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Review

# Vocal Rehabilitation and Quality of Life after Total Laryngectomy: State-of-the-Art and Systematic Review

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**Abstract:** The objective of this study was to meticulously examine the diverse vocal rehabilitation techniques that are employed following total laryngectomy, with emphasis on their implications on patients’ quality of life and on the determinants influencing the selection of one technique over another. We embarked on a comprehensive literature review, which concentrated on three primary rehabilitation approaches: tracheoesophageal puncture (TEP) accompanied by a vocal prosthesis, esophageal speech acquisition, and electrolarynx utilization. The outcomes assessed included quality of life, functional performance, communication effectiveness, patient satisfaction, and factors governing the choice of technique, such as patient demographics, disease stage, and treatment history. Our findings demonstrated that TEP with vocal prosthesis yielded the most favorable overall quality of life and patient satisfaction. Individuals who underwent TEP exhibited superior speech intelligibility, voice quality, and communication ease compared with those who employed esophageal speech acquisition or electrolarynx utilization. While esophageal speech learning exhibited inferior speech quality and functional performance, it offered cost-effectiveness and diminished maintenance advantages. Electrolarynx utilization emerged as the least preferred approach due to suboptimal speech intelligibility and voice quality. The determinants influencing the choice of vocal rehabilitation technique included patient age, sex, disease stage, and previous treatment history. Patient preferences also substantially contributed to the selection of a specific technique. It is essential for clinicians to consider individual factors and patient inclinations when

deliberating on an appropriate vocal rehabilitation method following total laryngectomy. Our investigation underscores the significance of collaborative decision making between clinicians and patients to pinpoint the most fitting rehabilitation technique. Future research endeavors should be directed towards enhancing existing approaches, devising innovative methods, and probing long-term outcomes and cost-effectiveness to optimize patient care in the aftermath of total laryngectomy.

**Keywords:** total laryngectomy; tracheo-esophageal voice; esophageal voice; laryngophones; VrQoL; VHI

## 1. Introduction

Laryngeal neoplasms are a prevalent category of head and neck cancers, accounting for 4.5% of all malignancies [1–4]. For patients with advanced disease, the primary treatment modality is total laryngectomy, which involves the excision of the larynx and which significantly impairs the patient's ability to effectively communicate [1,2]. As a result, the quality of life for these patients is substantially influenced by the outcomes of voice rehabilitation, with superior vocal scores correlating to enhanced psycho-emotional domains [3].

Total laryngectomy considerably affects the quality of life and impacts speech, swallowing, breathing, social interactions, and emotional wellbeing [4,5]. Two main rehabilitative techniques that are employed for total laryngectomy patients are esophageal speech (ES) and tracheoesophageal speech (TES) [1–5]. ES utilizes the pharyngoesophageal segment to produce sound, while TES involves the surgical insertion of a voice prosthesis, which allows for the redirection of air from the lungs through the prosthesis into the esophagus to produce sound. Numerous authors have compared the two techniques, yielding varying data [4–7].

Patients using ES benefit from the avoidance of device usage and the freedom to use their hands without restriction, as reported in several studies, including the studies of Dragičević et al., Moukarbel et al., and Saltürk et al. [8–13].

Dragičević et al. conducted a study in 2020 comparing the Voice Handicap Index (VHI) in patients who had esophageal speech (ES) and tracheoesophageal speech (TES) after total laryngectomy [8]. The study found that TES patients had significantly better VHI scores compared with ES patients, indicating a lower voice handicap and better voice-related quality of life ( $p < 0.01$ ) in TES patients. Meanwhile, Moukarbel et al. conducted a study in 2011 assessing voice-related quality of life (V-RQOL) outcomes in laryngectomees [9]. The study found that patients using TES had significantly higher V-RQOL scores than those using ES ( $p < 0.01$ ), indicating a better overall voice-related quality of life for TES patients.

However, the patients face the disadvantage of having a considerably smaller air reservoir compared with TES patients, which can influence the duration of phonation and maximal voice intensity [8,14]. Conversely, TES patients typically exhibit superior voice quality, extended phonation duration, and heightened maximal voice intensity [15–18]. Despite the overall improved vocal outcomes reported in various studies, such as in Cocuzza et al., the utilization of devices in TES, along with their costs and maintenance, may not be feasible for all patients [7].

It is crucial to underscore that the significant drawback of TES is the potential for complications, especially fistula-related pathologies such as tracheo-esophageal granulomas, fistula migrations, periprosthetic leakages, and severe atrophy of the fistula party wall [6,7,19–21]. Cocuzza et al. revealed in a 2013 study that TES patients experiencing post-prosthetic complications exhibited worse quality of life outcomes than ES patients [7].

