th and first postoperative days, respectively. In both cases, it continued on the outpatient clinic, with a weekly frequency and variable duration. Voice therapy was terminated upon reaching predefined clinical criteria, namely: perceptually acceptable vocal quality, effective use of the tracheoesophageal voice in daily communication without excessive effort, and satisfactory adaptation of the patient to the replacement voice. All patients were habitual users of peristomal attachment systems (adhesive baseplates or soft silicone cannulas) and heat and moisture exchangers (HMEs). Patients undergoing adjuvant radiotherapy or chemoradiotherapy began VT before the start of treatment and, when possible (ie, when the patient underwent radiotherapy at our hospital), continued with daily monitoring to check the skin and maintain pharyngoesophageal vibration. Weekly sessions resumed 10 days after the end of radiotherapy. If the patient underwent radiotherapy at another center, VT resumed 7–10 days after the end of radiotherapy.

During the retrospective analysis, cases were categorized according to vocal symptoms, their underlying causes, and the possible influence of the neoglottis (ie, anatomical anomalies and/or features affecting voice production), in order to identify specific categories of voice-related issues and their potential subtypes. Upon admission, each patient underwent a structured diagnostic work-up, including joint otolaryngology (ENT) and SLP assessments. This work-up comprised clinical examination, postural and aerodynamic assessment, palpation of the residual cervical musculature, neoglottic manipulations to assess voice stimulability, the lidocaine test, and perceptual voice evaluations conducted by experienced clinicians (> 5 years in post-TL rehabilitation). During this joint ENT–SLP assessment, clinicians systematically analyzed vocal quality, airflow characteristics during phonation, neck and shoulder posture, palpatory findings, and the coordination between breathing, stoma occlusion, and phonation. The presence of specific vocal signs and clinical findings allowed the differential identification of the underlying voice-related issue. In patients presenting with multiple coexisting barriers, the predominant functional limitation affecting voice production was identified as the primary therapeutic target.

Hypertonicity was diagnosed exclusively through clinical assessment performed jointly by the ENT specialist and the SLP. Two distinct forms of hypertonicity were clinically differentiated. Extrinsic (external) hypertonicity was identified through palpation of the residual cervical

musculature and was characterized by increased muscle stiffness, reduced tissue compliance, and associated postural rigidity of the neck and shoulder girdle during phonation. Intrinsic hypertonicity, involving the pharyngeal constrictor muscles and/or the pharyngoesophageal segment, could not be directly palpated. It was inferred from specific vocal and functional signs, including strained and effortful voice production, interrupted airflow during phonation, reduced phonation duration, and frequent association with swallowing discomfort or dysphagia. Diagnostic confirmation was supported by neoglottic manipulation maneuvers and by observing immediate voice improvement following relaxation or facilitating postural techniques during the clinical examination. This clinical distinction guided the selection of the specific voice therapy protocol and, when necessary, the indication for botulinum toxin injection.

Each training protocol (Training 1–8) proposed was not a generic set of exercises but a structured therapeutic sequence organized into: (1) initial facilitation phase, (2) functional training phase, and (3) generalization to connected speech. The choice and progression of exercises followed a consistent internal logic aimed at addressing the underlying pathophysiological mechanism responsible for the voice disorder.

The review of clinical records also enabled the identification, for each patient, of the number of VT sessions performed, the type of training provided, and whether definitive resolution was achieved.

Outcomes

To evaluate treatment effectiveness, problem resolution, and the impact of the prosthetic voice on patients' quality of life (QoL), data were extracted from clinical records. These results were derived from the standardized use of the INFVo Perceptual Rating Scale and patient-reported outcome measures (PROMs). PROMs were administered both at baseline (before the initiation of voice therapy) and at the end of the rehabilitation pathway.

In our clinical practice, at the end of the rehabilitation path, two SLPs, experts in TE voices and not directly involved in the patient's treatment, perform a perceptual assessment while the patient reads the passage "Il Deserto."[17] The evaluators have extensive experience in the assessment and rehabilitation of dysphonia, with specific expertise (> 5 years) in post-laryngectomy VP rehabilitation. The INFVo scale was used for perceptual assessment. This tool is specifically designed for the clinician-based perceptual evaluation of substitute voices[18] and has been validated and translated into Italian.[19] The INFVo assesses substitute voices according to four key parameters: (I) overall impression, (N) additional noise, (F) fluency, and (Vo) voicing. Each parameter is scored on a scale from 0 (representing the poorest result) to 10 (representing the optimal result).

