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Voice rehabilitation after total laryngectomy using voice prostheses

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Abstract

Laryngeal cancer is one of the most common malignant tumors of the upper respiratory tract. Total laryngectomy remains the primary treatment method for its advanced stages. Although

the procedure can achieve oncological cure, it leads to numerous multidimensional consequences, the most significant of which is the permanent loss of voice. Voice rehabilitation is a key component of postoperative adaptation, enabling patients to reintegrate into social life. Among the available methods of speech restoration, tracheoesophageal voice prostheses allow for rapid recovery of communication ability, provide the highest quality of substitute speech and significantly improve quality of life. The wide range of available models allows for individualized selection according to patient needs, and the use of automatic speaking valves facilitates hands-free speech. Despite these advantages, the use of voice prostheses is associated with complications that may impair daily functioning and reduce patient comfort. Tracheoesophageal voice prostheses remain the most effective and functionally satisfactory method of post-laryngectomy voice rehabilitation, although their use requires proper care, patient education, and regular medical follow-up to minimize complications. Implementation of timely and individualized voice rehabilitation using tracheoesophageal prostheses plays a crucial role in improving communication, psychosocial well-being, and overall quality of life in patients after total laryngectomy. The aim of this review is to present current methods of post-laryngectomy voice rehabilitation with particular emphasis on tracheoesophageal voice prostheses, considered the gold standard in restoring communication ability.

Keywords: esophageal speech, tracheoesophageal speech, tracheoesophageal voice prosthesis, voice rehabilitation, hand-free speech

Introduction

Laryngeal cancer is among the most common malignant neoplasms of the head and neck region [1,2,3]. In the treatment of its advanced stages, total laryngectomy remains the primary and

most widely used therapeutic method. This procedure involves the surgical removal of the larynx-the organ responsible for phonation-which results in permanent loss of voice and verbal communication ability. These consequences constitute the main source of psychosocial difficulties experienced by such patients [2,4,5,6]. Therefore, postoperative speech rehabilitation represents a crucial component of the adaptation process, enabling patients to adjust to their new functional condition [7]. Among the available methods of voice restoration, tracheoesophageal speech is considered the gold standard, and it will be the subject of detailed analysis in the present study.

Methods

The literature search strategy was carried out using the PubMed database based on a combination of keywords: esophageal speech, tracheoesophageal speech, tracheoesophageal voice prosthesis, voice rehabilitation, hand-free speech. Additionally, references within selected publications were reviewed to identify related studies. After screening titles and abstracts, incomplete articles and those not directly related to voice rehabilitation after total laryngectomy were excluded. The final analysis included 63 publications that met the inclusion criteria.

Review results

Total laryngectomy is the standard radical treatment for advanced cancers of the head and neck region, including laryngeal carcinoma [8,9]. After complete removal of the larynx, the trachea takes over the function of the initial segment of the respiratory tract. The surgery results in separation of the upper and lower airways and loss of the functions of air filtration, warming, and humidification. Consequently, cold and dry air reaches the trachea, causing unfavorable changes; as a defense mechanism, mucus production and coughing increase [10]. Patients after total laryngectomy are therefore more susceptible to lower respiratory tract infections, particularly if pre-existing bronchial or pulmonary diseases are present, such as chronic obstructive pulmonary disease (COPD) [11].

The main disability following laryngectomy is the loss of voice, which profoundly affects psychosocial functioning [12]. Studies show that head and neck cancer survivors have some of the highest rates of anxiety, depression, and suicidal ideation-up to four times higher than among other oncology patients [13-15]. Therefore, restoring the patient's ability to communicate verbally represents one of the most important aspects of postoperative adaptation.

Three main methods of voice rehabilitation are distinguished: esophageal speech, electrolarynx, and tracheoesophageal puncture with voice prosthesis [16]. The method focused on in this article is tracheoesophageal speech. It involves the creation of a tracheoesophageal puncture by inserting a trocar through the posterior tracheal wall into the esophagus and placing a voice prosthesis, which functions as a simple one-way air valve [17]. The task of the prosthesis is to redirect exhaled air from the lungs into the esophagus, enabling vibration of the pharyngoesophageal segment when the tracheostoma is closed [18]. This segment serves as an alternative acoustic energy source for sound generation by modulating the airflow from the lungs through the patient's vocal tract [19]. Additionally, the one-way valve mechanism prevents reflux of food and saliva from the esophagus into the trachea, protecting the airways from aspiration and possible pulmonary complications. Figure 1 illustrates the postoperative anatomy, showing the tracheoesophageal puncture with the inserted voice prosthesis and the tracheostoma.