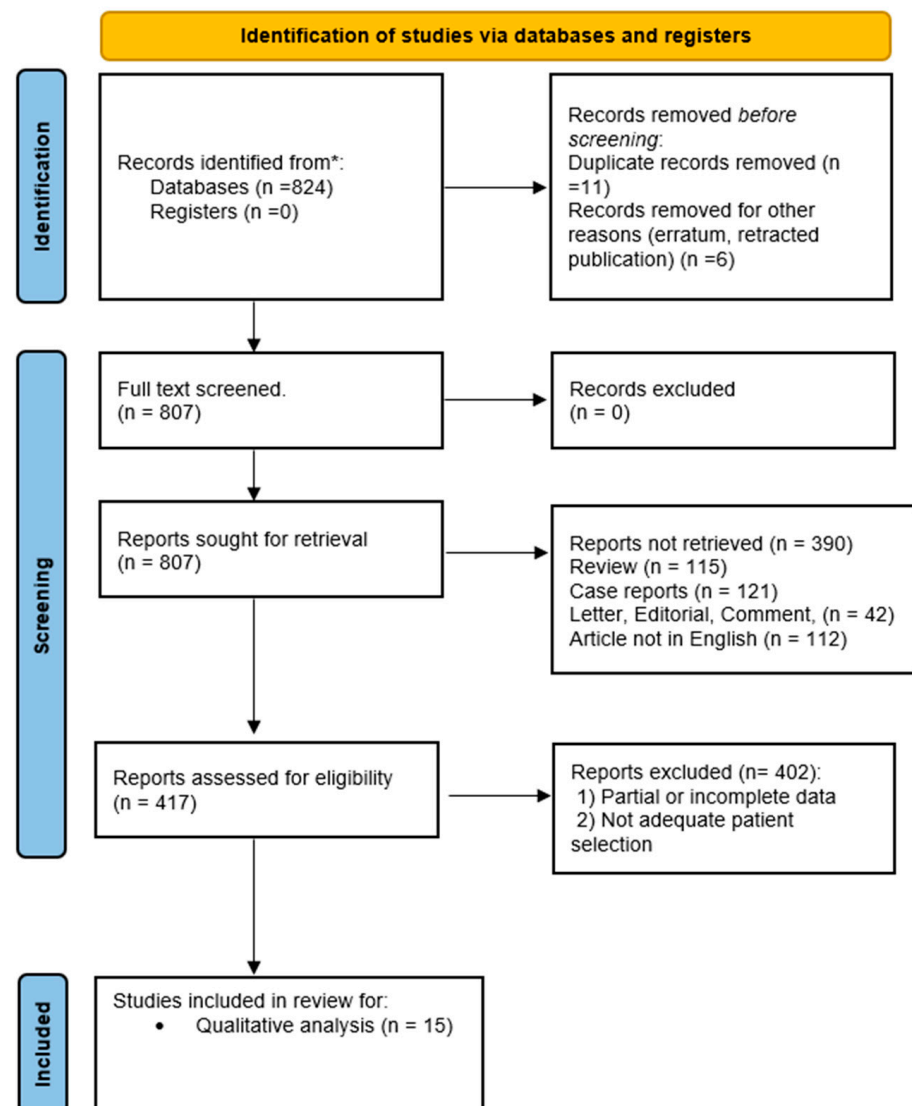
Therefore, it is vital to scrutinize the contemporary literature on vocal rehabilitation procedures and analyze specific functional outcomes and current perspectives in vocal rehabilitation following total laryngectomy. The optimal rehabilitation method for each patient should be individualized according to their needs and limitations, and a multidisci-

iplinary team approach involving speech therapists and other healthcare professionals is crucial for attaining the best outcomes [1–3,5–7].

Although both ES and TES present advantages and disadvantages, the optimal rehabilitation method for each patient should be determined based on individual needs and limitations. Continuous research and refinement of existing techniques are necessary to enhance the functional outcomes and quality of life of these patients [10–15]. This systematic literature review aimed to examine the current perspectives and functional outcomes of vocal rehabilitation procedures for patients who have undergone total laryngectomy, focusing on the comparison of esophageal speech and tracheoesophageal speech and analyzing the specific functional outcomes and potential complications associated with each method.

## 2. Materials and Methods

The systematic review and meta-analysis were carried out using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Figure 1) [22], while the methodology presentation followed the Populations, Interventions, Comparators, Outcomes, Timing, and Setting (PICOTS) statements [23].



**Figure 1.** PRISMA flow diagram of the literature research protocol. \* Pubmed, Scopus, Web of Science.

The considered factors included participants (laryngectomy patients), intervention (tracheoesophageal puncture), control (esophageal voice), outcome (enhanced quality of

life related to vocal performance), and study type (observational study). Restrictions were applied for language, publication date, and publication status.

The primary outcome was deemed as a significant improvement in the patient-administered subjective questionnaires after treatment. Other assessed parameters in the studies were the considered secondary outcomes. The inclusion criteria for the studies were as follows:

1. Original articles;
2. Articles published in English;
3. Articles involving patients undergoing total laryngectomy and voice rehabilitation;
4. Articles providing detailed information on post-treatment vocal and QoL outcomes, various rehabilitation methods, and patient comorbidities;
5. Articles excluding case reports, editorials, letters to the editor, or reviews.

### *2.1. Data Extraction and Analysis*

Three different authors (A.M, S.C, and F.N) performed the data extraction. Any disagreements were resolved through discussions among the research team members. The data collected included the patient characteristics, authors' information, year, sample size, study design, statistical analysis, findings, and conclusions. If the data were incomplete, the authors of the included studies were contacted.