The Italian version of the Self-Evaluation of Communication Experiences after Laryngeal Cancer (I-SECEL)[20] consists of 35 items exploring the communicative experiences of patients. It is divided into three subscales: general, environmental, and attitudinal. The total score ranges from 0 to 102, with a clinical cut-off of 36 ± 12. Scores exceeding 60 indicate significant challenges in adapting to the substitute voice, suggesting that psychological support or targeted counseling may be warranted.

The University of Washington Quality of Life Questionnaire-version 4 (UWQoL-v4) assesses QoL in patients with head and neck cancer.[21] It consists of 12 items grouped into two subscales: The Physical scale and the Social-Emotional scale. Each subscale includes six domains: the "Physical" (chewing, speech, swallowing, taste, saliva and appearance) and the "Social-Emotional" (anxiety, mood, pain, activity, recreation and shoulder function). For each domain, responses are rated from 0 (worst) to 100 (best). Each subscale score is the average of the six domains score. The closer the score is to 100, the better the perceived QoL.

Building an algorithm

Importantly, during the 14-year clinical activity, therapeutic decisions were made based on clinical expertise and individualized patient assessment, without the use of a predefined algorithm. The algorithm proposed in this study was reconstructed retrospectively by analyzing recurring patterns linking vocal symptoms, clinical findings, therapeutic choices, and outcomes across patient records. This process allowed the formalization of an implicit clinical reasoning pathway into a reproducible decision-making framework for future clinicians.

Statistical analysis

Statistical analysis was performed using MS Excel spreadsheets (Microsoft Corporation, Redmond, WA). Demographic and clinical characteristics of the sample were summarized using standard descriptive statistics. Quantitative variables with a normal distribution were expressed as mean ± standard deviation, as well as in absolute and relative frequencies (percentages). Qualitative variables were analyzed using the Chi-square test. The Shapiro-Wilk test was used to assess the normality. Student's t test with Bonferroni correction was applied to identify differences between patients with and without voice-related issues. For variables not-normally distributed, particularly those related to perceptual evaluation, the Kruskal-Wallis test was used. Results were considered statistically significant when $P < 0.05$.

RESULTS

Of the 194 patients who underwent TL and VP placement, 100 (51.55%) experienced a voice-related complication (82 males, 18 females; mean age 67 ± 9.35 years, range 44–88 years). The remaining 94 patients (48.45%) did not encounter difficulties in learning and using TE voice and thus underwent standard VT, with an average of 5.15 ± 1.67

TABLE 1.
Demographic and Clinical Characteristics of Patients With and Without Voice-Related Issues Expressed With Absolute Value, Incidence Percentages and Values of *P*

		Patients With Voice-Related Issues N = 100	Patients Without Voice-Related Issues N = 94	*P*
Age > 65 years	Yes	64 (64%)	45 (47.87%)	**0.02**
	No	36 (36%)	49 (52.13%)	
Sex	M	82 (82%)	88 (93.62%)	**0.01**
	F	18 (18%)	6 (6.38%)	
Flap	Yes	16 (16%)	7 (7.45%)	NS
	No	84 (84%)	87 (92.55%)	
Primary prosthesis placement	Yes	81 (81%)	69 (73.40%)	NS
	No	19 (19%)	25 (26.60%)	
RT	Yes	66 (66%)	56 (59.57%)	NS
	No	34 (34%)	38 (40.43%)	
RT adjuvant	Yes	48 (48%)	38 (40.43%)	NS
	No	52 (52%)	56 (59.57%)	
CHT	Yes	2 (2%)	3 (3.19%)	NS
	No	98 (98%)	91 (96.81%)	
CHT(RT)	Yes	6 (6%)	12 (12.77%)	NS
	No	94 (94%)	82 (87.23%)	
Salvage TL	Yes	21 (21%)	23 (34.04%)	NS
	No	79 (79%)	71 (75.31%)	

Abbreviations: CHT, chemotherapy; CHT(RT), radio-chemotherapy; F, female; M, male; NS, not-significant; TL, total laryngectomy.
Bold font underlines the significant values.

sessions (range 2–15). These patients achieved a voice rated as being of good quality according to the INFVo scale (mean values: I = 7.21 ± 1.50, N = 7.01 ± 1.80, F = 8 ± 1.55, Vo = 6.06 ± 2.25) and were generally well adapted to their new voice (mean total I-SECEL score = 27.77 ± 13.76). Furthermore, the QoL was above the expected average in both the physical subscale (mean score: 88.08 ± 13.16) and the social subscale (mean score: 78.33 ± 24.22).

