

## Tracheoesophageal prostheses in voice rehabilitation after total laryngectomy

DOMINIK PAWLICKI<sup>1</sup>, MARTA GAMROT-WRZOŁ<sup>1</sup>, JAKUB SOJAT<sup>2</sup>,  
OLGA KARŁOWSKA-BIJAK<sup>1</sup>, ALICJA PAWLICKA<sup>3</sup>, PAWEŁ SOWA<sup>1</sup>

<sup>1</sup> Clinical Department of Otorhinolaryngology and Oncological Laryngology, Faculty of Medical Sciences in Zabrze, Medical University of Silesia in Katowice, Zabrze, Poland

<sup>2</sup> Department of Anatomy, Faculty of Health Sciences in Katowice, Medical University of Silesia in Katowice, Poland

<sup>3</sup> Adult Ophthalmology Department, Prof. K. Gibiński University Clinical Center, Medical University of Silesia in Katowice, Poland

**Corresponding author:** Dominik Pawlicki, M.D.

Clinical Department of Otorhinolaryngology and Oncological Laryngology  
Faculty of Medical Sciences in Zabrze, Medical University of Silesia in Katowice  
ul. Marii Curie-Skłodowskiej 10, 41-800 Zabrze, Poland  
Phone: +48 531 160 128; E-mail: pawlicki.d@gmail.com

**Abstract:** Loss of voice in patients after total laryngectomy is a significant issue that medicine has been grappling with since the 19th century. Scientific literature reports unequivocally confirm the substantial impact of total laryngectomy on patients' quality of life, which directly translates into their psychological well-being. The purpose of this study is to compile and organize the latest scientific findings on tracheoesophageal prostheses and subsequently integrate the description of this treatment modality with its rehabilitative aspects. In light of the growing number of patients using TEP, this paper also aims to reintroduce and clarify the topic for a broad range of ENT surgeons and other physicians who are increasingly likely to encounter TEP patients in clinical practice. The tracheoesophageal prosthesis (TEP), first described in 1972 by Professor Erwin Mozolewski and independently introduced into the English-language literature in 1980 by Blom and Singer, has become a key method for voice rehabilitation in patients who have undergone total laryngectomy and currently, used prostheses function based on a one-way air valve implanted in a surgically created tracheoesophageal fistula. This method is considered highly effective, as it is utilized in over 90% of cases. In addition to providing better voice quality compared to other techniques, the TEP prosthesis also positively impacts the overall quality of life of the patients who use it. Scientific studies highlight the analysis of quality of life and the effectiveness of voice rehabilitation as key endpoints in assessing the success of both surgical and rehabilitative treatment in laryngectomized patients. Over the years, various methods of voice rehabilitation have been developed in an effort to find the best approach that meets the needs of patients.

**Keywords:** total laryngectomy, laryngeal cancer, vocal rehabilitation, tracheoesophageal prostheses.

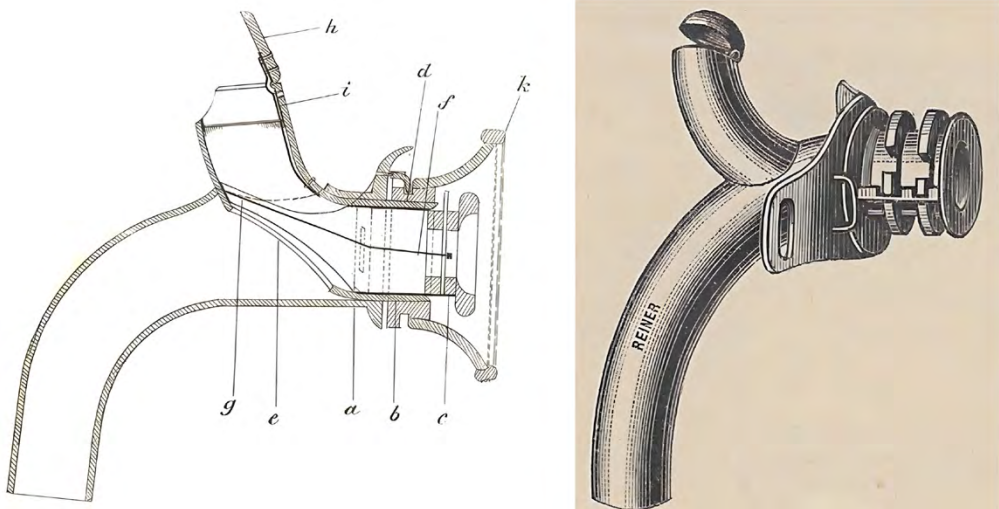
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## Background

The history of voice rehabilitation using prostheses dates back to the early days of performing total laryngectomy procedures. Indications for this procedure include subglottic tumors, tumors occupying more than one region of the larynx, recurrence of disease after radiation therapy or previous treatments, tumors infiltrating adjacent organs, histopathologic subtypes resistant to radiation therapy (e.g. sarcoma, chondrosarcoma, melanoma), severe trauma to the larynx, diseases leading to chronic aspiration of food, recurrent laryngeal papillomatosis with increased risk of tracheal invasion [1]. Contraindications include, but are not limited to, the presence of untreatable distant metastases or other concomitant tumors, severe systemic disease, and tumor infiltration of the deep parts of the tongue, prevertebral fascia, common or internal carotid artery segments [1–5].

