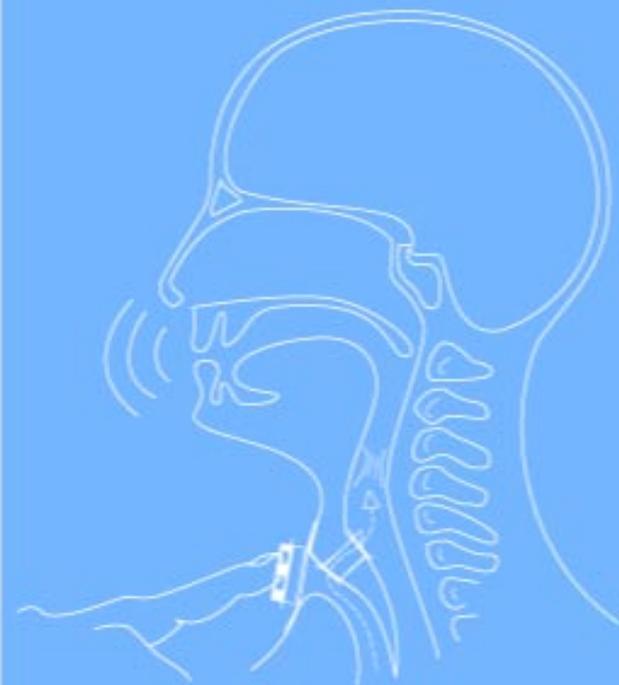


# **A practical guide to postlaryngectomy vocal, pulmonary and olfactory rehabilitation**

**4<sup>th</sup> Edition**



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# General introduction

The increasing use of voice prostheses has improved the prospects of vocal rehabilitation after total laryngectomy considerably. Consistently high success rates have been reported in the last 20 years, after the first description of a useful prosthetic device by Singer and Blom in 1979. Compared with esophageal and electrolarynx speech, a higher percentage of patients achieve an acceptable voice, enabling communication under almost all social circumstances. Success rates up to 90% are not exceptional any longer, making prosthetic voice rehabilitation the method of choice for early and reliable restoration of oral communication after total laryngectomy.

In general, two types of voice prosthesis can be distinguished, i.e. non-indwelling and indwelling devices. The former devices can be removed and replaced by the patient. The latter stay in place permanently and have to be removed and replaced by the clinician at the end of the device life, which is determined by leakage of fluids through the prosthesis or an increased airflow resistance. Indwelling devices have the definite advantage that the patient's dexterity plays a less important role in the daily maintenance of the device, which mainly consists of cleaning with a brush and/or a flushing device without the need of regularly replacing the prosthesis. Even with increasing age and/or decreasing health a useful (prosthetic) voice can be preserved.

Based on our experiences with surgical and prosthetic voice rehabilitation (Staffieri's procedure, and the Blom-Singer, Panje, and Groningen prostheses), acquired since 1979 in the Department of Otolaryngology-Head & Neck Surgery of the Netherlands Cancer Institute, we co-developed since 1988 a novel low-resistance, indwelling silicon voice prosthesis, Provox, in close collaboration with the medical engineering industry.<sup>1,2</sup> It has been successfully used in our Institute since then in all laryngectomized patients. The long-term clinical results obtained with this voice prosthesis are favorable.<sup>3-6</sup>

Additional instruments and devices to facilitate its application have been developed as well.<sup>1</sup> Their use, along with the surgical techniques involved and the management of many of the clinical and technical aspects, are the subject of this manual. The subsequent development of a second generation (Provox2) voice prosthesis for bi-directional, i.e. anterograde and retrograde, application is a further improvement of the Provox system.<sup>7</sup> The anterograde replacement in the outpatient office has considerably decreased the discomfort of this procedure for the patient and the medical professionals involved.<sup>7,8</sup>

The problem of post-laryngectomy pulmonary function disorders has also been addressed extensively in our clinic.<sup>9-11</sup> The relevance of simultaneous pulmonary rehabilitation for optimal voice restoration and an improved quality of life has become increasingly clear in recent years.<sup>12-14</sup> The development of a novel, dedicated 'valved' Heat and Moisture Exchanger (HME, Provox HME) has added a new tool to the armamentarium of the clinicians, in this respect.<sup>15-17</sup>

Handsfree speech is the ultimate goal of postlaryngectomy voice rehabilitation, preferably taking care of pulmonary protection and rehabilitation at the same time. This is now possible with the newly developed Provox FreeHands HME.<sup>18</sup>

A further problem resulting from the permanent disconnection of the upper and lower airways is a deterioration of the sense of smell. The main cause for this disturbing side effect of total laryngectomy is the lack of a nasal airflow, which normally transports odorous substances to the olfactory epithelium high up in the nose. There are two types of smelling: 'passive' and 'active' smelling. Passive smelling continuously takes place during normal nasal breathing, whereas active smelling ('sniffing') is used intentionally. Recent research in our Institute has given more insight in the magnitude of the olfaction problem after total laryngectomy.<sup>19</sup> Stoma breathing precludes passive smelling and only some 30% of the patients is still able to actively smell something. However, it now appears to be possible to restore olfaction in a considerable number of laryngectomized individuals.<sup>20,21</sup> The nasal airflow-inducing maneuver (or 'polite yawning' technique), which enables active smelling again, will be described in detail.