Analysis of all demographic and clinical variables showed that age over 65 years ($P = 0.02$) and female sex ($P = 0.01$) were associated with a higher incidence of voice-related issues (Table 1).

The retrospective analysis identified eight categories of voice-related issues. Table 2 summarizes the key clinical signs and symptoms that guided the differential identification of each voice-related issue during assessment.

By analyzing the treatments provided to the patients, it was also possible to identify eight types of training, each specific to the complication addressed. Table 3 details the content of each training protocol. These protocols represent structured therapeutic pathways rather than simple lists of exercises. Although the therapeutic decisions were individualized, the analysis of clinical records showed that each of the eight trainings followed a recurrent internal structure.

Phase 1 – Facilitation and awareness: aimed at reducing dysfunctional patterns (eg, excessive tension, incorrect posture, esophageal air injection, poor stoma occlusion) through manual guidance, posture correction, neoglottic manipulations, and proprioceptive exercises.

Phase 2 – Targeted phonatory exercises: focused on restoring efficient vibration of the pharyngoesophageal segment through specific phonation tasks (soft onset, relaxed phonation, volume modulation, breathing coordination, articulatory modeling).

Phase 3 – Transfer to speech: exercises progressed to words, sentences, reading tasks, and spontaneous speech to ensure automatization of the new vocal behavior.

The content of each phase varied according to the voice-related issue (Table 3), but this three-step structure was consistently observed across patients.

Analysis of individual voice-related issues

For each complication, the incidence, resolution rate following the proposed VT, the average number of sessions required, and patient outcomes - in terms of voice quality and adaptation to the substitute voice - are reported below.

In this context, the term "specific voice therapy (VT)" refers retrospectively to the set of targeted therapeutic strategies (Training 1–8, Table 3) that were consistently selected by clinicians when managing patients presenting similar voice-related issues.

Stoma-related issues

Seven out of 100 patients (7%) presented issues related to the tracheostoma. Among these, 3/7 (42.85%) exhibited issues due to tracheostoma irregularities, and 4/7 (57.14%) had issues related to inadequate digital pressure.

All patients (100%) resolved these issues through specific VT, achieving good voice quality, although some

TABLE 2.
Description of the Symptoms Associated With the Eight Identified Voice-Related Issues

Voice-Related Complication	Description
Stoma-related difficulties	Presence of accessory noises, air leakage, or fragmented voice during stoma occlusion caused by irregular stoma shape/size or inadequate digital pressure. Voice improves when occlusion is manually corrected.
Hypertonic voice	Effortful, strained, interrupted or spasmodic phonation due to hypertonicity or spasm of the pharyngoesophageal segment or cervical musculature. Often associated with visible neck tension and poor stimulability.
Hypotonic voice	Weak, breathy, asthenic voice with short phonation time caused by reduced neopharyngeal muscle tone, presence of a neck bulge, or incorrect head posture. Improves with increased digital pressure or postural support.
Breathing, coordination and posture difficulties	Incoordination between breathing, stoma occlusion and phonation, thoracic breathing pattern, forced inhalations, and incorrect head/neck posture leading to unnatural, effortful speech.
Residual vocal tract anomalies	Gurgling voice, reduced intelligibility, or articulation problems due to anatomical alterations (flap, stenosis, redundant mucosa) or maladaptive articulatory habits.
Interference between prosthetic and esophageal voice	Persistence of esophageal air injection before speech, resulting in difficulty initiating TE phonation, strained voice, and short phrases.
Effects of radiotherapy	Voice deterioration associated with edema, painful stoma occlusion, tissue rigidity, xerostomia or fibrosis following radiotherapy.
Poor voice quality	Monotone, low-intensity, poorly modulated voice caused by insufficient pulmonary support, incorrect posture, and excessive muscular effort despite adequate TE mechanism.

difficulties persisted regarding airflow management and voicing (mean values: I = 5.14 ± 2.27, N = 3.86 ± 2.34, F = 6.57 ± 2.76, Vo = 3.71 ± 1.80). Furthermore, all patients showed satisfactory adaptation to the new voice (mean total I-SECEL score = 27.29 ± 15.50) (See Table 4).