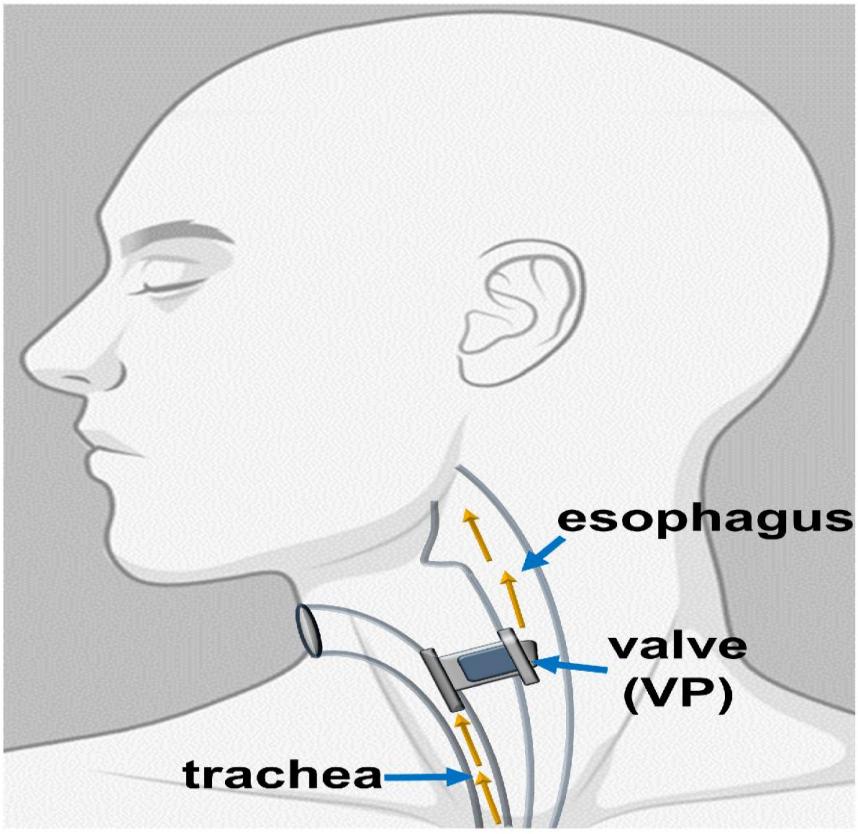

Figure 1. Schematic representation showing the location of implanted voice prosthesis (VP). The tracheoesophageal fistula is typically located on the posterior wall of the trachea, about 5 mm under the upper edge of the tracheostoma. There is a tightly placed VP inside the fistula that acts as a one-way valve [20].

Voice rehabilitation using voice prostheses

The voice, as a tool used to convey our thoughts, emotions, and needs to others, enables active participation in socjety and it also co-creates our personality. Therefore, since the early dissemination of laryngectomy procedures, efforts have been made to restore patients' ability to communicate verbally with their surroundings, with increasing focus over time on achieving speech as close to natural as possible [21,22]. Currently, the most commonly used method for this purpose-considered the gold standard-is the tracheoesophageal voice prosthesis [23,24].
The first voice prosthesis was developed by Blom and Singer in 1980. It revolutionized the process of speech rehabilitation by shortening the time required to regain speaking ability to just a few days [25] and by improving the quality of the produced voice [24]. Over the years, the prosthesis design has undergone numerous modifications, and currently used models are characterized by low airflow resistance, optimal retention in the tracheoesophageal wall, extended device lifespan, and ease of maintenance and replacement [23]. This method enables effective voice rehabilitation-defined as the ability to communicate verbally with the environment-in 80-90% of patients [23,26-31]. Acoustic analyses have demonstrated that prosthetic speech is characterized by a more normalized fundamental frequency, longer phonation time, greater intensity, and lower noise-to-harmonic ratio (NHR) [2,16,22,32-35].

