



## Voice Rehabilitations in Laryngectomy: History, Present and Future

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### Keywords

Rehabilitation; Voice Prosthesis; Laryngectomy

### Short Communication

Loss of voice is one of the serious consequences of laryngectomy patients. Inability to speak is an important factor for a laryngeal cancer patient, as some of the patients get reluctant to get operated. It plays an important role in identity of the person. As a result, patient may consider loss of voice as a loss of part of identity. Malignancy of larynx accounts for 2% all malignant cancers. It has been estimated that more than 1 lakh new cases occur annually. In India, it is the tenth leading cause of cancer in Indian men. It accounts of 3% to 6% of all cancers in Indian men [1]. The possible voice rehabilitation techniques following laryngectomy have to be educated to patients prior to the procedure. It plays an important role as the patient can prepare for the voice rehabilitation technique and moreover, it will give a positive impact on patients to consider themselves for procedure [2].

### History

When we dig into the history of laryngectomy, the work done by Vincenz von Czerny, in 1870, on dogs is one of the earliest records available. He assessed its feasibility and opined its feasibility in humans too. He also understood that the voice produced in the larynx is articulated into speech in oropharynx [3]. Theodore Billroth is credited with first successful laryngectomy in humans in 1873. The patient underwent multiple procedures before ending up in total laryngectomy. Colleague of Theodore Billroth, Carl Gussenbauer is credited with restoration of patient voice [4]. The idea of voice prosthesis also ages from mid nineteenth centuries. In 1859, Johan Nepomuk Czermak described a 15-year-old girl with complete laryngeal stenosis. The girl was able to produce husky voice. For increasing the loudness, he routed flow of air from lungs to upper esophagus [5].

Later on, people started studying and developing devices which helped in phonation. The initial devices made were based of devices with multiple cannulas. The device designed by Carl Gussenbauer had three cannulas, tracheal cannula, pharyngeal cannula and phonation cannula. The idea of multiple cannulas was further modified by many surgeons and is been explored. David Foulis modified the Gussenbauer prosthesis by using only pharyngeal and tracheal cannula. He introduced an alloy of silver and copper to produce a metallic voice. Foulis modified his surgical technique and preserved epiglottis to ensure closure of cranial opening of pharyngeal mucosa [6].

In 1881, Gluck, Sorenson and Zeller modified the surgical technique of total laryngectomy. They succeeded in completely separating the airway from the digestive tract and closing pharyngeal defect. But they had to modify the devices accordingly for rehabilitating voice. Over the years many devices have been designed. Understanding the role of pharyngoesophageal segment as the key in voice production in laryngectomy patient over the years have led to eminence of voice prosthesis or electrolarynx. Changing the surgical technique in closure and innovation with help of pedicled flaps have also been tried in voice rehabilitation. Laryngo-tracheal transplants have also been tried in a couple of patients for voice rehabilitation.

### Present techniques in voice rehabilitation

Different methods of voice rehabilitation till date can be classified as:

- A. Pseudo whispering and alaryngeal speech
- B. Esophageal Speech
- C. External Devices

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Received Date: 02 May 2019

Accepted Date: 14 Jun 2019

Published Date: 17 Jun 2019

#### Citation:

Prakasan Nair N, Sharma V, Goyal A, Kaushal D, Soni K, Choudhury B, et al. Voice Rehabilitations in Laryngectomy: History, Present and Future. Clin Surg. 2019; 4: 2478.

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- a. Mechanical
- b. Electromechanical
- D. Tracheoesophageal Fistula
- E. Laryngeal Transplant

**A. Pseudo whispering:** It mainly works on the principle of using the air present in the oral and pharyngeal spaces, with appropriate articulation. Patient will be able to communicate with a weak aphonic voice. They can use it to communicate in quiet places. The basic idea was laid down by John Nepmucz Czermak [8].

**B. Esophageal speech:** In this modality of voice rehabilitation, the air released in a controlled manner esophagus causes vibration of pharyngo-esophageal segment, which can be articulated into speech. The utility of esophageal speech was initially described by Strubbing and Landois [9]. In 1896, considering the voice quality in esophageal speech, Stork reported in his serious of patients who used esophageal speech that voice prosthesis is not required for speech rehabilitation [10]. A maximum volume of 70 mL to 100 mL air in upper esophageal reservoir can be used to produce a few words with esophageal speech. Hence this rehabilitation modality tends to have more frequent interruptions in speech. The quality of voice is found to be superior. It requires vigorous effort and constant practice from patients. All patients cannot master it too. Only 1/3<sup>rd</sup> of laryngectomised patients are able to learn esophageal speech and is been to communicate with satisfaction.

#### C. External devices:

a). **Mechanical devices:** Different external devices have been designed over the years. These devices consisted of multiple cannulas which directed air into the pharynx. Some modified the surgical technique and created a pharyngostoma along with tracheostoma and with help of multiple cannulas directed the air to pharynx. Most of the devices were modification of device made by Carl Gausenbauer. Due to advent of tracheoesophageal prosthesis, these external voice prostheses are obsolete now.

b). **Electromechanical Devices:** T Gluck found an electrically operated vibrating device which can make the pharyngeal or oropharyngeal muscles to vibrate to produce sound. It is otherwise known as electrolarynx. Electrolarynx are of three types, External transoral, External transcervical and Intraoral.