It should be stressed that vocal, pulmonary and olfactory rehabilitation after total laryngectomy is a multidisciplinary team effort and that the motivation of the Otolaryngologist, the (head&neck) oncology nurse, the speech therapist and last, but not least, the patient is mandatory to obtain optimal results.

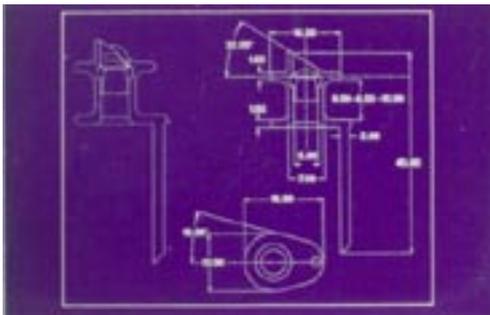
# The Provox System

## Original Provox voice prosthesis



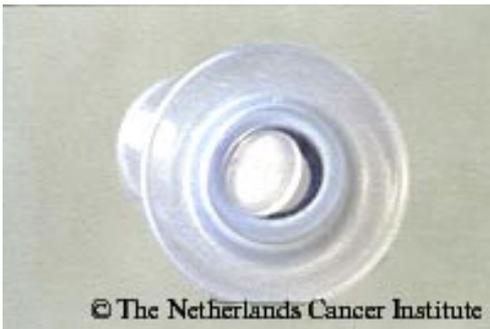
The original Provox Voice Prosthesis is a self-retaining, indwelling, easy to manage device for prosthetic voice rehabilitation after total laryngectomy.

The prosthesis is suitable for laryngectomized patients with a tracheoesophageal (TE) fistula, also when created for several other types of voice prostheses. The Provox voice prosthesis is made of medical grade silicone rubber and is available in four shaft lengths, i.e. the distance between the esophageal and tracheal flange is 4.5, 6, 8 or 10 mm.



The other dimensions of the prosthesis are: diameter of the esophageal flange 14.5 mm, oval tracheal flange 12 x 16 mm, inner diameter of the shaft 5 mm and outer diameter 7.5 mm (i.e. 22.5 Fr.).

The tracheal flange entails an introduction string. The valve is molded in one piece with the prosthesis and is supported by a radiopaque ring (20% barium sulphate), to enhance the visibility on X-ray examination.



The Provox voice prosthesis is inserted in the TE-fistula and remains in situ without replacement by the patient. Primary introduction at the time of total laryngectomy is the method of choice, but secondary introduction at a later stage is also easily accomplished.

For the introduction and replacement of the prosthesis a special **Guide Wire** is available. This disposable instrument has a connector for easy attachment of the introduction string of the new prosthesis and an 8 mm stop for transoral removal of the remnant of the old prosthesis. It has a flexible tip, which facilitates its retrograde introduction through the esophagus and pharynx.



If the guide wire becomes entrapped in the pharyngeal mucosa wall, the wire will bend near the tip and can still slide upwards through the pharynx.

Each prosthesis is packed together with a disposable scalpel and the disposable guide wire.





## Provox2 voice prosthesis

More recently, a second generation Provox voice prosthesis, intended for anterograde and retrograde use, Provox2, has been developed. This adapted prosthesis can be inserted during primary puncture at the time of laryngectomy, or during a secondary procedure at a later date, in the same manner as the original Provox prosthesis, using the separately available guide wire. Replacement in the outpatients office, however, can be carried out now in an anterograde manner directly through the tracheostoma.

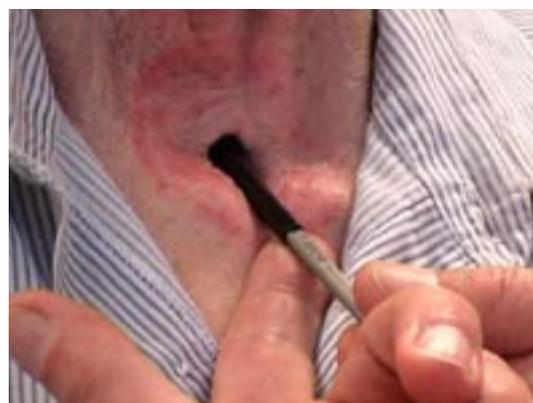


For this replacement a simple disposable tool, consisting of a loading tube and an inserter, is available in the package (figure above). The Provox2 is available not only in 4.5, 6, 8, and 10 mm shaft lengths, but also in two additional length, i.e. 12.5 and 15 mm (figure left). The dimensions of the Provox2 prosthesis are comparable with those of the original Provox device, but the flanges have been adapted. The flanges are thinner: the esophageal flange is 1.5 mm instead of 1.6 mm to enable easier removal from the fistula tract, and the tracheal flange is 1.3 mm instead of 1.6 mm, to make the resistance towards the esophagus lower than that

towards the trachea, to decrease the possibility of inadvertent dislodgment into the trachea. Furthermore, the valve construction has been improved and the tracheal flange contains the size number, allowing in vivo identification of the length of the prosthesis.