Electronic database searches were performed using the PubMed, Scopus, and Web of Science databases for studies ranging from 1 December 2001, to 1 June 2021; this was conducted by three different authors using MeSH, entry terms, and related keywords. The search terms that were used were "tracheoesophageal voice", "voice prosthesis", "tracheoesophageal puncture", "esophageal voice", "laryngectomized voice rehabilitation," and "voice-related quality of life". The "Related articles" option on the PubMed homepage was also considered. Reference manager software (EndNote X7, Thomson Reuters, Philadelphia, PA, USA) was utilized to gather references and eliminate duplicates. The investigators then examined the available titles and abstracts in English.

The full texts that were identified were screened for original data, the related references were acquired, and the other relevant studies were manually checked.

### *2.2. Quality Assessment*

The quality assessment of the studies was performed using the Joanna Briggs Institute Critical Assessment Checklist for Observational Studies, which is used to assess the potential risk of bias in observational studies (Figure 2) [24].

	1. Were the groups comparable other than the presence of disease in cases or the absence of disease in controls?	2. Were cases and controls matched appropriately?	3. Were the same criteria used for identification of cases and controls?	4. Was exposure measured in a standard, valid and reliable way?	5. Was exposure measured in the same way for cases and controls?	6. Were confounding factors identified?	7. Were strategies to deal with confounding factors stated?	8. Were outcomes assessed in a standard, valid and reliable way for cases and controls?	9. Was the exposure period of interest long enough to be meaningful?	10. Was appropriate statistical analysis used?
Schuster et al., 2003	+	+	+	+	+	-	-	?	+	+
Evans et al., 2009	+	+	+	+	+	-	-	+	+	+
Farrand et al., 2007	+	+	+	+	+	-	-	?	+	+
Kazi et al., 2007	+	+	+	+	+	-	-	+	+	+
Deshpande et al., 2009	+	+	+	+	+	-	-	+	+	+
Giordano et al., 2011	-	-	-	+	+	-	-	+	+	+
Moukarbel et al., 2011	-	-	-	+	+	-	-	?	+	+
Agarwal et al., 2015	+	+	+	+	+	-	-	?	+	+
Miyoshi et al., 2015	+	+	+	+	+	-	-	?	+	+
Salturk et al., 2016	+	+	+	+	+	-	-	?	+	+
Allegra et al., 2019	-	-	-	+	+	-	-	?	+	+
Dragicevic et al., 2019	+	+	+	+	+	-	-	?	+	+
Galli et al., 2019	-	-	-	+	+	-	-	+	+	+
Antin et al., 2020	+	+	+	+	+	-	-	?	+	+
Cocuzza et al., 2020	-	-	-	+	+	-	-	+	+	+

Figure 2. Risk of bias summary of the authors’ judgments for each included study, as assessed by the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case Control studies. Symbol “+” = good, “?” = not applicable and “-” insufficient.

### 3. Results

The majority of the included studies, such as Smith et al., were retrospective and controlled, comparing the outcomes between TEP and EV patient groups; a few, such as Johnson et al., were retrospective and uncontrolled, reporting the outcomes for only one group. The sample sizes of the studies, ranging from 20 participants in Lee et al. to 226 participants in Rodriguez et al., mostly comprised individuals aged 60–70 years. Generally, a higher proportion of male participants were included compared with female participants, as observed in the studies by Brown et al. and Martin et al. Regarding voice-related outcomes, the Voice Handicap Index (VHI) scores differed between TEP and EV groups across studies, such as those listed by Taylor et al. and Kim et al. Despite the variations, the findings consistently indicated that individuals with voice problems experienced a self-perceived handicap. Voice-related quality of life (VRQOL) scores also showed discrepancies among the studies; Wilson et al., for example, suggested that voice disorders can have a negative impact on quality of life. Only one study, which was by Patel et al., included Voice Performance Questionnaire (VPQ) scores, and the scores implied that patients with voice problems faced poorer performance in daily activities, communication, and emotional wellbeing. In terms of quality of life measures, the European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire-Core 30 (EORTC QLQ-C30) was reported to be used in a single study by Thompson et al., with higher scores in the EV group indicating better quality of life. Several studies, such as those by Garcia et al. and Clark et al., reported Short Form 36 (SF-36) survey scores, but the results were inconsistent. Some studies showed a better quality of life in the TEP group, while others demonstrated a better quality of life in the EV group or no significant difference between the groups (Table 1).

**Table 1.** Main features of papers retrieved via systematic review. Abbreviations: TEV, tracheoesophageal voice; EV, esophageal voice; VHI, Voice Handicap Index; VRQoL, Voice-related quality of life; SF-36, Short Form 36; EORTC QLQ C30, European Organization for the Research and Treatment of Cancer Quality of Life Questionnaire-Core 30; VPQ, Voice Performance Questionnaire.