The first such operation for laryngeal cancer was performed by Billroth in 1873 and described by Gussenbauer a year later. It was Gussenbauer who introduced the first ‘Artificial Larynx’ (Fig. 1), which was a complex metal device consisting of two tubes and multiple valves [1]. In those years, the throat was not sewn up after laryngectomy surgery, leading to the creation of two stomas for the patient: a pharyngostomy and a tracheostomy. The valves, like those in today’s prostheses, were intended to ensure the flow of air from the trachea into the esophagus, thus preventing aspiration of contents from the digestive tract into the trachea. At the end of the 19th century, Gluck and Sorenson worked intensively to improve the surgical technique. For the first time ever, they succeeded in closing the pharyngeal defect, eliminating the need for a pharyngostomy, making the ‘artificial larynx’ unnecessary and eventually forgotten [6–7].



**Fig. 1.** Original illustration from Gussenbauer’s work showing the first artificial larynx, a mechanical device designed to restore speech after total laryngectomy.

In 1932, Guttman described an unusual case of a patient who, after undergoing laryngectomy surgery, due to frustration over his lack of voice, performed the procedure on himself. Using a heated auger, he created a connection between the trachea and the esophagus. With the fistula created, the patient was able to speak while closing the tracheostomy opening with his finger. To

prevent fluids from entering the airway, he blocked the fistula with a reed pen while drinking [8]. This situation proves that as early as 1932, the effectiveness of tracheoesophageal fistula in obtaining voice was recognized. Since then, it took almost 50 years before an effective one-way mechanism was developed to prevent aspiration. Over the ensuing years, the technique has undergone various stages of evolution and refinement [7].

Over the years, numerous surgeons have developed complex surgical techniques to create a valve mechanism. Among them were Conlay (1958), Calcaterra (1971), Arslan (1972), Asai (1972), Amatsu (1980), Griffith (1980) and Staffieri (1981) [9]. These methods, while effective, were characterized by difficulty in execution and thus low reproducibility. The first to describe the use of a valve prosthesis were Blom and Singer in 1980 [9], although the pioneering work is often attributed to Professor Erwin Mozolewski of the Department of Laryngology in Szczecin [10]. The prosthesis developed by Professor Mozolewski and his team was made of silicone and adapted to the anatomy. The inner diameter of the shaft ranged from 3 mm to 6 mm, and the wall thickness was 0.6 mm. The prosthesis, like the models used today, consists of two flanges: esophageal and tracheal. On the esophageal side there was a valve, made of two or three layers of 0.007 mm thick polyethylene film, the walls of which collapsed during swallowing, thus preventing aspiration of food content. The function of the tracheal collar, on the other hand, was to fix the prosthesis in the tracheoesophageal fistula. Despite Professor Mozolewski's groundbreaking innovations, his work went unnoticed for a long time. He was the first to describe this type of prosthesis, but the original publication was written in Polish, which significantly limited its dissemination worldwide [11]. A prosthesis of his authorship is shown in Fig. 2 [4]. This prosthesis, unlike current voice prostheses, was placed using the retrograde method, that is, the prosthesis was inserted from the side of the cutaneous fistula toward the throat (i.e. 'from the outside in') [11].



**Fig. 2.** Illustration of Professor Mozolewski's voice prosthesis, developed to restore phonation after total laryngectomy.

The use of tracheoesophageal prostheses as we use them today has become routine since 1988. Today, the use of these prostheses in surgical voice rehabilitation in patients after total laryngectomy is considered highly effective. Although their use is sometimes associated with complications, patients using these prostheses generally present better speech intelligibility and loudness, as well

as longer phonation times compared to those using other rehabilitation methods, which will be described later [12].

## Aim

The purpose of this review is to compile and organize the latest scientific findings on tracheoesophageal prostheses (TEPs) and integrate their description with their rehabilitative aspects. Additionally, this paper aims to reintroduce and clarify the topic for ENT surgeons and other physicians increasingly encountering TEP patients in clinical practice, providing a comprehensive overview of TEP history, techniques, complications, and rehabilitation strategies.