## Provox Measure

It is important to use a voice prosthesis that has the correct length. Although a slightly too long device is seldom a problem, a too short prosthesis is troublesome and might cause fistula problems. In most instances, the existing prosthesis can be used as its own measuring device. By gently pulling with a forceps at the tracheal flange, it can be determined easily, whether the device still is of the proper length. In case the length of the (already for some time established) TE fistula tract is not known, the **Provox Measure** (figure right) can be used to determine the size of the prosthesis needed. The measure has a disposable flange on its tip, which is inserted into the TE-fistula. After the flange is allowed to open up in the esophagus, the sliding part of the device is gently pushed against the trachea back-wall, and the fistula length can be read on the scale (figure right). After having established the right size of the prosthesis, the measure is tilted out of the TE fistula tract. **Warning:** the Provox measure should not be used during surgery to establish the length of a freshly created fistula tract or in a 16 Fr TE-fistula. The disposable flange has 2 different sides: a curved one for a 22.5 Fr fistula tract and a 'hollow' side, which allows easier removal out of a 20 Fr fistula tract.



## Provox Dilator

The TE-fistula tract of a Provox prosthesis does not need dilation during replacement of the device. However, if a prosthesis with a smaller diameter is replaced by one of the Provox prostheses, the procedure might be easier after some dilation of the fistula tract, using the **Provox Dilator** (figure). Some guidelines are: in a 16 Fr fistula tract insertion of a Provox 4.5, 6, or 8 mm can be attempted without dilation, but in most instances, especially in case a longer prosthesis is needed, the dilator should be applied first. The device can be lubricated with some gel and gently inserted in the TE-fistula until a diameter of 24 Fr and left in situ for 10-15 minutes (figure). After removal of the dilator, the insertion of the Provox prosthesis should be carried out immediately, in order not to lose the dilation effect. In a 20 Fr fistula tract dilation is seldom needed, because of the retrograde insertion of the Provox (1) prosthesis and the conical end of the Provox2 insertion tube.



## Surgical instruments

For the creation of the TE-fistula a special **Trocar and Can- nula** has been developed, which can be used both for primary and secondary puncture (figure bottom and right).

A **Pharynx Protector** has been designed for protection of the posterior esophageal wall and the fingers of the surgeon during primary TE-puncture. The handle of this instrument can be rotated to accommodate both right and left-handed surgeons.





## Patient maintenance

To facilitate the daily maintenance of the prosthesis a **Brush** has been developed. The brush has a collar to preclude insertion too deep into the prosthesis and a round tip to prevent damage to the esophageal mucosa. The cleaning of the prosthesis with this brush is effective and safe. After its use the brush can be cleaned easily with water and be used for several weeks or even months. For the longer devices (12.5 and 15 mm, an extra long brush is available (Brush XL).



Also available is a flushing device (**Provox Flush**), which enables easy and save flushing of the prosthesis, for instance with tap water. An additional benefit of this device is that it assists in the clearance of the pharynx from the thick mucus, many laryngectomized patients have as a result of radiotherapy. They often report that this flushing gives them a fresh feeling in the throat and an easier start in the morning.



Prosthesis replacement is almost always indicated because of leakage through the prosthesis itself due to candida overgrowth causing insufficient valve closure. For temporary control of leakage through the prosthesis a special **Plug** has been developed. If thorough internal cleaning of the prosthesis with the Provox brush or flush does not solve the leakage and the valve remains incompetent, replacement of the prosthesis is indicated. In case the patient is not able to have the prosthesis replaced at short notice, for instance during weekends or holidays, this plug can be used during the consumption of liquids (solid food only rarely causes problems). The plug can be easily placed on top of the handgrip of the cleaning brush and then introduced into the tracheal opening of the voice prosthesis. The plug contains a string with a proper sized button to prevent its loss into the trachea. It is suggested that all patients are provided with this plug, especially if they are not living close to their hospital or when traveling abroad. In practice, it has been shown that, since most of the time leakage is mild, the patient does not have to bother organizing replacement of the prosthesis somewhere else, but instead can postpone this procedure for several days with the application of this plug until a visit to his/her own clinician can be arranged.



## Pulmonary protection and respiratory rehabilitation

For pulmonary protection and respiratory rehabilitation, as well as an improved vocal rehabilitation, a special heat and moisture exchanger (HME) has been developed, which contains also a 'speech valve' with a spring for easy and comfortable digital closure of the stoma, the **Provox HME**. This device is shown in right figure, and will be discussed in chapter VII in more detail.