Hypertonic voice

Forty out of 100 patients (40%) developed a hypertonic voice. Among these, 15/40 (37.5%) presented hypertonicity of the pharyngeal constrictor muscles (intrinsic hypertonicity), while 11/40 (27.5%) showed hypertonicity of the external cervical musculature and postural rigidity (extrinsic hypertonicity). Additionally, 6/40 (15%) exhibited a mixed form of both. Finally, 8/40 (20%) presented with spasm of the pharyngoesophageal segment.

One patient refused any form of treatment.

Twenty-eight out of 39 patients (71.79%) resolved this issue through specific VT Nine of the remaining 11 patients (81.82%) achieved resolution after botulinum toxin injection followed by VT.

Overall, 37 out of 39 patients (94.87%) with hypertonic voice achieved resolution, obtaining good voice quality (mean values: I = 5.91 ± 2.20, N = 6 ± 2.15, F = 6.25 ± 2.39, Vo = 5.88 ± 2.64). Furthermore, all patients demonstrated satisfactory adaptation to the new voice (mean total I-SECEL score = 35.67 ± 16.84) (See Table 5).

Five out of 100 patients (5%) developed a spasm of the pharyngoesophageal segment associated with post-radiation fibrosis. (Table 6) None of these patients resolved the issue through VT alone.

Hypotonic voice

Three out of 100 (3%) patients presented with hypotonic voice. All patients (100%) resolved the condition through specific VT, achieving good vocal quality, although a residual area of fragility persisted regarding voice sonority (mean values: I = 5 ± 1, N = 4.33 ± 1.53, F = 7.67 ± 0.58, Vo = 2.33 ± 0.58). Moreover, all patients demonstrated satisfactory adaptation to the TE voice (mean total I-SECEL score = 33.33 ± 15.70) (see Table 7).

Breathing, coordination and posture problems

Fourteen out of 100 patients (14%) presented with difficulties related to breathing, coordination, and posture. Specifically, 6/14 (42.86%) had coordination issues, 4/14 (28.57%) exhibited thoracic breathing and forced inhalation, and 4/14 (28.57%) presented with pneumo-phonic incoordination combined with incorrect head and neck posture.

One patient refused all forms of treatment.

Twelve out of 13 patients (92.31%) resolved the issue through specific VT, achieving a voice of moderate quality (mean values: I = 4.6 ± 1.78, N = 4.7 ± 1.77, F = 5.1 ± 2.51, Vo = 4.6 ± 2.50). Furthermore, all patients demonstrated adequate adaptation to the substitute voice, although the mean total score was close to the clinical cut-off (mean total I-SECEL score = 41.83 ± 21.05) (see Table 8).

Vocal tract anomalies

Twelve out of 100 patients (12%) presented with issues related to vocal tract anomalies. Among these, 11/12 (91.67%) exhibited anatomical anomalies due to the

TABLE 3.
Description of Specific Voice Therapy Protocols for Each Voice-Related Issue