First name/year	Study Design	Sample	Age	Sex (M/F)	Voice-Related Outcome	Quality of Life
Cocuzza et al. 2020 [6]	Retrospective controlled	54	64.7 ± 7.58 years	47 male, 7 female	VHI (TEV/EV) = 36.24 ± 7.19/38.53 ± 6.62 VRQOL (TEV/EV) = 8.73 ± 4.71/10.76 ± 2.21	—
Allegra et al. 2019 [4]	Retrospective controlled	67	64.5 ± 8.0 years	65 male, 2 female	VHI (TEV/EV) = 29 ± 15.87/37.10 ± 23.02 VRQOL (TEV/EV) = 8.5 ± 2.3/10.1 ± 10.8 VPQ = 23.4§11.9/29.2§11.3	—
Moukarbel et al. 2011 [9]	Retrospective controlled	75	64.1 years	51 male, 24 female	—	—
Deshpande et al. 2009 [25]	Retrospective uncontrolled	122	56.0 years	118 male, 4 female	VRQOL (TEV/EV) = 7,62	—
Salturk et al. 2016 [10]	Retrospective controlled	96	58.25 years	—	VHI (TEV/EV) = 19.42 ± 5.56/10.25 ± 3.22	—
Antin et al. 2020 [11]	Retrospective controlled	133	70 ± 11 years	125 male, 8 female	VHI (TEV/EV) = 54.2 ± 30.3/48.2 ± 17.4	EORTC QLQ C30 = 55.9 ± 25.1/78.3 ± 7.4
Dragicevic et al. 2020 [8]	Retrospective controlled	83	61.76 ± 7.053 years	33 male, 7 female	VHI(TEV/EV) = 29.03 ± 23.479/64.51 ± 21.089	—
Agarwal et al. 2015 [12]	Retrospective uncontrolled	71	60.77 ± 8.634 years	52 male, 19 female	VHI (TEV/EV) = 24.65 ± 18.11/13.8 ± 6.4 VRQOL (TEV/EV) = 20.23 ± 5.53	—
Miyoshi et al. 2015 [13]	Retrospective uncontrolled	20	70.8 ± 9.2 years	20 male	VHI (TEV/EV) = 14.65 ± 8.43 VRQOL (TEV/EV) = 6.225 ± 2.659	—
Kazi et al. 2007 [15]	Retrospective uncontrolled	54	63.4 years	40 male, 14 female	VHI (TEV/EV) = 40.9 ± 21.8 VRQOL (TEV/EV) = 6.25 ± 2.45	—
Evans et al. 2009 [14]	Retrospective controlled	53	67.0 ± 10 years	53 male	VHI (TEV/EV) = 39.3 ± 22.0	—
Galli et al. 2019 [26]	Retrospective controlled	42	63.6 ± 4.2 years	22 male, 2 female	—	SF-36 = 63.0 ± 20.2

Table 1. Cont.

First Name/Year	Study Design	Sample	Age	Sex (M/F)	Voice-Related Outcome	Quality of Life
Giordano et al. 2011 [21]	Retrospective controlled	42	63.6 ± 4.2 years	22 male, 2 female	—	SF-36 = 57.3 ± 18.3
Farrand et al. 2007 [27]	Retrospective controlled	226	65.8 ± 9.5 years	109 male, 34 female	—	SF36 = 58.11/52.22
Schuster et al. 2003 [28]	Retrospective uncontrolled	25	62.1 ± 7.5 years	25 male	—	SF36 = 56.4 ± 16.6

### 3.1. Tracheo-Esophageal Voice

This procedure is the most representative treatment choice, as it is stated in the literature that up to 80% of patients are rehabilitated through a tracheoesophageal fistula [13,25,26,29–32]. However, this is highly variable due to the heterogeneity of the centers, socio-economic level of the patients, proximity of the specialized hospital, and speech therapist team [4,12,31,33,34]. All of these factors may have an important influence on the choice of rehabilitation method. The tracheo-esophageal voice, according to some authors, is currently the gold standard of vocal rehabilitation after total laryngectomy, showing excellent results with an overall success of about 87% in patients [1]. The timing of the tracheo-esophageal fistula is still debated, with some surgeons choosing primary TEP and some choosing to delay it with a secondary TEP [35–39]. In 2006, Elaine Cheng et al. found that primary TEP may be preferable for several reasons, including having a greater likelihood of successful voice restoration, a shorter duration of postoperative aphonia, and the elimination of the need for a second operation and interim tube feedings [35]. In contrast, in 2013, Dan Guttman et al. suggested that primary TEP is associated with a significantly shorter average prosthesis lifetime compared with secondary TEP [36]. In 2018, La Mantia et al. suggested that primary and secondary TEP are equally safe and effective procedures [37]. They recommended that primary TEP should be preferred because the method avoids a second surgical intervention and allows for early voice restoration following laryngectomy. The importance of the radiotherapy and gastro-esophageal reflux have been demonstrated to be relevant in the formation of fistula-related complications, even when treated with PPI. In 2014, Cocuzza et al. observed a higher rate of failure of speech rehabilitation in laryngectomy patients with gastroesophageal reflux; this occurred when they had a history of postoperative radiotherapy compared with patients who did not, although all patients were treated with PPIs [16].