An additional device, used in conjunction with the Provox HME Adhesive base plate, is the Provox **Shower Aid**, (figure right below) which prevents aspiration of water during showering.



## Provox FreeHands HME

A solution for the need for digital stoma occlusion in prosthetic tracheoesophageal speech is the use of an automatic speaking valve. Such a device should not only incorporate a valve mechanism that allows airtight occlusion of the stoma and, thus, diversion of pulmonary air into the pharyngoesophageal PE segment (or neoglottis) for voicing, but also should optimally integrate a heat and moisture



exchanger (HME), which is indispensable for pulmonary rehabilitation.

The Provox FreeHands HME (see figures and videoclips on cd-rom) is an automatic speaking valve, which has the following properties:

- an HME is the basic and mandatory part of the device, situated directly in front of the stoma to keep the valve free of mucus;
- inhalation takes place through side openings to allow breathing in pre-heated and pre-moisturized air from the body;
- voicing is possible with low air pressures by keeping the flexible speaking valve closed with magnets;
- the speaking valve comes in three different flexibilities to accommodate individual patient needs;
- a locking position protects against involuntary closure of the speaking valve during physical exertion;
- a self-centering, freely movable cough relief valve acts as cover, and the force needed for its opening is individually adjustable by means of magnets;
- optimal cleaning and hygiene is achievable by means of a special cleaning container;
- the device is usable in combination with existing valve housings, e.g. Provox HME adhesives and/or LaryTube cannulas.



## Provox LaryTube

For patients who need a cannula to stabilize the stoma, a special cannula system (the Provox LaryTube) has been developed, allowing the use of an HME without the necessity to use an adhesive (see figure below to the left). A very practical feature of this system is that for those patients who only use a cannula during the night, there is a LaryTube version containing a blue ring that fits in any of the Provox Adhesives (see figure right). This enables the patient to wear the HME in the usual Adhesive base plate during the day, and at night time allows the use of the cannula without the need to remove the Adhesive, if this is still properly glued in place. A LaryTube with a blue ring inserted in an Adhesive is also useful for combination with the Provox FreeHands HME. The cannula in the trachea stabilizes the automatic valve during voicing, which decreases the pressure on the adhesive even further, and potentially increases the time an airtight seal can be kept. Another advantage of the LaryTube cannula is that it enables the patient to use an HME during the postoperative radiation period, when the use of adhesives is often not recommended by most physicians, even not the hydrocolloid version (OptiDerm). Also in case of an irritated skin, when the use of adhesives is (temporarily) not possible, patients can still wear an HME, by using a LaryTube cannula.

The LaryTube is available in a fenestrated version, which is ready for use in patients with a voice prosthesis. There is also a fenestration punch (see figures below to the right) for individualized fenestration of the standard LaryTube (with or without the blue ring).



# Surgical Procedures

## Primary prosthetic voice rehabilitation

### *Total laryngectomy*

Primary prosthetic vocal rehabilitation with immediate insertion of the voice prosthesis during total laryngectomy is presently our method of choice. A rule of thumb can be, that if a patient is fit enough to be submitted to this surgical procedure, he/she is fit enough for a simultaneous prosthetic voice restoration procedure. There are no obvious contraindications against this policy, except in case the tissues are in a 'too poor condition', such as after exceptional high doses of radiotherapy, i.e. exceeding 70 Gy in 7 weeks, or equivalent doses.

Optimal results of voice rehabilitation with an indwelling Provox voice prosthesis can only be obtained if the technique of total laryngectomy fulfils certain requirements. Besides keeping in mind the standard oncology principles, care should be taken to create a pharynx, which is wide and 'flexible' enough to enable effortless speech, without hypertonicity of the constrictor pharyngeus muscles. Furthermore, the tracheostoma should be wide enough for comfortable breathing and narrow enough to be easily occluded by the patient when speaking, although the latter is less important with the availability of the Provox HME.



In the Netherlands Cancer Institute a standard wide field total laryngectomy is carried out with 24 hours peri-operative antibiotic prophylaxis (e.g. gentamicin and clindamycin). After transoral intubation, a modified Gluck-Sörensen incision (figure left) is utilized, extending over the lateral border of the sternocleidomastoid muscles and approximately 1.5 cm proximal of the manubrium sterni. Through this incision a combination of the laryngectomy with a uni- or bilateral neck dissection is easily accomplished.