## Material and Methods

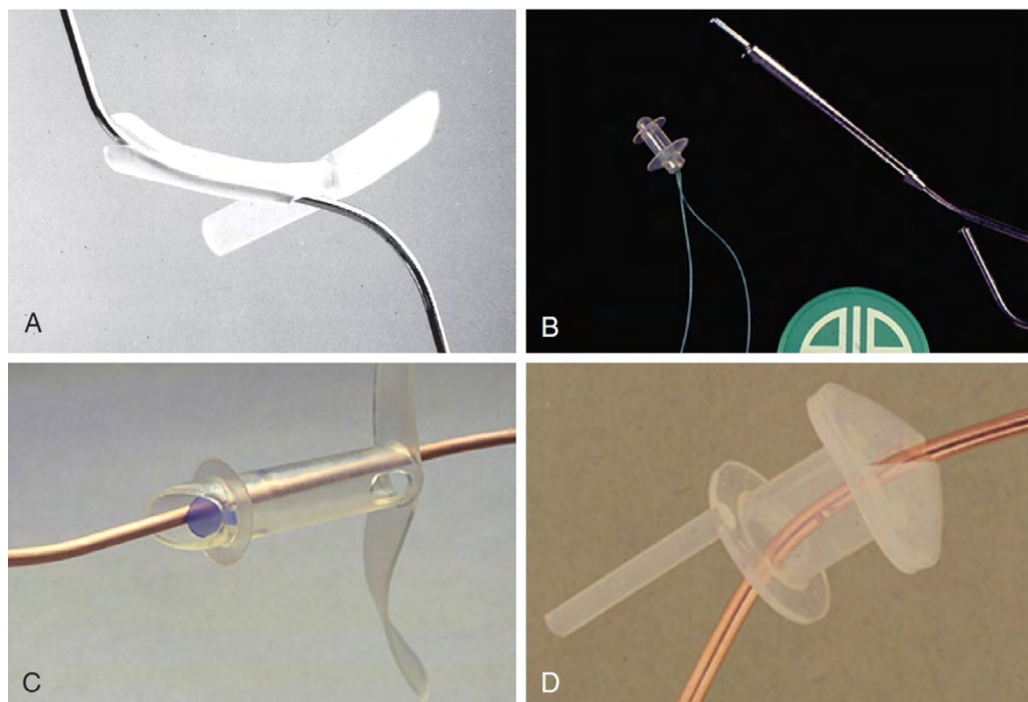
This article is a narrative review based on a comprehensive analysis of scientific literature available in PubMed, Embase and ScienceDirect. Key search terms included ‘total laryngectomy’, ‘tracheoesophageal prosthesis’, ‘voice rehabilitation’, and ‘laryngeal cancer’. Studies published between 1972 and 2024 were prioritized, focusing on historical developments, surgical techniques, TEP designs, complications, and rehabilitation outcomes. Only peer-reviewed articles, clinical guidelines, and book chapters from reputable sources were included. Data were synthesized to address the history, mechanisms, clinical applications, and multidisciplinary rehabilitation strategies associated with TEPs. References cited in the text are listed at the end of the article.

## Review and Discussion

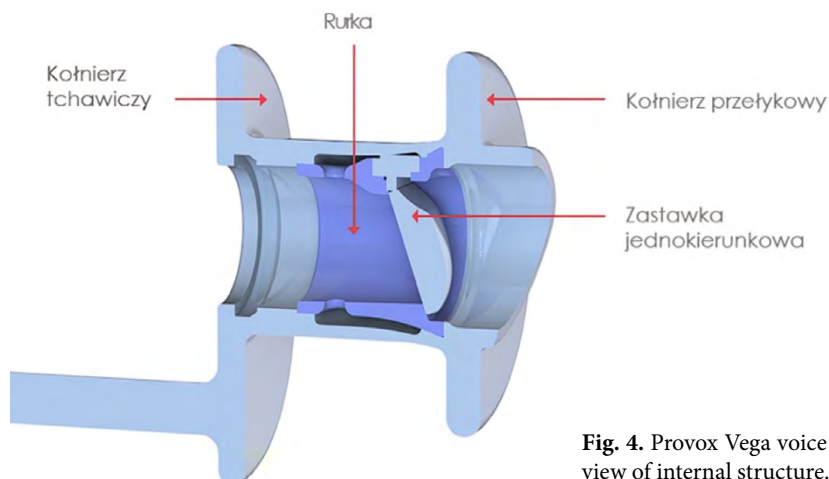
### *Tracheoesophageal Prostheses*

Tracheoesophageal prostheses (TEPs) are categorized into two main types: non-stationary and stationary. Non-stationary prostheses are regularly removed, cleaned, and reinserted by the patient after receiving proper training in this area. There are different types of TEP prostheses, models of which are shown in Fig. 3, including “duck-billed” or low-pressure valves, available in different sizes, diameters and levels of valve resistance. Stationary TEP prostheses, on the other hand, require fitting and replacement to be performed by a qualified speech therapist or otorhinolaryngologist. They also come in a variety of sizes, diameters, and with valves of increased resistance, made from fungus-resistant materials, and with enlarged tracheoesophageal collars. Among the stationary prostheses are Atos (Provox 2, Provox Vega, ActiValve) and Blom-Singer (Classic, Advantage, Large Flange, Dual Valve) products. The choice of prosthesis depends on the patient’s needs and abilities, voice quality, the durability of the valve, and the required effort for phonation. Once the prosthesis is in place, a voice evaluation and leak check are performed. Patients are taught daily cleaning and regular evaluation of the prosthesis function [13–15].

For example, the Provox Vega prosthesis (Fig. 4), which we use most often with our patients in the Clinical Department of Otorhinolaryngology and Laryngological Oncology in Zabrze, can be placed initially, that is, during the laryngectomy surgery itself, or secondarily, that is, some time after the surgery. The prosthesis is made of biocompatible medical silicone and is equipped with cuffs at both ends: a tracheal cuff, 1.3 mm thick and 12 mm in diameter, and an esophageal cuff, 1.5 mm thick and 14.5 mm in diameter. Provox Vega is available in six length sizes, ranging



**Fig. 3.** Illustration of various tracheoesophageal prostheses, including stationary and non-stationary types, used for post-laryngectomy voice rehabilitation.



**Fig. 4.** Provox Vega voice prosthesis — detailed view of internal structure.

from 4 to 15 mm, which corresponds to the distance between the tracheal and esophageal cuffs. The procedure for replacing this vocal prosthesis is done under local anesthesia. In Poland, the National Health Fund provides reimbursement for the replacement of vocal prostheses. In case

of complications in the earlier period, the replacement of this prosthesis in a hospital setting is available.