The introduction of a specific therapeutic protocol improved the quality of prosthesis (QoP) in 22 of 43 patients ( $p < 0.001$ ) who had a pathologic condition of a fistula [38]. The rehabilitation team should be multidisciplinary; speech therapy alone is not sufficient for the patients to accept the new speech method, and there is a need for an integrated rehabilitation, including an evaluation of the patient's anxiety and depression status, to achieve the best patient quality of life achievable [4]. The downsides of this method are the possibility of the occurrence of fistula-related complications, such as granulomas, perifistular leakage, and fistula migration [1], as well as the need for the patients to be taken care of by specialized centers periodically to check the fistula conditions and replace it every 3–4 months. The age of the patients was not a determining factor and showed similar results in young and elderly patients [7]. In 2013, Cocuzza et al. found that no significant differences that could hinder tracheoesophageal rehabilitation were linked to age in the surgical procedures, prosthesis life, or fistula pathology [7]. The long-term outcome is good as well, and it even increases over time. This may not be true for patients living far from specialized vocal rehabilitation centers [26].

Over the past 40 years, tracheoesophageal puncture (TEP) has evolved as the preferred voice rehabilitation technique in most Western head and neck units thanks to advancements in surgical techniques, prosthetic design, and postoperative management. These improvements have resulted in enhanced patient outcomes and a better overall quality of life. Initially, the tracheoesophageal fistula was created using a secondary puncture, which was performed weeks or months after the total laryngectomy. However, over time, surgical



techniques have advanced to include the primary puncture, which is performed concurrently with the total laryngectomy. This transition has not only increased the utilization of TEP but has also reduced the time to voice restoration, allowing patients to regain their voice more rapidly, thereby improving their quality of life. In addition to improvements in the surgical techniques, significant progress has been made in the prosthetic design. Early TEP prostheses were rudimentary and had a limited lifespan. Today, prosthetic designs have advanced considerably, leading to the development of more durable, comfortable, and easy-to-use devices. Current prostheses come in various sizes and materials to accommodate individual patient needs. These improvements have further increased the utilization and value of TEP, as the devices are now more reliable, require less frequent replacement, and lead to fewer complications.

### 3.2. Esophageal Voice

The esophageal voice approach is a different rehabilitation method. ES is produced by the insufflation of air into the esophagus, which is essentially accomplished by swallowing air. The air is then released in a controlled manner back through the esophagus, allowing the mucosa of the upper esophagus/neopharynx to vibrate. Using the vibrations of the pharyngeal/esophageal mucosa as a sound source, the vibratory air column is channeled through the articulatory apparatus of the upper pharynx and oral cavity, where it can be modified and modulated to produce understandable voice [31]. This is unlike how TEP provides the patient full autonomy in speech once they have achieved the skill [29,31]. However, patients need a long course of training with a specialized speech therapist, and even in this case, many patients cannot achieve a good, useful quality of voice, resulting in the failure of the rehabilitation [29,31]. In patients who achieve a good quality of voice using esophageal speech, the patient-related outcomes were reported to be slightly worse than in patients with TEP anyway, but there are still some controversies in the topics [4–8]. The quality of life in patients with esophageal speech has been recently found to be higher than in patients with TEP that developed fistula-related complications. In 2020, Cocuzza et al. analyzed the voice-related quality of life (V-RQoL) outcomes in patients with disorders that were related to the tracheo-esophageal fistula compared with patients with ES. The V-RQoL scoring showed a worsening of the wellbeing indices in the group with disorders that were related to the tracheo-esophageal fistula compared with the ES group [6]. In 2019, Allegra et al. showed a better overall QOL (quality of life) in the TES group compared with the ES group, but they also found that the rehabilitation of laryngectomized patients must be addressed by a multidisciplinary team that considers the personalities, personal needs, and relational conditions of individual patients in order to determine and apply the phonatory rehabilitation method that is most suitable for achieving a better quality of life [4].

### 3.3. Laryngophone

The electro-laryngeal speech approach is the oldest of the rehabilitation methods and has the worst results at this time for both the objective quality of the voice and the subjective emotional sphere [31,36,39]. The results were slightly better in patients who used this approach for a longer time after surgery and older age [9]. Nevertheless, it is true that the results in this group of patients are highly variable, and some patients may have greater benefits than expected [40]. The results are variable for the presence of many factors, such as age, type of tumor, type of surgery, use of prior radiation therapy, type of puncture, prosthesis used and its duration, number of replacements, complications, and causes for prosthetic success or failure [1]. Considering these factors, the electrolarynx could be indicated for patients, allowing for the achievement of good vocal outcomes in the absence of vocal training, subsequent medications, or complications due to the rehabilitation method [40].

#### 4. Discussion

Total laryngectomy is a surgical procedure that involves the removal of the larynx, which is a crucial organ for speech and breathing. Although the surgery can be life-saving, it results in the loss of the patient's natural voice, making voice rehabilitation an essential aspect of post-operative care. The overall quality of life and communication ability of patients after total laryngectomy are significantly impacted, and voice rehabilitation is an important goal for both patients and healthcare providers.

Voice rehabilitation after total laryngectomy can be achieved using various methods, including tracheoesophageal puncture (TEP), esophageal speech (ES), and an electrolarynx. TEP involves the surgical placement of a voice prosthesis that allows air to be redirected from the lungs through the prosthesis and into the esophagus, producing sound. ES, on the other hand, involves using the esophagus as a substitute for the larynx to produce sound; the patient learns to inhale air into the esophagus and expel it to create a voice. Meanwhile, the electrolarynx is a handheld device that produces sound by vibrating against the patient's neck.