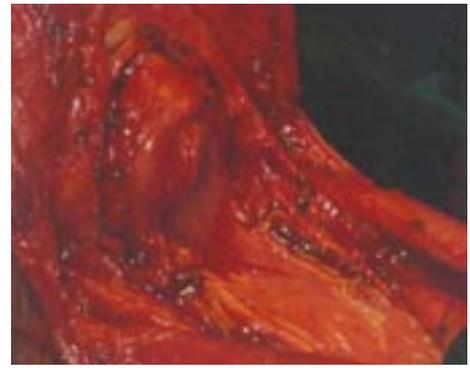
The U-shaped skin and platysma flap is then dissected until the hyoid bone is reached. The cranial extension of the surgical field is the region of the submandibular glands, the lateral extension the carotid arteries and internal jugular veins. The omohyoid muscles are cut a few centimeters lateral to the thyroid cartilage, and the sternohyoid and sternothyroid muscles are undermined and severed as well. This ensures proper soft tissue coverage of the specimen. This is also realized by leaving the homolateral thyroid lobe including the isthmus on the specimen. The contralateral lobe of the gland is preserved with its arterial and venous blood supply. This lobe is dissected away from its attachments to the thyroid cartilage and trachea. Both superior laryngeal arteries and veins are ligated and cut, as well as the laryngeal nerves. The hyoid bone is now dissected from its attachments to the tongue musculature, starting with the greater cornu. Care should be taken at this stage to preserve the lingual arteries and the hypoglossal nerves. The dissection is deepened until the pharyngeal mucosa, i.e. the vallecula is reached. The pharyngeal constrictor muscles are cut just ventral to the posterior thyroid cartilage rim.

The trachea is incised between the second and third, or the third and fourth ring, depending on the subglottic extension of the tumor. An endotracheal tube replaces the orotracheal tube. The trachea is sectioned completely, while care is taken to keep the cartilage of the tracheal rings intact. The trachea is dissected cranially from the esophagus, leaving the trachea and esophagus carefully attached to each other at the upper tracheal rim.

The piriform sinus is opened contralateral to the tumor, and with a palpating finger inside the pharynx, the incision is extended towards the vallecula with a pair of scissors. The specimen can be rotated and the tumor can be seen directly.

Under direct vision of the tumor the dissection can be continued to the homolateral side and the larynx is pulled downwards with the postcricoid and hypopharyngeal mucosa clearly visible. Depending on the extension of the tumor more or less of the mucosa in the postcricoid area is preserved and the specimen can be removed. In the figure to the right the situation after removal of larynx is shown.

After careful haemostasis and rinsing with saline or distilled water, the operation field is re-draped. The trachea is sutured in position with vicryl 1-0. By suturing the caudal skin flap as far back as possible to the



posterior tracheal cartilage, the tracheal lumen remains open due to the tension in the skin (figure left). Another (preferred) option is to create a separate opening in the skin for the formation of the stoma (see page 17). This can be done if the skin incision at the beginning of the surgical procedure is positioned more cranially (Gluck-Sörenson incision). If the sternal heads of the sternocleidomastoid muscle are protruding too much, it is advisable to incise them (see under Tracheostoma construction), in order to form a flatter and easier to occlude stoma. This later also facilitates the application of a speech valve and/or heat and moisture exchanger.

At this stage, the tension of the cricopharyngeus muscle, also and preferably referred to as the upper esophageal sphincter, should be judged by palpation with the index finger (figure right). When hypertonicity of this muscle is observed, indicated by tension of the muscle around the finger, a longitudinal myotomy has to be performed. This procedure is not to be confused with a (primary) myotomy of the constrictor pharyngeus muscle, which is not routinely used by us, since primary unilateral neurectomy of the pharyngeal plexus is a good method to prevent hypertonicity of this muscle group (see figure page 17).



### ***Surgical technique of primary TE puncture and introduction of the Provox voice prosthesis***

At this stage of the surgical procedure the primary tracheoesophageal puncture (TE) is carried out. No temporary stenting of the TE-fistula is needed with the Provox system. First, the proper size of the voice prosthesis should be selected. For this reason, the thickness of the tracheoesophageal party wall should be judged with a palpating finger. The original Provox prosthesis is available in four lengths: 4.5, 6, 8, and 10, millimeters, and the Provox2 device in two additional lengths, 12.5 and 15 mm. In most patients an 8 or 10-millimeter prosthesis is appropriate. In case of doubt, use the longer prosthesis to allow for postoperative swelling and edema at the puncture site.

The use of the special Provox pharynx protector is recommended. This instrument can be placed through the open pharynx into the cervical esophagus and positioned just cranially of the tracheostoma. The use of the Provox trocar and cannula is recommended for the TE-puncture (figure left). If this instrument is not available, a non-cutting sharp trocar is preferred over any cutting device, e.g. a scalpel, because this could cause an oval shaped TE fistula tract. The trocar is placed in the midline of the trachea back wall 5 mm under the upper tracheal mucosa rim. The trocar is directed towards the opening of the pharynx protector. With a slight twisting movement of the hand, a clean hole is punctured in the tracheoesophageal party wall.

The trocar is removed, leaving the cannula in situ and the flexible guidewire, included in the Provox package, or separately available in case the Provox2 prosthesis is used, is introduced through the cannula. The connector of the guidewire appears in the upper opening of the pharynx protector, which can then be removed. A prosthesis of the proper size is attached to the guidewire with its introduction string and the trocar is removed from the puncture opening (figure right).