Voice-Related Complication	Training
Stoma-related difficulties	**Training 1**
	Selection of the most suitable fixation system for the tracheostoma
	Education on airtight and well-coordinated digital occlusion
	Increase/reduction of digital pressure
	Training for correct finger positioning
	Selection of the preferred hand and finger
	Use of automatic speaking valve
Hypertonic voice	**Training 2**
	Stretching maneuvers
	Passive/active gymnastics exercises
	General and local relaxation exercises
	Neoglottic manipulations
	Use of facilitating maneuvers and posture
	Relaxed phonation exercises
	Use of soft vocal onset
	Exercises for volume reduction
	Tongue base detention maneuvers
	Reduction of esophageal pressures through induction of gag reflex and voluntary belching
	Botulinum toxin injection
	Post-botox training
	Use of facilitating maneuvers and postures
	Relaxed phonation exercises
	Use of soft vocal onset
	Phonation duration exercises
	Exercises with progressively longer phrases
Hypotonic voice	**Training 3**
	Phonation exercises with posture changes
	Increase of digital pressure
	Use of customized neckband
Breathing, coordination and posture difficulties	**Training 4**
	Establishment of costo-diaphragmatic breathing
	Inhibition of deep and forced inhalations
	Use of pre-set pauses during reading and conversation
	Vocal production exercises with progressively increasing length
	Proper head posture
	Shoulder alignment
	Correct adherence of the arm to the chest
Residual vocal tract anomalies	**Training 5**
	Posture adjustments
	Selection of the most suitable fixation system
	Modeling exercises
	Articulatory training
Interference between prosthetic and esophageal voice	**Training 6**
	Enhancement of patient proprioception and awareness
	Inhibition of esophageal air injection mechanism
	Initiation of phonation with open mouth
	Use of soft vocal onset (verbal material starting with a vowel) and/or aspirated onset
	Abdominal breathing
	Exercises with progressively longer phrases and automatic speech (tongue twisters)
Effects of radiotherapy	**Training 7**
	Do not interrupt vocal training
	Maintain pharyngoesophageal segment vibration
	Find alternative fixation systems to adhesive baseplates when the skin is damaged

TABLE 3 (*Continued*)

Voice-Related Complication	Training
Poor voice quality	**Training 8** Local and general relaxation exercises Posture changes Neoglottic manipulations Volume reduction Articulatory training and reduction of speech rate Crescendo and decrescendo exercises Glissando exercises, stress and intonation variations, singing, projected voice

TABLE 4.
Stoma-Related Issues: Specific, Causes, Training Performed, Patients Treated, Resolution Rate, Mean Number of Speech Therapy Session

Stoma						
Specific	Influenced by Neoglottic Characteristics	Cause	Solution	Patients Undergoing Treatment	% of Resolution	Mean Voice Therapy Sessions (± SD)
Stoma-related	No	Deep or irregular stoma	Training 1	3/3	3/3 (100%)	9.33 ± 7.51 range 5–18
Inadequate digital pressure	No	Weak pressure	Training 1	4/4	4/4 (100%)	14.75 ± 7.32 range 9-25

TABLE 5.
Hypertonic Voice: Specific, Causes, Training Performed, Patients Treated, Resolution Rate, Mean Number of Voice Therapy Session

Hypertonic Voice						
Specific	Influenced by Neoglottic Characteristics	Cause	Solution	Patients Undergoing Treatment	% of Resolution	Mean Voice Therapy Sessions (± SD)
Intrinsic hypertonicity N = 15	Yes	Hypertonicity of the pharyngeal constrictor muscles	Training 2	14/15	10/14 (71.43%)	20.8 ± 14.99 range (10-51)
			Botox	4/14	4/4 (100%)	20 ± 11.34 pre-Botox + 5 post Botox
Extrinsic hypertonicity N = 11	No	Tension during speech, postural rigidity	Training 2	11/11	11/11 (100%)	17.27 ± 12.11 range (10-48)
			Botox	0	-	-
Mixed form N = 6	Yes	Hypertonicity of the pharyngeal constrictor muscles + Tension during speech and postural rigidity	Training 2	6/6	6/6 (100%)	19.83 ± 11.32 range (10-35)
			Botox	0	-	-
Spasm N = 8	Yes	Spasm	Training 2	8/8	1/8 (12.5%)	29
			Botox	7/7	5/7 (71.43%)	10.2 ± 0.45 pre-Botox + 5 post Botox

TABLE 6.
Hypertonic Voice Associated With Fibrosis: Causes, Training Performed, Patients Treated, Resolution Rate, Mean Number of Voice Therapy Sessions

Hypertonic Voice + Post Radiation Fibrosis						
Specific	Influenced by Neoglottic Characteristics	Cause	Solution	Patients Undergoing Treatment	% of Resolution	Mean Voice Therapy Sessions (± SD)
-	Yes	PES spasm + fibrosis	Training 2 Botox	5/5 5/5	0/5 (0%) 0/5 (0%)	- -

TABLE 7.
Hypotonic Voice: Causes, Training Performed, Patients Treated, Resolution Rate, Mean Number of Voice Therapy Sessions

Hypotonic Voice						
Specific	Influenced by Neoglottic Characteristics	Cause	Solution	Patients Undergoing Treatment	% of Resolution	Mean Voice Therapy Sessions (± SD)
-	Yes	Loss of neopharyngeal muscle tone, neck bulge, head posture	Training 3	3/3	3/3 (100%)	5 ± 2 range (3-7)

presence of a free flap, esophageal stenosis, or redundant esophageal mucosa, while 1/12 (8.33%) presented with hypoarticulation.