Depending on the timing of tracheoesophageal puncture relative to the laryngectomy, two types are distinguished: primary punctures (performed during the laryngectomy) and secondary punctures (performed during a subsequent procedure). Most available studies and meta-analyses do not show significant differences in the final success rate of voice rehabilitation or the quality of speech achieved by patients [27,28,36]. It has also not been demonstrated that the timing of prosthesis placement significantly affects the overall incidence of complications [24,28,36]. Therefore, both primary and secondary punctures should be considered safe and equally effective methods of restoring speech ability. However, primary punctures are generally preferred, as they eliminate the need for an additional surgical procedure and accelerate the process of regaining communication ability, which has a positive effect on patients' psychological well-being [28]. Nevertheless, the optimal timing of puncture creation should always be determined individually, based on a comprehensive clinical assessment of the patient's condition, comorbidities, previous surgical interventions, applied treatment strategies, and plans for further management.

A variety of voice prostheses are currently available on the medical market, manufactured by different companies, including Blom-Singer (InHealth Technologies, CA), Provox (Atos Medical**,** Hörby, Sweden), Nijdam and Groningen [37]. They are produced in different sizes and shapes, allowing better adjustment to each patient's anatomical and functional needs. Specialized models are also available for specific clinical situations - for example, prostheses with flanges reducing the risk of periprosthetic leakage, or valves made of fluoroplastic materials with increased resistance to biofilm formation, thereby extending device longevity. Most comparative studies evaluating prostheses from different manufacturers in terms of voice quality, device lifespan, and overall patient quality of life have found no significant superiority of one type over another [38-40]. Nevertheless, some individual studies have reported differences in performance between prosthesis brands. WVBS Ramalingam et al. observed better voice quality and greater user comfort with the Provox prosthesis compared to the Blom-Singer model [41]. Their study also demonstrated a significantly lower incidence of complications such as granuloma formation, leakage, and fungal overgrowth on the valves in patients using Provox devices [41]. Similarly, Tawfik GM et al. found Provox prostheses to be superior when compared to Groningen and Nijdam models [42]. The Provox-2 prosthesis was the most preferred by patients and exhibited the lowest airflow resistance, minimal displacement risk, reduced granuloma formation, and fewest size mismatch issues [38]. Conversely, the study by Kathelijne Delsupehe et al. demonstrated a slight advantage of Blom-Singer prostheses in terms of voice quality [38]. The authors noted that for this reason, these prostheses may be more frequently chosen by younger patients, for whom achieving the best possible speech quality is a priority. The same study also indicated that Provox prostheses were superior in terms of ease of maintenance, making them a better option for older patients with limited manual dexterity [38]. Thus, the selection of the appropriate prosthesis should be based primarily on the patient's individual abilities and preferences [38].

As previously mentioned, the use of a voice prosthesis is an effective method of speech generation and allows good voice quality. However, it requires the patient to manually occlude the tracheostoma during speech in order to redirect exhaled air through the prosthesis into the pharyngoesophageal segment. This significantly limits communication freedom, makes simultaneous gesturing or two-handed activities difficult [43], and negatively affects the psychological state of patients by constantly reminding them of their disability. The solution to this problem was the introduction of automatic speaking valves (ASV), which close automatically during exhalation, allowing hands-free speech [31,43-46]. This innovation also

represents the only viable speaking option for patients with comorbidities impairing manual dexterity (e.g., rheumatoid arthritis) [44]. However, despite clear benefits, only about 20% of post-laryngectomy patients regularly use ASVs, mainly due to difficulties in achieving a stable and airtight attachment [47]. Most patients use peristomal adhesive baseplates, but because of high pressure during hands-free phonation, skin irritation, excessive mucus production, and sweating, detachment often occurs prematurely [48]. Alternative stabilization methods, such as intratracheal cannulas or buttons, can also be used. Although less popular, they are particularly suitable for patients who experience skin irritation or air leakage when using adhesive baseplates [46-49]. Additionally, to strengthen the adhesive housing and reduce the frequency of baseplate replacements, an external neck brace can be used. By applying gentle pressure, it effectively maintains the baseplate's position during phonation. Studies conducted by Richard Driven, MD, et al. confirmed the effectiveness of this method in prolonging the lifetime of adhesive baseplates and reducing the need for their replacement, with over 80% of participants finding the neck brace a helpful tool facilitating hands-free speech [50,51].