By pulling of the guidewire, the string of the prosthesis with the flange appears in the TE-fistula. By careful pulling with two curved non-toothed hemostats, the flange is rotated in position (figure right).

Thereafter, the introduction string is cut off and the prosthesis is turned with the oval part of the flange pointing downwards in the trachea.

Closure of the pharynx is carried out in a T-shape. This enables a low-tension closure, tailored to the size of the defect and avoids the development of a ridge at the base of tongue i.e. the formation of a “neo-epiglottis”. Before closure of the pharynx is carried out, a nasogastric feeding tube is brought into position. The mucosa is closed with running atraumatic vicryl 3-0 sutures with a round needle starting cranially and laterally (figure right). Tissue surplus caudally is closed with a purse string suture.

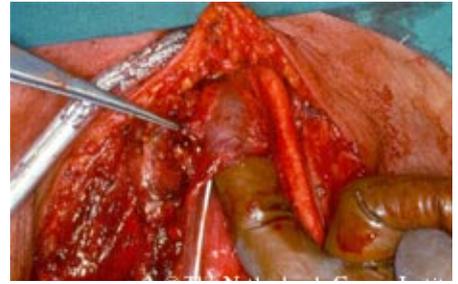
A second submucosa layer is also closed with running sutures. Finally the pharyngeal constrictor muscle is closed, running or with mattress sutures. This layer should not be closed too tightly. The figure to the right is showing the PE segment after closure of the muscle layer.



### **Primary tonicity control of the PE-segment**

Before skin closure is completed, the final aspect of the tonicity control of the pharyngoesophageal (PE) segment should be carried out. As already mentioned, a short myotomy of the upper esophageal sphincter is performed before closing the pharyngeal mucosa (figure right). A neurectomy of the pharyngeal plexus can be added if desired. The pharyngeal plexus branches innervating the constrictor pharyngeus muscle are localized, cut and partially removed as careful as possible (figure right). Mostly, three to five branches can be identified. This procedure is carried out unilaterally, preferably on the side of the hemi-thyroidectomy and/or neck dissection. A myotomy of the constrictor pharyngeus muscle is not recommended routinely, since this neurectomy largely prevents hypertonicity of this muscle group.

After introduction of wound drains, the skin is closed in two layers: the subcutaneous tissue with 3-0 vicryl interrupted and the skin with 4-0 nylon monofilament running sutures. The end result is shown in the last figure on the right.



### **Tracheostoma construction**

The best results are obtained when it is possible to make the stoma in the inferior skin flap, using a separate fenestra in the skin (figures right), at a distance of close to one centimeter to the skin incision. This may be round, but in our experience, the most effective shape is semi-circular, with the same size and orientation as these of the trachea. The anterior (intact cartilaginous) portion of the trachea is sutured to the circular part of the fenestra, and the posterior (membranous) portion of the trachea is sutured to the straight/horizontal part, which runs parallel to the incision of the inferior skin flap. The sutures should be placed meticulously and ensure that there is skin cover over the bare edge of the trachea, so that no cartilage is exposed (figure right). Exposed cartilage may lead to perichondritis, infection, granulations and eventually stenosis.

In the same way, the postoperative use of a cannula, button or tracheostomy tube is to be avoided, if possible, since they cause friction to the mucocutaneous anastomosis, with the same end-result. In our experience in the Netherlands Cancer Institute it appears to be possible to have most patients leave the operating room without a cannula. A temporary cannula is only used if there is excessive edema of the skin flaps, causing obstruction, or excessive secretions, where a tube may aid in decreasing trauma to the tracheal mucosa caused by suction catheters. Once a stoma has started to form fibrous tissue, as in the case of tracheal stenosis, it is extremely difficult to arrest the process, and such a patient may be condemned to the use of a stoma button for all or much of the time. A typical example of a stoma created in this way with a Provox voice prosthesis in situ is shown in the figure to the left.

As already mentioned earlier, an additional improvement of the stoma can be obtained by **cutting the sternal head of the sternocleidomastoid muscles** (figure). This causes no functional deficits, but results in a flatter peristomal area, which facilitates the use of external stoma appliances such as an HME and/or an automatic tracheostoma valve.

After wound healing is completed and possibly checked with a barium swallow (approximately 10 days postoperatively), the patient can start with vocal rehabilitation under the guidance of the speech therapist.