All 12 patients (100%) resolved these problems through specific VT, achieving good vocal quality, although lower scores were recorded specifically in the voicing parameter (mean values: I = 5.63 ± 1.92, N = 5.5 ± 3.16, F = 6.13 ± 2.30, Vo = 4.75 ± 2.71). Furthermore, all patients demonstrated satisfactory adaptation to the TE voice (mean total I-SECEL score = 27 ± 12.59) (see Table 9).

Interference between esophageal and TE voice

Five out of 100 patients (5%) exhibited interference between esophageal and TE voice. All patients (100%) resolved the issue: specifically, four out of five (80%) through specific VT, and one out of five (20%) via the early introduction of an automatic speaking valve. Patients achieved good voice quality (mean values: I = 5 ± 1.87, N = 5.00 ± 2.12, F = 5 ± 1.73, Vo = 6.6 ± 2.07) and a satisfactory level of adaptation to their new voice (mean total I-SECEL score = 37 ± 8.15) (see Table 10).

Radiotherapy

Seven out of 100 patients (7%) presented with complications related to radiotherapy. Among these, six out of seven (85.71%) exhibited phonation difficulties, while one out of seven (14.29%) presented with complete aphonia due to post-radiation fibrosis. The patient with post-radiation fibrosis refused all forms of treatment. The remaining six patients (100%) resolved the condition through specific VT,

TABLE 8.
Breathing, Coordination and Posture Problems: Specific, Causes, Training Performed, Patients Treated, Resolution Rate, Mean Number of Voice Therapy Sessions

Breathing, Coordination, Posture						
Specific	Influenced by Neoglottic Characteristics	Cause	Solution	Patients Undergoing Treatment	% of Resolution	Mean Voice Therapy Sessions (± SD)
Incoordination	No	Patient habits	Training 4	6/6	5/6 (83.33%)	11.17 ± 7.19 range (5-22)
Thoracic breathing and forced inhalation	No		Training 4	4/4	4/4 (100%)	15.25 ± 6.08 range (10-21)
Incoordination + incorrect head-neck posture	No		Training 4	3/4	3/3 (100%)	13 ± 8.19 range (4-20)

TABLE 9.
Vocal Tract Issues: Specific, Causes, Training Performed, Patients Treated, Resolution Rate, Mean Number of Voice Therapy Sessions

Vocal Tract Anomalies						
Specific	Influenced by Neoglottic Characteristics	Cause	Solution	Patients Undergoing Treatment	% of Resolution	Mean Voice Therapy Sessions (±SD)
Anatomical anomalies	Yes	Presence of flap, esophageal stenosis, redundant mucosa	Training 5	11/11	11/11 (100%)	10.18 ± 7.39 range (3-24)
Hypoarticulation	No	Patient habits	Training 5	1/1	1/1 (100%)	5

achieving a voice of moderate quality (mean values: I = 4.83 ± 3.19, N = 4.67 ± 3.88, F = 4.67 ± 3.72, Vo = 5 ± 3.16). Furthermore, all patients demonstrated satisfactory adaptation to the new voice (mean total I-SECEL score = 38.17 ± 23.84) (see Table 11).

Poor voice quality

Seven out of 100 patients (7%) presented with poor voice quality. All of them (100%) resolved the condition through specific VT, achieving good voice quality (mean values: I = 5 ± 1.79, N = 4.33 ± 2.58, F = 6.33 ± 2.07, Vo = 6.83 ± 1.94). Furthermore, they demonstrated adequate adaptation to the new voice (mean total I-SECEL score = 38.29 ± 13.46) (see Table 12).