A Provox Vega XtraSeal prosthesis has also been developed with an additional flange on the esophageal side to prevent leakage around the prosthesis in patients with enlarged fistulas. A special Provox ActiValve voice prosthesis is also available on the market for patients who experience premature leakage through the prosthesis or unintentional opening of the valve during swallowing or inspiration due to negative pressure generated in the trachea or esophagus. The prosthesis valve is held in a closed position by magnets that prevent it from accidentally opening during breathing or swallowing.

In addition, there are numerous accessories to assist with breathing, speaking, and care for TEP patients (the description provided is based on publicly available products offered and developed by Atos) [15] (Fig. 5).

### *Vocal Prosthesis Insertion Technique Using the Provox Prosthesis as an Example*

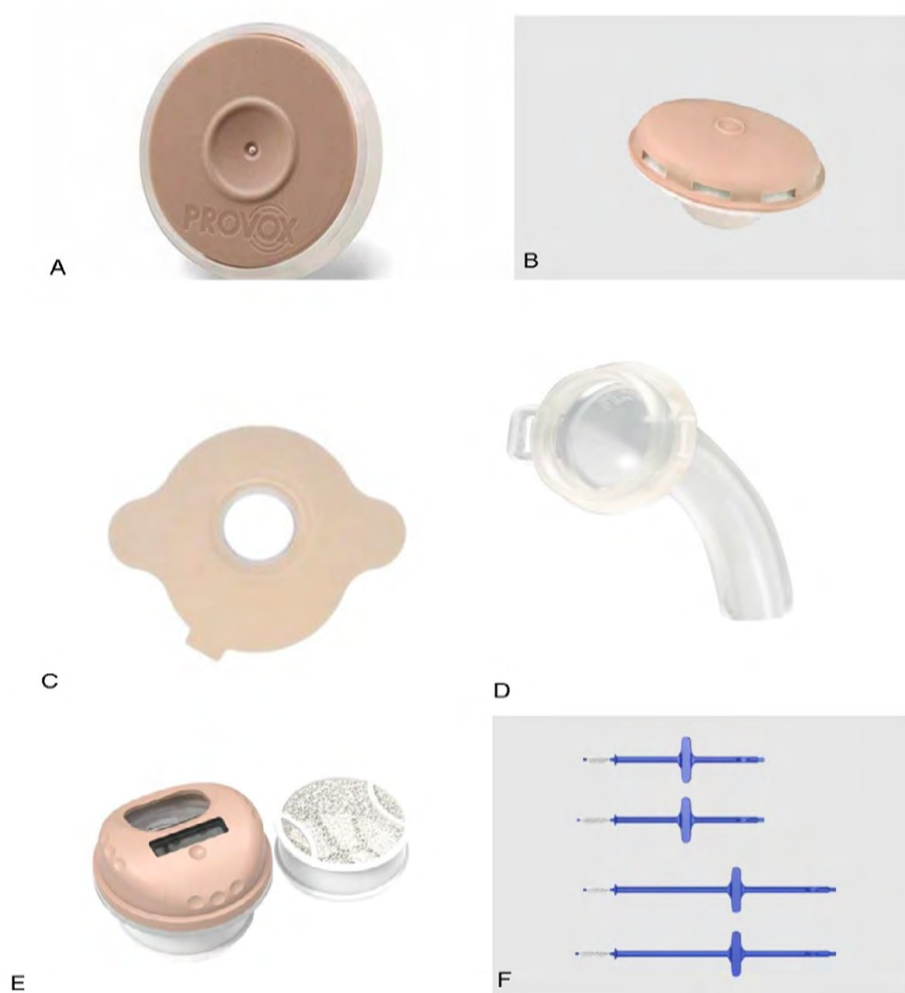
#### **Primary Puncture Using the Provox Vega Puncture Set**

A single-use surgical kit for primary and secondary prosthesis implantation (PVPS, or Provox Vega Puncture Set), based on the Seldinger technique, allows immediate insertion of a vocal prosthesis. The set consists of a curved puncture needle, a guidewire and a dilator with a pre-installed Provox Vega prosthesis, used to dilate the tracheoesophageal (TE) fistula and insert the prosthesis. Additionally, the kit includes a plastic pharyngeal protector, which is used solely for the primary implantation of the prosthesis during a total laryngectomy procedure. The guidewire is inserted into the TE fistula through the puncture needle, while the plastic protector is placed in the esophagus. After the puncture needle and esophageal protector are removed, the guidewire is attached to the dilator, using a simple locking system. The dilator is conical in shape, with increasing diameter, which allows for gradual expansion of the TE fistula (Seldinger's principle). Insertion of the prosthesis into the fistula is accomplished through a silicone loop at the end of the dilator, which folds the elastic tracheal collar of the vocal prosthesis [15].