## Secondary prosthetic voice rehabilitation

### **Indications**

Failure to obtain useful esophageal, and/or electrolarynx speech, or dissatisfaction with the results of either of the two, is the main indications for a secondary prosthetic voice rehabilitation procedure. The percentage of successful secondary prosthetic voice rehabilitations seems to be somewhat lower, compared with primary rehabilitation, probably due to the fact that the patient has not been using pulmonary driven speech for some time. Furthermore, there might be a negative selection aspect, because failed esophageal speakers might have more problems with hypertonicity of the PE-segment. Nevertheless, with proper training, and if necessary, treatment of hypertonicity of the PE segment, many secondary patients should be able to regain a useful prosthetic voice. In fact, we think that, as is the case for the primary prosthetic procedure, there are no real medical **contraindications** to this technique, with the exception of radiotherapy doses well exceeding 70 Gy in 7 weeks or the equivalent. As a matter of caution, it should be mentioned, that secondary punctures should not be performed within 6 weeks after completion of the irradiation. Severe stenosis of the pharynx, or a too narrow stoma are relative contraindications since in most patients these problems should be correctable. Also in patients in whom the pharynx and/or esophagus are reconstructed with a gastric pull-up procedure, the colon, a free tubed radial forearm flap, or a free revascularized jejunal graft, the method is applicable. If the patient is motivated enough, the method is worthwhile trying.

### **Preoperative screening**

Apart from a regular **ENT examination**, including inspection of the pharynx for the presence of a stenosis or web formation at the base of the tongue and checking the stoma size, a **barium swallow** should be performed to check the size and mobility of the pharyngoesophageal (PE) segment. This to anticipate on possible problems with the introduction of the rigid endoscope and to see whether dilation of the PE segment is needed.

**Insufflation test:** Often this test is advocated in order to predict the outcome of secondary prosthetic voice rehabilitation. The test is performed by introducing a 12-14 Fr nasogastric catheter into the PE segment. Either the examiner blows air into the pharynx in order to obtain speech, or the catheter is connected to the stoma and the patient tries to speak blowing air through the catheter himself.

However, the results of this test are not very reliable and a negative result should not be interpreted as a contraindication against secondary prosthetic voice rehabilitation. A negative result could be indicative of a hypertonicity of the constrictor pharyngeus muscles, which can be corrected surgically with a myotomy or chemically with Botox.

In general, however, we are not in favor of combining the secondary introduction of the voice prosthesis with a myotomy of the constrictor pharyngeus muscle. It is advisable to wait for the results of the speech therapy. Only if hypertonicity of the constrictor pharyngeus muscle becomes apparent, and results do not improve after proper training, a chemical neurectomy with Botox or a surgical myotomy of this muscle could be considered. In the Netherlands Cancer Institute very few hypertonicity treatments have to be performed, as this problem appears to be quite rare after introduction of primary plexus pharyngeus neurectomy and upper esophageal sphincter myotomy. If needed, however, results of voice rehabilitation can be expected to be improved considerably. For the technique of secondary myotomy, [see page 25](#).

### **Surgical technique of secondary TE puncture and introduction of the Provox voice prosthesis**

The instruments needed for this procedure are besides the contents of the original Provox (1) package, i.e. the voice prosthesis (of a proper length), the guide wire and the scalpel, or in case the Provox2 device is used, a prosthesis with the proper length and a separately packed guide wire, a short rigid esophagoscope with a light source, the Provox trocar and cannula and 2 curved non-toothed hemostats (figure right). The secondary puncture is performed under peri-operative 24 hours broad-spectrum antibiotic prophylaxis.



The laryngectomized patient is intubated. The short rigid esophagoscope is introduced and moved towards the tracheostoma (figures below). In case of a stenosis, it might be helpful to introduce a thin nasogastric tube first, to facilitate the introduction of the scope and to guide the dilatation, which should be carried out first. When the tip of the esophagoscope reaches the tracheostoma, the scope is swiveled 180°, turning the oblique open side of the esophagoscope upwards. An assistant keeps the instrument in this position.



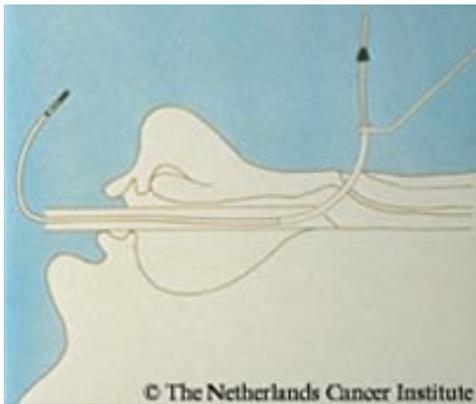
By removal of the ventilation tube of the anesthetist, a clear view inside the tracheostoma is obtained. The proper position of the scope is checked by palpation with a finger.

At this stage, selection of the proper size of the prosthesis should be made. The thickness of the tracheoesophageal party wall is also judged with the palpating finger. Four lengths of the Provox voice prostheses are available: 4.5, 6, 8 and 10 millimeters, and two additional lengths of 12.5 and 15 mm of Provox2. In most patients an 8 or 10 millimeter prosthesis is sufficient. In case of doubt, use the longer prosthesis to allow for postoperative swelling and edema at the puncture site.