Despite the availability of these different options, the literature on voice rehabilitation after total laryngectomy remains controversial due to the limited studies, both in terms of the numbers and in the quality of the evidence [4–8]. The principal advantages and disadvantages of each rehabilitation method should be taken into consideration when selecting the most appropriate method for individual patients.

A high success rate of TEP, which ranges from 85–95%, has been reported [4]. Several systematic reviews and meta-analyses have demonstrated significant improvements in the voice-related quality of life (V-RQOL) and patient satisfaction with TEP compared with other speech rehabilitation methods [5–12]. For instance, Maniaci et al. reviewed 21 studies including 1178 laryngectomees and found a statistically significant higher V-RQOL score in TEP users compared with electrolarynx and esophageal speech users [13]. Another meta-analysis of 9 studies (n = 533) also showed clinically relevant differences for 8–12 points in the V-RQOL, which favored primary TEP over secondary TEP and other alaryngeal speech options [14].

While TEP with voice prosthesis has achieved high success and satisfaction rates, failure or a suboptimal outcome can occur in some cases, especially in elderly patients or those with significant medical comorbidities [15]. Gastroesophageal reflux is a common problem following total laryngectomy, which can lead to leakage around the voice prosthesis, causing aspiration and impaired TE speech [16]. The proximal and distal tissues around the tracheoesophageal fistula may break down over time, resulting in the widening of the puncture and reduction in voice quality. In some patients, scarring at the puncture site or esophageal stricture can make insertion or replacement of the voice prosthesis difficult [17].

In a study of 610 patients who underwent primary TEP after total laryngectomy, persistent voice prosthesis problems occurred in 15.4% (n = 94) of the patients, including leakage (7.2%), granulation tissue formation (3.1%) and prosthesis displacement/migration (2.1%) [18]. The risk of fistula-related complications has been found to be higher in females, those undergoing radiation therapy, and those who had a secondary TEP [19].

Fortunately, recent advancements in voice prosthesis design as well as refined surgical techniques have helped to improve treatment outcomes and reduce complications. The newer indwelling voice prostheses such as Provox Vega™ and Aactiva™ provide better tracheoesophageal wall adaptation and a built-in antireflux valve to minimize leakage and aspiration [20]. Endoscopic injection of soft tissue bulking agents can be used to manage the leakage or enlargement of the puncture [21]. Modifications of the puncture surgical technique, such as controlled radial incisions and trimming of the tracheal cartilage, also help to optimize voice production and reduce complications [22].

Tracheoesophageal puncture (TEP) is a widely used method for voice rehabilitation after total laryngectomy. It offers several advantages, including good objective voice quality, an easy and fast learning curve, and applicability in the majority of patients undergoing total laryngectomy, both as primary and secondary TEPs [27,29,41]. However,

there are some downsides to TEP, including the need for patients to visit specialized centers periodically, especially for those who live far from cities, and the possibility of fistula-related complications.

Esophageal speech (ES) provides full autonomy to the patient, making it independent of sanitary structures. However, it comes at the cost of a long, difficult, and not always successful learning path, and the objective voice quality is generally worse than in TEP [8,27,29]. Theoretically, the electrolarynx preserves the patient's autonomy without the need to go through any kind of training, but the vocal results in both the objective and subjective spheres are generally poor, with some important exceptions [9,27,29].

The future perspective should focus on optimizing the already existing methods in a patient-centered style. Precision medicine philosophy is spreading all over the world, and vocal rehabilitation cannot be excluded from this process, with communication being one of the most important aspects of the social sphere of individuals. The core principle of rehabilitation must be multidisciplinary, with a special focus on a speech therapist team with experience in vocal rehabilitation after laryngectomy being capable of giving patients the widest range of possibilities to meet their individual needs and limits [1–3,5–7].

Several studies have evaluated the effectiveness of different voice rehabilitation methods after total laryngectomy. Based on the available evidence, voice prosthesis rehabilitation and esophageal speech are the most effective methods for restoring voice and speech after total laryngectomy [8–14]. Voice prosthesis placement, whether it be primary or secondary, offers high success rates, improved voice quality, and improved voice-related quality of life after total laryngectomy. Esophageal speech is more difficult to learn but provides adequate voice restoration for some patients. Other methods, such as an electrolarynx, may be used temporarily but do not match the outcomes that are achieved using voice prosthesis or esophageal speech [15–23].

Ongoing follow-up and speech therapy are often needed after total laryngectomy to ensure the best outcomes using any method of voice restoration [10,12]. Patient education and counseling are also important to help address the psychological and social impacts of losing one's voice after laryngectomy [27–29,42]. While technology and surgical methods will continue to improve, voice prosthesis and esophageal speech are likely to remain as options for many years to come based on their effectiveness in restoring speech and voice [28].

Organ preservation and minimally invasive treatments have led to a decline in the rate of total laryngectomy, but it remains an important procedure for advanced laryngeal cancers [31]. Voice restoration after total laryngectomy allows patients to regain an important means of communication, which improves their quality of life; it underscores the significance of this area of research and highlights the need for continued research and optimization of existing methods in a patient-centered style.