Complications of voice prostheses and their management

Although the use of tracheoesophageal punctures and voice prostheses represents the gold standard for voice restoration, it is associated with various complications. In a study on prosthesis-related complications conducted by Tong et al., the most frequently reported adverse events included prosthesis aspiration, the presence of a foreign body during placement, aspiration pneumonia, aspiration or detachment of the cleaning brush tip, leakage, and tearing of the esophageal flange [52]. The same study emphasized that many complications arise from improper handling or maintenance, which highlights the importance of patient and medical staff education regarding both the procedure and the care of the voice prosthesis. Previous research has not demonstrated a significant influence of timing of prosthesis placement on the overall incidence of complications [24,28,36]. However, some studies suggest potential differences between primary and secondary tracheoesophageal punctures regarding specific risks. For instance, primary prosthesis implantation allows for earlier initiation of voice rehabilitation, shortens hospital stay, and results in a longer interval before the first prosthesis replacement.

Discussion

An important direction for ongoing research is the improvement of quality of life for post-laryngectomy patients, focusing on the clinical problems they most often report. Studies are

currently being conducted on the benefits of gastroesophageal reflux therapy using proton pump inhibitors (PPIs) for patients with voice prostheses [53]. Another challenge is biofilm formation, which colonizes the surface of voice prostheses and shortens their functional lifespan. Promising results have been obtained regarding the use of vibrational stimuli and surface modification techniques to extend device longevity [54,55].

Numerous studies have demonstrated that voice prostheses significantly improve quality of life and reduce the degree of voice-related disability compared with other methods of voice restoration [2,33,56-59]. Moreover, they more effectively alleviate social difficulties and psychological, emotional, and sexual disturbances, while enhancing self-image reconstruction and self-confidence [6,60,61]. Since the loss of speech is the main factor lowering post-laryngectomy patients' quality of life and the most common cause of psychological distress, early initiation of voice rehabilitation is strongly emphasized [4]. In this respect as well, voice prostheses have a distinct advantage, as they allow patients to regain the ability to speak within a few days after fitting [25].

Although most studies confirm the superiority of prostheses in improving quality of life, some research suggests a potential advantage of esophageal speech in certain aspects. In a study conducted by Cristina Tiple et al., patients using esophageal speech achieved better Voice Handicap Index (VHI) scores than those using voice prostheses [7]. However, the authors noted that this difference may have been influenced by the longer postoperative period among the esophageal speech group, allowing more time for rehabilitation and adaptation [7]. Another possible explanation is that patients using esophageal speech do not require additional surgical intervention (tracheoesophageal puncture) or periodic specialist consultations, which are often necessary for prosthesis users in case of device-related complications [7]. Similar findings were reported by Z. Saltürk et al., who observed that participants using esophageal speech demonstrated higher quality of life and lower stress levels than those using prostheses or electrolarynx devices, possibly due to the absence of external devices and the ability to produce hands-free speech [62].

Despite the fact that voice prostheses are considered the most effective method of speech restoration and provide the best voice quality, users often face various complications, such as periprosthetic leakage or recurrent granuloma formation, which reduce device lifespan and require frequent medical or surgical interventions. These procedures can cause physical discomfort and psychological distress, negatively affecting quality of life [61,63]. Another

major concern, especially among patients living far from specialist centers, is the need for frequent travel to receive prosthesis maintenance or replacement [6].

Summary

Voice rehabilitation after total laryngectomy is the most important element in the process of patient adaptation and reintegration into social life. Although various methods are available, voice prostheses are currently regarded as the most effective means of restoring verbal communication. They are distinguished by their rapid speech restoration, relatively simple learning process, and superior voice quality compared with alternative methods. Furthermore, the use of voice prostheses significantly enhances patients' quality of life and has the most positive psychological impact. Nevertheless, prosthesis use may lead to medical and technical complications requiring repeated interventions. Thus, comprehensive postoperative management including patient education, timely follow-up and psychosocial support, is essential. In addition to physical discomfort, post-laryngectomy patients face numerous psychosocial challenges. The complexity of these issues highlights the need for comprehensive medical care combined with psychological and social support, enabling patients to successfully adapt to their new reality.

Disclosure

Author's Contribution

Conceptualization: Natalia Staszko, Kamila Bała
Formal analysis: Natalia Staszko, Kamila Bała
Investigation: Kamila Bała, Natalia Staszko
Writing rough preparation: Natalia Staszko, Kamila Bała
Writing review and editing: Natalia Staszko, Kamila Bała
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