#### **Secondary Puncture Using the Provox Vega Puncture Set**

In the Clinical Department of Otorhinolaryngology and Laryngologic Oncology in Zabrze, we use a rigid esophagoscope for secondary puncture, which has the following functions: it protects the esophageal walls when the needle passes through the tissues, serves as a guidewire for performing TE puncture in the correct location, and allows the Guidewire to be safely guided through the pharynx and inserted by mouth. After inserting the esophagoscope into the esophagus, the puncture site on the trachea should be checked by palpation. If in doubt, additional orientation can be obtained with a flexible endoscope. The puncture needle is then inserted about 8–10 mm from the edge of the tracheostomy until it reaches the inner wall of the esophagoscope. The next step is to insert the Guidewire through the needle and esophagoscope, ensuring it extends approximately 20 cm beyond the esophagoscope. The puncture needle should be removed before removing the esophagoscope to prevent damage to the esophagus. After removing the protective tool, only the guidewire remains at the fistula site.

The Guidewire should then be connected to the dilator and locked. When pulling the dilator through the fistula, hold the edges of the fistula with two fingers to reduce the force on the tissues. We pull the dilator along with the loop, place the prosthesis in the newly created fistula, and then rotate the prosthesis to the correct position. Finally, we cut off the securing strap [15].



**Fig. 5.** Accessories for the Provox Vega voice prosthesis supporting improved quality of life and health: A — Heat and moisture exchangers are designed to heat and humidify the inhaled air, thereby reducing respiratory resistance. By pressing the lid of the exchanger with a finger, the patient can speak. B — Anti-bacterial, antiviral and anti-dust filter version of Heat and moisture exchangers. C — Patches that seal the tracheostomy opening and allow the installation of a heat exchanger. D — Tracheostomy tube — this is a silicone tube that allows the attachment of an HME exchanger or phoniatic valve. E — The phoniatic valve is a device that allows hands-free speaking. This accessory has two modes. The automatic speaking mode ensures that exhaled air is diverted through the voice prosthesis by closing the diaphragm, which automatically reopens during inhalation. The blocked mode prevents the diaphragm from closing during heavy breathing; it is recommended during physical activity. F — Tools for cleaning the prosthesis and removing debris from it.

To gain a comprehensive understanding of the techniques discussed, the following text will outline both the benefits of their use and the primary limitations [16].

### *Primary TEP Placement*

Advantages:

1. There is no need for multiple surgical procedures.
2. Faster vocal rehabilitation after total laryngectomy.
3. Easier creation of a fistula in the correct location.

Disadvantages:

1. Increased risk of developing pharyngocutaneous fistula.
2. Limited effectiveness of the prosthesis during acute complications of adjuvant radiation therapy.
3. Possible displacement of the prosthesis as a result of postoperative healing.
4. Difficult maintenance of the fistula during chemotherapy or chemoradiotherapy postoperatively.

### *Secondary TEP Placement*

Advantages:

1. Reduced risk of pharyngocutaneous fistula formation.
2. Longer time for the patient to decide on the choice of voice rehabilitation after laryngectomy, taking into account the higher costs associated with the use of the TEP, among other things, the need for regular medical check-ups to replace the prosthesis and the possible purchase of accessories that significantly improve quality of life.
3. Optimal placement of the prosthesis after the healing process is complete.
4. The possibility of performing the procedure on an outpatient basis under local anesthesia.

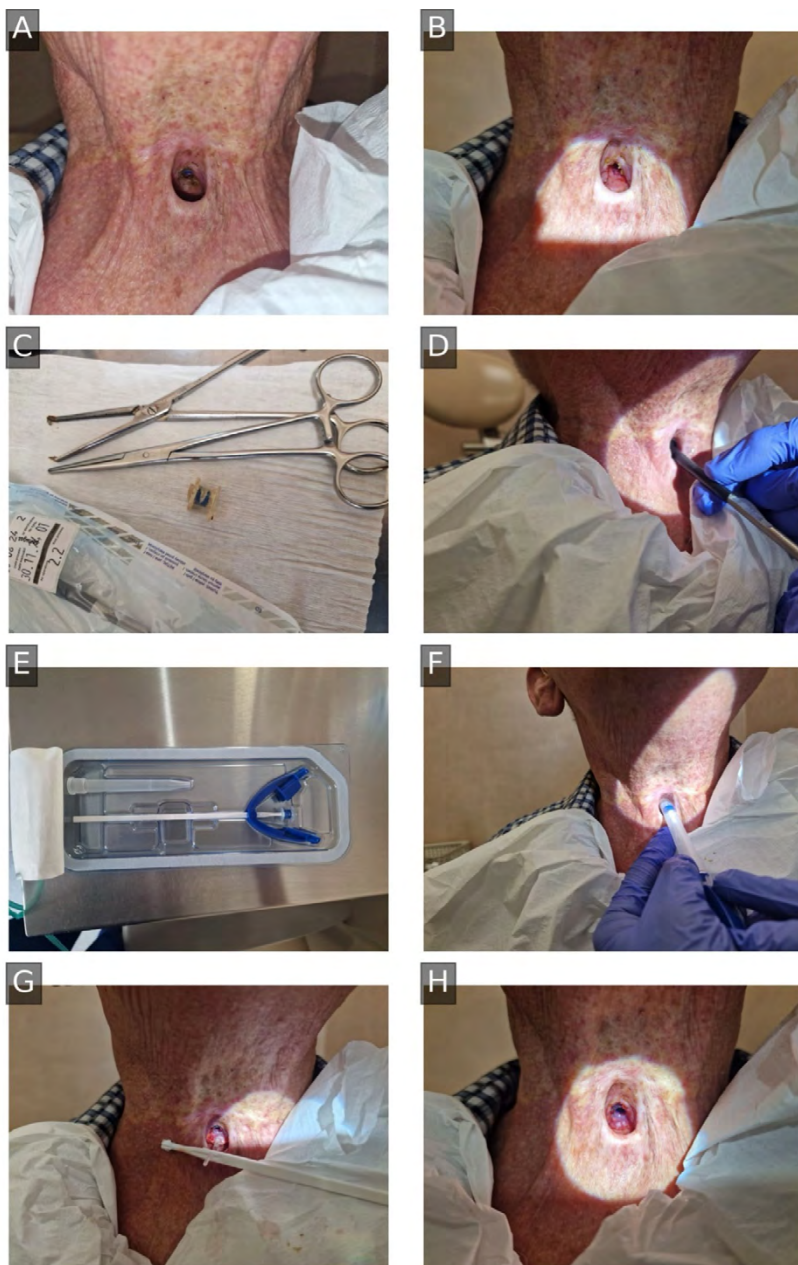
Disadvantages:

1. Delayed start time for voice rehabilitation.
2. Reduced patient motivation to undertake voice rehabilitation when initially postponed.
3. The complex procedure of prosthesis insertion in case of structural changes due to complementary treatment and individual healing process after surgery.

Both primary and secondary TEP placement is usually safe, including in cases requiring postoperative radiation therapy. The decision on the timing of implantation should be individual and based on the benefits of primary placement, the potential risks, the team's experience, and the patient's needs and cooperation. Although adjuvant radiotherapy rarely increases complications or affects long-term outcomes, it can hinder TEP use and communication during treatment. For this reason, secondary TEP placement is often preferred in patients who are scheduled for postoperative radiation therapy [16].

### **Outpatient Voice Prosthesis Replacement Technique**

The following is a step-by-step description of vocal prosthesis replacement based on the experience of the Clinical Department of Otorhinolaryngology and Laryngological Oncology in Zabrze (Fig. 6).



**Fig. 6.** Replacement of a voice prosthesis in a patient from the Clinical Department of Otorhinolaryngology and Oncological Laryngology in Zabrze, Medical University of Silesia in Katowice: A — Condition before replacement of the prosthesis. B — Condition after removal of the prosthesis. C — Prosthesis removed. D — Measurement of fistula length performed with Atos Meter. E — Atos prosthesis replacement kit with Provox Vega 8mm prosthesis. F — Implantation of the prosthesis. G — Positioning the prosthesis in the correct position and cutting off the securing strap. H — Condition after prosthesis replacement with no apparent leakage.

1. Anesthesia of the prosthesis area with Lignocainum hydrochloricum solution in spray.
2. Removal of the prosthesis with an instrument such as Pean or Kocher.
3. Suctioning mucus and lingering contents from the fistula area.
4. Measuring the length of the tracheoesophageal fistula.
5. Inserting the prosthesis into the fistula using the prepared kit.
6. Assessing the tightness of the fistula and the function of normal phonation.

### *Complications*

Attention is drawn not only to the advantages of using TE prostheses, but also to the complications associated with them. Early complications include impaired wound healing after laryngectomy (in the case of primary LP), infections occurring after secondary LP, and inflammatory reactions in the fistula region in patients undergoing radiation therapy after primary implantation [8, 17]. Late complications include: enlargement of the fistula channel leading to leakage past the prosthesis, leakage of saliva and digestive contents through the lumen of the prosthesis, infections in the fistula area, mainly caused by *Candida albicans* [18, 19], formation of granulation tissue around the prosthesis, and arbitrary protrusion or prolapse of the prosthesis [8]. Prolapse of the prosthesis into the airway can be considered a serious complication requiring urgent bronchoscopy [20].

### *Mechanism of Voice Production under Physiological Conditions and in Patients after Laryngectomy*

Under physiological conditions, the mechanism of voice production can be described as follows:

1. Air generator: the lungs generate a stream of air that flows through the larynx.
2. Vibratory apparatus: the approximation of the vocal folds under the influence of the air stream generates undulating vibrations, creating the speech sound.
3. Articulatory track: sound is modulated through the pharynx, oral cavity and nasal cavities to produce a phonetic voice [20].

Patients who have undergone a total laryngectomy (TL) have lost their vibratory apparatus. Although the air generator and articulatory track remain, the airflow is redirected and does not pass through the articulatory track, resulting in a loss of the ability to produce voice. Depending on the severity of involvement in the throat or tongue base, the articulatory track may be subject to modification during surgery. The goal of voice restoration is to artificially create a sound source by reintroducing a vibrating column of air, which is then modified by the articulatory apparatus.

The mechanism of voice production in patients who have had their larynx removed and a TE voice prosthesis inserted is different than one might think — for the voice is not produced by the prosthesis. Air from the lungs passes through the prosthesis and vibrates the pharyngoesophageal (PE) mucosa, which allows sonorous speech to be produced. The TE prosthesis is a one-way valve that is placed in an artificially created fistula between the trachea and esophagus. When the patient exhales and closes his tracheostomy, air passes from the trachea through the prosthesis into the esophagus and then into the pharynx, where it causes the pharyngoesophageal (PE) mucosa to vibrate, resulting in the production of voice. Optimal muscle tension, i.e. a normotonic or slightly

hypertonic PE section, is essential for the prosthesis to function properly. Both excessive hypertonia and hypotonia are among the main causes of failure to produce good-quality voice with TE prostheses [9, 21].