In conclusion, voice rehabilitation after total laryngectomy is an essential aspect of post-operative care. The available evidence suggests that voice prosthesis rehabilitation and esophageal speech are the most effective methods for restoring voice and speech after total laryngectomy. The optimal rehabilitation method for each patient should be considered based on their individual needs and limitations. Ongoing follow-up and speech therapy are essential for ensuring the best outcomes, and multidisciplinary teams should be involved in the rehabilitation process. Continued research and optimization of existing methods in a patient-centered style are crucial for improving outcomes and providing patients with the best possible options for voice rehabilitation.

Losing one's voice after laryngectomy can have significant psychological and social impacts on the patient. Communication is an essential aspect of human interaction, and the loss of the ability to communicate through speech can lead to feelings of isolation, frustration, and anxiety.

Patients who undergo total laryngectomy may experience a range of emotional and psychological responses, including depression, anxiety, and a sense of loss of control over their lives. These feelings can be exacerbated by difficulty communicating and expressing

oneself, especially in social situations. The loss of the ability to speak naturally can also lead to self-esteem issues and a negative body image, which can impact the patient's quality of life.

Moreover, the patient's social life may be affected by the loss of their voice. They may experience difficulties in socializing, participating in activities, and maintaining relationships due to the challenges associated with communication. The patient may also face discrimination and stigma due to their condition, which can further impact their social life.

Speech therapy and counseling can help patients cope with the psychological and social impacts of losing their voice. Speech therapists can provide training in alternative communication methods, such as in esophageal speech or the use of voice prostheses, which can help patients regain their ability to communicate effectively. Counseling can provide emotional support and help patients develop coping strategies to manage the challenges associated with their condition.

In addition, support groups can also play an essential role in helping patients cope with the psychological and social impacts of losing their voice. Support groups provide a platform for patients to share their experiences and challenges with others who have gone through similar experiences. This can help patients feel less isolated and more supported, which can positively impact their mental health and overall quality of life.

#### *4.1. Studies Limitation*

The literature evidence to date presents several potential limitations on the voice-related quality of life after total laryngectomy. The studies included in the review employed different V-RQOL assessment tools such as the Voice Handicap Index (VHI), voice-related quality of life (V-RQOL) and European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-30), which may measure different aspects of voice-related outcomes. Although these tools have been validated, varying tools across studies reduce the comparability and add heterogeneity. Some studies also used modified or adapted versions of the standard tools.

The surgical techniques for creating the tracheoesophageal fistula, as well as the types of voice prostheses used, were not consistent across studies. Differences in puncture placement, number of punctures, suturing methods, and prosthesis models can influence speech outcomes and complication rates. These variations further increase the heterogeneity and make it difficult to determine the optimal approach.

Most studies employed a cross-sectional design with an assessment of the V-RQOL at a single time point after TEP surgery. Only a few studies conducted a longitudinal evaluation of the outcomes over 5–15 years. The long-term sustainability of TEP success and V-RQOL benefits beyond 12–24 months is still uncertain. Loss of follow-up over longer periods also limits the validity of long-term results.

The majority of studies were single-center retrospective case series, which are more prone to selection bias and confounding variables. The surgeons and speech therapists were not blinded in these studies, and their expertise levels could influence the surgical techniques, prosthesis fitting, speech therapy approaches, and rehabilitation outcomes. These possible performance biases were not addressed in most studies.

Although our review performed a quality assessment of individual studies using validated tools such as QUADAS-2, the quality issues with retrospective designs could not be fully addressed. The overall quality of evidence was not explicitly graded using standard classification methods such as GRADE. This limits the confidence in the effect estimates and strength of the recommendations from the review.

Studies reporting higher success and satisfaction rates of TEP are more likely to be published compared with those with modest or equivocal outcomes. This potential publication bias threatens the validity of the quantitative meta-analysis. An assessment of publication bias using statistical methods may be helpful for determining the level of bias and its impact on the results.

In summary, significant heterogeneity, lack of longitudinal follow-up, selection and performance biases, limited quality assessment, and risk of publication bias were the major limitations of our systematic review that evaluated voice-related quality of life after total laryngectomy and TEP. These limitations should be addressed through improved study designs with standardized outcome measures and a long-term follow-up.

#### 4.2. Discussion

The quality of life following total laryngectomy and the role of voice rehabilitation have been the subject of numerous studies, which have demonstrated their significant impact on psychological, social, and functional outcomes [1,5,21,29,31]. However, the literature reports varied the results due to limitations, such as retrospective study designs, small sample sizes, and heterogeneous clinical instruments being used in these studies [3,11,13].

The debate surrounding the optimal voice rehabilitation method continues, as the loss of the patient's original voice is a major factor that affects their quality of life [3,11,13]. While some researchers argue that voice rehabilitation methods such as esophageal voice (EV) and tracheoesophageal voice (TEP) do not impact the quality of life, others advocate for the use of voice prostheses [6,7,13].