In 1957, Cooper Rand developed transoral electrolarynx, which produces a medium frequency sound. The vibrations were routed into the oropharyngeal space via a plastic tube inserted through mouth. Hence it was affected by saliva. Later an external transcervical electrolarynx was discovered which can be held against the neck and vibrate the muscles and mucosa of oropharynx. Many scientists have modified the device later based on same principle. R V Tait developed a device that was attached to the teeth of a patient in 1959 [11]. IN 1961, H J Pitcher developed a device which was based on electromagnetic induction with helps of coil. He fixed one coil around the teeth and other one around the neck [12]. In 1975, R L Goode developed a device which was based on radiofrequency [13]. A completely intra oral device was discovered by Dowry L in 1981. The kind of voice quality obtained with electrolarynx was a monotonous sound which articulated to produce a robot-like speech. Hence the acceptance and satisfaction with electrolarynx is low.

**D. Tracheo-esophageal Fistula:** In 1930s, M R Guttman created

fistula by puncture technique with a needle and help of diathermy to create a fistula between trachea and hypopharynx. This helped patient to phonate by occluding the tracheostoma. For preventing aspiration patient had to occlude the fistula with a goose quilt. It was associated with high rates of aspiration, related complications and high rates of spontaneous closure of fistula [14]. Different techniques were prescribed later for more compatible technique of voice prosthesis. Conley proposed a technique in which he shunted the esophageal mucosa towards the trachea. But obliteration of fistula tract was a problem in this case [15]. In 1970s, Staffieri, created a neoglottis. After making tracheostoma and tracheal chimney, pharyngeal mucosa was draped with a slit and sutured of the cut end of trachea. For a successful neoglottis he had to fashion it in a way with opening of appropriate size to allow air into pharynx and small enough to prevent aspiration, which was challenging task [16]. Partial laryngectomy techniques were also utilized in which a permanent end tracheostoma could be prevented. But these procedures were limited to early stage malignancies.

In 1975, E Mozolewski described first silicone made semipermeable voice prosthesis which is considered as the first modern voice prosthesis. A tracheal flange held prosthesis was places in tracheoesophageal fistula via oropharynx [17]. As the paper was written in Polish his work remained unrecognized. In 1978, using the principle of Mozolewski, Eric D Blom and Mark I singer developed a voice prosthesis. They called this prosthesis as duck bill prosthesis. They described the insertion process by a secondary puncturing on the posterior tracheal wall. Initial prosthesis made was non-indwelling type. Later in 1998, they modified the flanges to convert it into indwelling type which facilitated the anterograde insertion [18].

Provox voice prosthesis came into market in 1988. Hilgers and Schouwenburg developed this indwelling prosthesis. The flap valve within the prosthesis was made out of silicone disk, made it a one-way device and thus reduced the risk of aspiration. It can be inserted at the time of laryngectomy (primary tep) or later stage (secondary tep). Provox 2 was introduced in 1997 [19]. This new prosthesis can be inserted into the fistula tract in a retrograde or anterograde fashion. As per the metanalysis, primary tracheoesophageal puncture is safe and efficient approach for voice rehabilitation. They also concluded that secondary tracheoesophageal puncture should be preferred in cases of pharyngo cutaneous fistula [20].

**E. Laryngeal transplantation:** Laryngeal transplantation can also be considered as a therapeutic option for patients undergoing laryngectomy who desires for speech. But it has got high complication rates. Till date, two human laryngeal transplantation have been reported in medical literature. These patients are in high need for immunosuppression. The Patients whom it was used were post traumatic cases. The utility of laryngeal transplants may also be thought with respect to glottic cancers too. The two patients who have undergone laryngeal transplantation have reported improved quality of life and have been able to achieve near-normal speech.

#### Newer options for voice rehabilitation

In this new era of mobile phone and advances in technology, there are more options for speech rehabilitation for such patients. Certain mobile applications for generation of speech are made for rehabilitating patients with stroke or speech impairments. Such applications can be used in rehabilitating laryngectomy patients, as smart phones use is very common among the current population. There are fabric-based speech rehabilitation devices which are

developed for speech rehabilitation. Such devices have the advantages of tactile differentiability and hence can be used in patients who have vision impairment [20]. Still the various techniques have got their own limitation. Voice prosthesis which is currently mostly accepted method has got risk of stomal infection, peristomal granulation and peri prosthetic leak. A device with universal acceptance and user friendly with no associated complications is yet to be discovered.

### Silent speech Interfaces

It is a new field where extensive research is carrying on at time being. It is a system enabling speech communication when there is no audible communication [21]. It is mainly based on following principles,

1. Surface electromyography of facial articulatory muscles
2. Brain computer interfaces based on Electroencephalography
3. Video camera-based recording of lip movements
4. Permanent magnetic or electromagnetic articulography
5. Ultrasound or optical imaging of lips and tongue
6. Non audible murmur
7. Electroglottography to identify glottic activity

These techniques have the potential of development of devices which may aid in laryngectomy patients in future, which may give complete freedom of expression. Further researches are going on this field.

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