This retrospective analysis conducted over a 14-year period on a cohort of 194 patients demonstrated that identifying the underlying causes of voice-related issues and applying targeted, issue-specific VT allowed for the resolution of 91.75% (89/97 treated patients) of cases. In patients presenting with voice-related issues, comparison between baseline and post-treatment PROMs scores demonstrated statistically significant improvements in all administered questionnaires. The UWQoL-v4 Physical subscale increased from 64.76 ± 12.23 pre-treatment to 85.99 ± 15.44 post-treatment (P = 0.03), while the UWQoL-v4 Social-Emotional subscale improved from 54.76 ± 17.8 to 76.96 ± 18.31 (P = 0.04). Similarly, the I-SECEL total score showed a marked reduction from 63.43 ± 14.8 at baseline to 32.54 ± 10.32 after treatment (P = 0.02). These findings confirm that targeted voice therapy had a measurable impact not only on vocal performance but also on patients' perceived communicative effectiveness and QoL. Moreover, the QoL scores of these patients were comparable to those recorded in the 94 patients without voice-related issues (UWQoL-v4 physical scale post-treatment -: patients with voice problems: mean value = 85.99 ± 15.44 vs patients without voice problems: mean value = 88.08 ± 13.16, $P > 0.05$; UWQoL-v4 social scale post-treatment- patients with voice problems: mean value = 76.96 ± 18.31 vs patients without voice problems: mean value = 78.33 ± 24.22, $P > 0.05$).

Across the entire sample, the overall success rate of prosthetic voice rehabilitation in our cohort reached 94.33% (183 out of 194 patients).

The retrospective review of clinical records made it possible to identify consistent associations between symptom presentation, diagnostic categorization, therapeutic choice, and outcome. These associations allowed the reconstruction of a troubleshooting algorithm that reflects the clinical reasoning implicitly adopted by clinicians over time (see the Appendix Figure).

DISCUSSION

After TL, voice rehabilitation using a VP is consistently associated in the literature with a success rate greater than 90%.[2,7,8] However, to date, no study has clarified whether such rehabilitative success requires specific adjustments or

TABLE 10.
Issues Related to Interference Between Esophageal and TE Voice: Causes, Training Performed, Patients Treated, Resolution Rate, Mean Number of Voice Therapy Sessions

Interference Between Esophageal and Prosthetic Voice						
Specific	Influenced by Neoglottic Characteristics	Cause	Solution	Patients Undergoing Treatment	% of Resolution	Mean Voice Therapy Sessions (±SD)
	No	Persistence of the esophageal voice mechanism	Training 6 Use of ASV	5/5 1/5	4/5 (80%) 1/1 (100%)	13.25 ± 5.38 range (8-20) 5

TABLE 11.
Issues Related to Radiotherapy: Specific, Causes, Training Performed, Patients Treated, Resolution Rate, Mean Number of Voice Therapy Sessions

Radiotherapy						
Specific	Influenced by Neoglottic Characteristics	Cause	Solution	Patients Undergoing Treatment	% of Resolution	Mean Voice Therapy Sessions (±SD)
Reduced phonation	No	Edema, skin redness, painful stoma occlusion, excessive rigidity	Training 7	6/6	6/6 (100%)	9.17 ± 4.71 range (3-15)
Inability to phonate	No	Post radiation fibrosis	Training 7	0/1	0 (0%)	-

dedicated VT. The need for post-prosthetic VT remains a debated topic within the scientific community, and only limited evidence currently supports its implementation.

For these reasons, the present study aimed to objectively assess the role of VT in the postoperative management of totally laryngectomized patients rehabilitated with a VP, within a large cohort (N = 194) followed at a tertiary referral center. Within our sample, approximately half of the patients developed a satisfactory TE voice within the first five VT sessions, without the need for specific or targeted training. The remaining patients exhibited varying degrees of difficulty in producing a communicatively effective voice. These difficulties correlated with age over 65 and female sex; conversely, variables such as pharyngeal reconstruction using free flaps, primary versus salvage surgery, primary versus secondary prosthesis placement, and prior or adjuvant radio chemotherapy did not significantly influence the development of voice-related issues.