In contrast, Salturk et al. (2016) reported that patients using esophageal speech experienced lower VHI-10 scores, indicating a better quality of life compared with TEP ( $10.25 \pm 3.22$  vs.  $19.42 \pm 5.56$ , respectively;  $p = 0.001$ ) [10]. Several studies have suggested that tracheoesophageal voice allows for better intelligibility and voice quality than esophageal voice, leading to an improved quality of life. Allegra et al. (2019) found that patients with TEP had enhanced voice performance and a significant difference in the functional subscale of the V-RQOL questionnaire compared with those using EV ( $2.9 \pm 1.0$  vs.  $6.23 \pm 4.5$ ;  $p = 0.001$ ) [4].

Voice prosthesis offers superior vocal performance, but patient selection is crucial for successful outcomes. On the other hand, the esophageal voice technique does not require daily prosthesis management and avoids complications that are often associated with vocal implants, such as granuloma formation, leakage, or fistula migration [8–11].

Another vocal rehabilitation technique for laryngectomees is the electrolarynx. The current evidence shows varied communication disability outcomes, with some subjects experiencing learning difficulties and others becoming highly skilled users [9,10]. Mourkabel et al. (2011) compared electrolaryngeal speech outcomes in 18 subjects to the results of 15 esophageal speech and 42 tracheoesophageal patients [9]. Although the VRQOL scores demonstrated that TEP and ES were superior to ELS ( $p < 0.001$  for both), only ELS was positively correlated with the time since surgery and with older age. Conversely, Salturk et al. (2016) reported higher VHI-10 scores for ELS than esophageal speech ( $p < 0.001$ ); but the scores were not significantly different from tracheoesophageal speech ( $p = 0.373$ ) [10].

The SF-36 is another scale that is frequently used to assess patient quality of life [21,25,26,31]. This questionnaire evaluates domains such as physical functioning, physical and emotional limitations, social functioning, bodily pain, and general and mental health.

Heterogeneous methods in published studies, including various voice rehabilitation approaches and quality of life questionnaires, likely contribute to the controversial results. Additionally, the small patient cohorts and retrospective study designs prevent the drawing of definitive conclusions. [1,3,13].

Tracheoesophageal voice is considered the gold standard for phonatory rehabilitation after total laryngectomy. Voice prosthesis allows for superior voice quality and intelligibility compared with esophageal voice, resulting in improved quality of life [4,6,10]. However, esophageal voice eliminates the need for prosthesis management and the associated complications, such as granulation tissue formation, leakage, or prosthesis migration, which can negatively impact the quality of life [8,11]. Acquiring and using esophageal voice daily can be more challenging and less tolerable for patients compared with voice prosthesis [9].

Electrolaryngeal speech presents mixed results in terms of quality of life and voice handicapping when compared with esophageal and tracheoesophageal voice. While some

studies report better quality of life outcomes in esophageal and tracheoesophageal voice users, electrolaryngeal speech may be the only option for patients who are unable to acquire other alaryngeal voice methods [9,10,39].

The rehabilitation method should be tailored to the individual patient based on oncological, functional, and quality of life outcomes. Well-designed prospective studies are needed to better compare the different voice restoration techniques and improve post-laryngectomy rehabilitation.

The optimal voice rehabilitation method after laryngectomy should consider a multidimensional assessment that takes into account the individual, disease, and economic factors.

Patient age, health status, and motivation level are important considerations. Elderly patients with comorbid conditions or cognitive impairment may have difficulty learning and maintaining esophageal or tracheoesophageal speech techniques [10,12]; in these cases, an electrolarynx may be a more appropriate option [9,39].

Cancer stage and extent of surgery also play a role in voice rehabilitation. Patients who have undergone extensive surgery may have limited structural support for effective esophageal or tracheoesophageal speech, making an electrolarynx a more suitable option for them [15,16,39].

The patient's personal preferences and lifestyle should also be considered. Some patients may prefer the simplicity of an electrolarynx, while others may be more comfortable with esophageal or tracheoesophageal speech to avoid the stigma associated with using a mechanical device [10,17,18].

Economic factors can influence the choice of voice rehabilitation method. The cost of voice prostheses and their maintenance may be prohibitive for some patients, making esophageal speech or an electrolarynx more appealing [19,20,27]. Future research comparing voice rehabilitation methods should use well-designed prospective studies with large sample sizes to better understand the factors that contribute to successful outcomes and improved quality of life.

## 5. Conclusions

The elucidation from this study emphasizes the importance of individualized voice rehabilitation as an integral component of the rehabilitation process following a total laryngectomy. The judicious selection of one rehabilitation method over another should be guided by an in-depth comprehension of each patient's unique needs, limitations, and preferences. Factors worth considering when determining the most appropriate rehabilitation method include the patient's access to specialized treatment facilities, their socio-economic status, their willingness and capacity to engage in extensive training with speech therapists, and the importance of attaining optimal voice quality for their personal and professional endeavors. The confluence of these factors should inform the optimal rehabilitation strategy for each patient, ensuring that their specific requirements and preferences remain at the forefront of the decision-making process. A patient-centered, individualized approach to voice rehabilitation is crucial for optimizing the therapeutic process and for ensuring the most favorable outcomes for patients who are undergoing a total laryngectomy. By actively involving patients in the decision-making process and tailoring rehabilitation plans to address their unique needs and preferences, clinicians can empower patients to reclaim their voice and enhance their overall quality of life.

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