### *Comparison of Different Methods of Voice Rehabilitation*

The term “voice rehabilitation after total laryngectomy” encompasses a variety of treatment and rehabilitation methods aimed at restoring the ability to speak to patients after laryngectomy [22]. A holistic approach to voice rehabilitation in these patients is key to achieving the best possible results. It is important to keep in mind the multidisciplinary effects of laryngectomy, which include not only the loss of the voice, but also the loss of the protective barrier that the larynx serves as for the respiratory system and a significant reduction in the sense of smell [22, 23].

#### *The Most Important Methods of Voice Rehabilitation in Patients after Total Laryngectomy*

- **Esophageal Speech (ES):** Esophageal speech after a total laryngectomy mainly involves using the esophagus to generate voice. The principle is based on the fact that the patient learns to swallow air into the esophagus and then let it out with a so-called “burp” (burping) sound, causing the pharyngoesophageal segment to vibrate and thus produce sound. This method requires prolonged training and can be unpleasantly perceived by those around you, but it remains fairly well understood and requires no additional procedures or equipment [4, 24, 25].
- **Speech Using an Electrolaryngophon:** An electrolaryngophon is a small, portable device designed to generate vibrations. These vibrations are transmitted to the throat area, where they are modulated by the articulatory movements of the mouth and tongue to produce speech. Unlike the natural vibrations of the vocal cords, the electrolarynx phon produces a mechanical sound that not every patient finds satisfactory [24]. Training and practice are also necessary to achieve intelligible speech, but compared to esophageal speech, the training is easier and the effectiveness of rehabilitation is higher. There is no airflow through the phonatory apparatus of the upper airway. A negative aspect of this rehabilitation method is the need to purchase and potentially service the device [4, 25].
- **Tracheoesophageal Speech (TES):** TES speech is based on the use of a tracheoesophageal fistula, into which a TE prosthesis is surgically inserted (the methods of surgical insertion of the prosthesis are described above). Its main advantages, compared to other methods of rehabilitation, are the longer phonation time, the naturalness of the achieved voice and well-understood speech. Currently, it is the “gold standard” for voice rehabilitation in laryngectomized patients. Patients using this type of speech present the highest quality of life index. However, this method is not ideal, as it is associated with possible complications and requires daily hygiene of the voice prosthesis and periodic ENT checks for its replacement [4, 24, 25].
- **The Bionic Voice Pneumatic Prosthesis (PAL):** A hybrid device consisting of an electronic sound source, pressure sensors and a control unit that delivers artificially generated sound and airflow, providing speech quality comparable to TE prostheses while remaining non-invasive. Its main disadvantages are the bulky and unhygienic nature of having to connect the stoma to the mouth with a tube, and the lack of sufficient comparative studies with other rehabilitation methods [26].

### *Success Rates and Rehabilitation Techniques*

There are various studies reporting success rates and satisfaction levels related to the patient's overall psychophysical condition, the voice prosthesis method and rehabilitation techniques focusing on more than just phonation [27]. Factors influencing rehabilitation success include:

- **Voice Prosthesis Method:** Different methods of voice rehabilitation after total laryngectomy have varying effects on therapy success, quality of life and patient satisfaction. Each method, such as ES speech, electrolaryngophon, TES speech or PAL prosthesis, has its own unique advantages and limitations that can affect the effectiveness of rehabilitation.
- **Psychosocial Factors and Patient Motivation:** Active social functioning and the patient's intrinsic motivation play a key role in successful rehabilitation. Family support, the ability to work, and overall physical health also have a positive impact on the overall rehabilitation process [28].
- **Access to Care:** Proximity to highly specialized centers and the quality of speech therapy significantly affect outcomes. Patients living closer to therapy centers show better satisfaction with treatment long-term [17].

These findings underscore the importance of a multidisciplinary approach to voice rehabilitation, tailored to individual patients' needs and conditions, to achieve the best possible quality of life after laryngectomy. People who have undergone total laryngectomy can count on the support of laryngectomy clubs and associations, which operate at major cancer centers (including those in Kielce, Warsaw, Krakow, Poznan, Gdansk, Katowice, Wroclaw). They organize support groups and educational meetings, facilitating speech rehabilitation and exchange of experiences. Also important is the Polish Coalition of Oncology Patients (PKPO), which assists in medical, legal and financial matters. On the other hand, clinics and speech rehabilitation centers at cancer hospitals offer specialized speech therapy (such as learning esophageal speech or using voice prostheses) and psychological support. In addition, assistance is provided by cancer foundations, which advise on funding and integrate the patient community.

### *Multidisciplinary Voice Rehabilitation and Improving Quality of Life*

Physiotherapy in ENT, and particularly in laryngectomized patients, is rarely described in the literature. However, among the available materials, one can find publications on various forms of physiotherapy aimed at: reducing esophageal pressure [29], improving shoulder joint function [30], improving expectoration function [31], increasing general fitness [31], or returning to all forms of physical activity [32]. The use of a vocal prosthesis alone is already an important factor in raising quality-of-life standards after laryngectomy [33], but without individually tailored and targeted physiotherapy, it may not be effective. The implantation of a voice prosthesis requires regular follow-up and the use of various forms of physiotherapy in order to communicate more effectively. It is important to remember that only in a highly specialized therapeutic team including: an otorhinolaryngologist specialist, physiotherapist, speech therapist and psychologist can sustainable results be achieved and the quality of life of the patients improved [34].