Analyzing the distribution of complications, our findings confirm that the most common (40%) and rehabilitatively demanding voice-related complication - both in terms of frequency and number of required VT sessions -was hypertonic voice, particularly when caused by pharyngeal constrictor muscle hypertonicity. This complication, however, demonstrated a resolution rate of 95%, achieved through a combination of targeted VT and medical administration of botulinum toxin, and resulted in overall better perceptual voice outcomes compared to other patient categories. The most challenging condition to treat was hypertonic voice due to pharyngoesophageal segment (PES) spasm, for which VT alone achieved a success rate of 12.5%, while botulinum toxin injection led to resolution in 71.43% of cases. Of note are cases in which PES spasm co-occurred with post-radiation fibrosis of the cervical tissues; these patients were unable to resolve their voice-related issues. Difficulties related to respiration, coordination, and posture were observed in 14% of cases, with a 92% resolution rate achieved exclusively through targeted VT. The most challenging patients to rehabilitate were those presenting with pneumo-phonic incoordination involving breathing, stoma occlusion, and voice production. On average, these patients achieved moderate voice quality and lower adaptation levels compared to other categories investigated. Anomalies related to the vocal tract were found in 12% of our patients. All such cases were successfully resolved through VT, resulting in overall good vocal outcomes. It should be noted that, according to the INFVo perceptual scale, this group showed lower scores in the voicing (Vo) parameter, likely due to the inclusion of patients with reconstructive flaps. Stoma-related issues, radiotherapy-induced complications, and poor voice quality each showed an incidence of 7%. All three categories achieved a 100% resolution rate following targeted VT. Patients with radiotherapy-related or poor-quality voice issues reached good voice quality and adequate adaptation levels in fewer than 10 sessions on average. Conversely, those with stoma-related issues required longer treatment durations. While these patients scored well

TABLE 12.
Poor Voice Quality: Specific, Causes, Training Performed, Patients Treated, Resolution Rate, Mean Number of Voice Therapy Sessions

Poor Voice Quality						
Specific	Influenced by Neoglottic Characteristics	Cause	Solution	Patients Undergoing Treatment	% of Resolution	Mean Voice Therapy Sessions (±SD)
Volume/intensity, frequency, intonation/ modulation	Yes	Posture, pulmonary support, tension	Training 8	7/7	7/7 (100%)	8.57 ± 2.70 range (5-12)

on the INFVo overall impression (I) and fluency (F) parameters, they had lower scores for additive noise (N) and voicing (Vo). Nevertheless, all patients used their prosthetic voice effectively in daily life, demonstrating excellent adaptation levels (I-SECEL < 36). The least frequent issues were interference between esophageal and TE voice (5%) and hypotonic voice (3%). Both categories showed 100% resolution rates and satisfactory vocal outcomes, although hypotonic voices tended to persist with reduced voicing.

Overall, the success rate of prosthetic voice rehabilitation in our cohort aligns with previously reported findings,[2,8,22,23] reaching nearly 95%. It is important to highlight, however, that achieving such a high success rate required targeted VT in 51.55% of patients to address their distinct voice-related issues. Comprehensive patient assessment - including vocal symptom analysis, investigation of potential underlying causes, and a joint diagnostic workup -enabled the resolution of 92% of all voice-related issues managed over 14 years of clinical activity.

A key strength of this study lies in the retrospective reconstruction of an implicit clinical decision-making process. Although no predefined algorithm was used during patient management, the analysis of 14 years of clinical practice revealed consistent therapeutic patterns that could be formalized into a reproducible troubleshooting algorithm. A such diagnostic and therapeutic algorithm designed to assist ENT and SLPs and currently represents the first specific attempt in the literature aimed at providing a practical tool to identify the causes of poor TE voice quality and propose the most appropriate therapeutic approach. Within this algorithm, therapeutic success is defined through a multidimensional evaluation that includes perceptual voice quality (INFVo), functional use of the TE voice in daily communication, and patient-reported adaptation and quality of life (I-SECEL and UWQoL-v4), allowing consistent outcome evaluation despite inter-patient variability.

CONCLUSION

Tested across a large patient cohort, this systematic approach provides solid support for clinical practice. Our findings also underscore the pivotal role of the SLP as the central figure in managing prosthetic voice rehabilitation. The algorithm derived from this retrospective analysis represents the formalization of long-standing clinical expertise into a structured decision-making tool for future rehabilitation practice. By integrating this algorithm, SLPs can ensure timely interventions and optimize long-term communicative outcomes, establishing a new standard of care for this complex patient population.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jvoice.2026.04.038.

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