A study by Marszalek *et al.* showed that when manual therapy is used, which includes methods of musculo-fascial relaxation of the muscles of the neck, trunk, upper extremities and back, patients show a lower esophageal pressure value [29]. Reducing this value has a positive effect on the process of voice formation in laryngectomized patients, due to a reduction in the muscular

force that is needed to produce a prosthetic voice as well as esophageal speech. In addition, Crevenna *et al.* already showed at the beginning of the 21st century that the process of physiotherapy for laryngectomized patients should be multidimensional. The authors applied hydrotherapy, or physiotherapy in water, to laryngectomized patients. Using a specialized “Larchel” apparatus, the patients were able to breathe freely while in the water so that it did not enter the tracheostomy opening. They proved that the subjective quality of life improved in the patients studied, and this form of physiotherapy enabled many patients to return to their daily activities, including work. In addition, the subjects reported improved mobility of the shoulder girdle and the cervical spine, and most importantly, they reported improved function in expectoration of excessive secretions [31]. It should be emphasized that this form of therapy plays a significant role in combating the fear or phobia of physical activity in water and will increase the overall fitness of the body [31].

After removal of the larynx, the patient can have a voice prosthesis implanted. However, there are sometimes contraindications. Studies clearly indicate that the quality of life is better in patients with an implanted voice prosthesis compared to a group of patients using esophageal speech [33]. In conclusion, in the absence of contraindications to the implantation of a prosthesis, the decision of medical personnel should lean towards its application.

In the multidirectional process of rehabilitation after implantation of a voice prosthesis, the important role of the speech therapist should be emphasized. Speech therapy activities include a variety of exercises ranging from proper breathing in the rib-trunk pathway to exercises that extend phonation time [35]. It is important to remember that speech therapists, together with the nursing team, teach the principles of hygiene and daily management of the voice prosthesis [35].

According to Prgomet, the creation of multispecialty treatment teams in laryngeal cancer centers will enable patients to benefit from multiple therapeutic and treatment procedures in one place [34]. Comprehensive voice rehabilitation after vocal prosthesis implantation should include specialized physiotherapy for the treated area, speech therapy for voice rehabilitation, and continuous supervision by a laryngologist and phoniatrist. This approach will allow rapid communication between specialists and reduce treatment costs. It should be emphasized that early voice rehabilitation can reduce the likelihood of postoperative complications and create an opportunity to accelerate the treatment process, thereby speeding up recovery [36, 37].

The literature review presented by Maniaci *et al.* emphasizes the importance of an individualized approach to patient rehabilitation, taking into account the unique expectations, limitations, and preferences of each patient. Some of the most important variables to be considered when choosing an appropriate form of voice rehabilitation include access to highly specialized care, the patient's socioeconomic status, the ability to undertake intensive work with a speech therapist, and motivation from personal and professional aspects. The essence of successful rehabilitation is the joint undertaking of the choice of therapeutic method by both the medical team and the patient. Active involvement of the patient in this process ensures better cooperation after treatment [37].

## Conclusions

Tracheoesophageal prostheses (TEPs) represent a cornerstone of voice rehabilitation after total laryngectomy, offering superior voice quality, longer phonation times, and improved quality of life compared to other methods like esophageal speech or electrolarynx. The evolution from early surgical techniques to modern silicone valves, pioneered by Mozolewski and popularized by Blom and Singer, has made TEPs the gold standard, used in over 90% of cases. However, complications

such as fistula enlargement, infections, and prosthesis leakage necessitate careful patient selection and management. A multidisciplinary approach, integrating otorhinolaryngology, speech therapy, physiotherapy, and psychological support, is essential for optimizing outcomes. Support from organizations like the Polish Coalition of Oncology Patients and specialized cancer centers further enhances rehabilitation success. Future research should focus on minimizing complications, improving prosthesis durability, and increasing access to specialized care to ensure tailored rehabilitation for all laryngectomized patients.

### Ethics approval and consent

This is a narrative review of existing literature and does not involve original human or animal research. Therefore, no ethical approval or informed consent was required.

### Authors contribution

Study Design: D.P., M.G.W., A.P., P.S.; Data Collection: D.P., M.G.W., J.S., O.K.B., A.P.; Data Interpretation: D.P., M.G.W., J.S., O.K.B., P.S.; Manuscript Preparation: D.P., M.G.W., J.S., O.K.B., A.P., P.S.; Literature Search: D.P., M.G.W., J.S., O.K.B., A.P.; Funds Collection: A.P.

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### Conflict of interest

None declared.

### Abbreviations

ES	— esophageal speech
HME	— heat and moisture exchanger
PAL	— pneumatic artificial larynx Bionic Voice
PE	— pharyngoesophageal segment
PKPO	— Polish Coalition of Oncology Patients
PVPS	— Provox Vega Puncture Set (primary and secondary prosthesis implantation set)
TE	— tracheoesophageal (e.g., “tracheoesophageal fistula”)
TEP	— tracheoesophageal prosthesis
TES	— tracheoesophageal speech
TL	— total laryngectomy

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