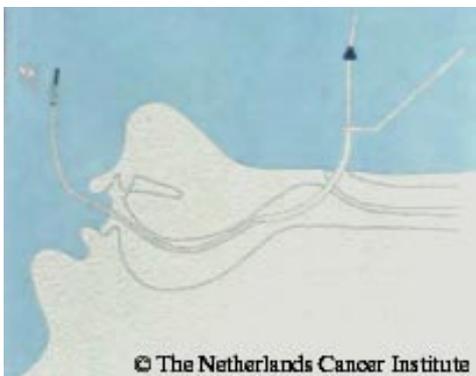
The trocar and cannula is then placed in the midline of the tracheoesophageal wall, 5 mm below the mucocutaneous junction, and a TE fistula is created by puncturing towards the lumen of the scope. The sharp tip of the trocar is caught in the esophagoscope under visual guidance of the assistant (figures below).



The cannula is removed and the flexible guidewire introduced through the trocar. The connector appears in the esophagoscope and is pushed upwards (figures below).



The esophagoscope is now removed and the Provox voice prosthesis is attached to the connector head of the guide wire (figures below). By pulling the guide wire inwards, the introduction string of the prosthesis is introduced into the TE fistula.



During this procedure the ventilation tube of the anesthetist is re-introduced for a few minutes. Finally after removal of the ventilation tube again, the prosthesis is pulled and rotated into the TE fistula with the help of two curved non-toothed hemostats (figures below).



The introduction string is cut. The prosthesis is then turned in its proper position with the oval side of the flange pointing downwards in the trachea (figures below).



After the patient is awake, the impermeability for liquids of the prosthesis and the TE fistula is checked by drinking of water. If there is no leakage, an oral feeding can be resumed right away. Speech therapy usually also starts the same day.

**Reminder:** It is important to place the Provox voice prosthesis at the correct position in the tracheal back-wall, i.e. the puncture should be carried out in the midline 5 mm below the upper tracheal rim, causing the upper border of the tracheal flange of the prosthesis almost to reach the mucocutaneous junction. A too low position of the prosthesis leads more easily to leakage, makes cleaning and replacement more difficult, and might result in less optimal speech.



### **Alternative surgical technique of secondary puncture**

Sometimes the introduction of a rigid esophagoscope can be difficult, making the standard secondary puncture technique too cumbersome, for instance in case of trismus or severe scarring of the neck. A good option then is the alternative procedure, described here. This procedure can also quite easily be performed under local anesthesia. Besides the instruments, used in the standard technique, a bendable uterine probe (Simm's Uterine Probe EO 12, 330 mm (13 inch), with a 4 mm blunt tip, Aesculap, Tuttlingen, Germany) is needed. The curvature of this probe



can be adjusted easily. Figure to the right shows the bent probe and the trocar and cannula, from which the cannula part is used in this procedure.

The probe is passed gently by feel through the mouth, pharynx and cervical esophagus towards the stoma. If needed, the curvature of the probe is adjusted according to the anatomical situation. The tip can be easily seen (figure left) and palpated in the posterior tracheal wall.

With the disposable scalpel of the original Provox package or any other scalpel with a sharp curved tip, the TE fistula is created by **puncturing** towards the tip of the probe at a distance of 5 mm from the mucocutaneous juncture (figure below to the left).

The tip of the probe then can slide outwards through the fistula (figure right).

Next, the cannula is placed on top of the tip and with gentle pressure onto the probe passed into the esophagus (figure left).

After removal of the probe, the remainder of the procedure is identical the standard secondary puncture technique, described earlier. The guide wire is passed through the cannula out of the mouth and the Provox prosthesis is attached (figure below to the left). The guide wire is pulled back into the TE fistula and the prosthesis is rotated into the fistula tract by pulling onto the tracheal flange with two non-toothed hemostats. Figure below to the right shows the prosthesis in its proper place, high up in the stoma.



## Secondary treatment for hypertonicity of the PE segment

### Introduction

Hypertonicity and/or spasm of the constrictor pharyngeus muscles in the pharyngoesophageal (PE) segment are the main causes for failure to acquire fluent tracheoesophageal speech. If patients are suspected to be troubled by this problem, it is important to confirm this diagnosis. *Insufflation* through the voice prosthesis into the PE segment using a catheter can give the clinician already a good idea about the too high resistance of the PE segment. Insufflation could also be done directly through the fistula after removal of the prosthesis to make sure that the problem is not related to the voice prosthesis itself. The too high resistance can be objectified further by *trachea pressure measurement* during voicing at a comfortable loudness level. A pressure above 0.4 kPa at a comfortable loudness level (approximately 65 dB at 30 cm mouth to microphone distance) indicates hypertonicity. The next diagnostic procedure should be *videofluoroscopy*, which can differentiate between hypertonicity, stricture, and recurrence.<sup>1</sup> Finally, a *diagnostic plexus pharyngeus blockade* with 1% lidocain can be carried out, to establish whether a short-term pharmacological denervation of the constrictor pharyngeus muscles solves the problem temporarily.

The primary mode of treatment of hypertonicity of the PE segment is *intensified speech therapy* (see chapter on speech therapy), where the addition of *relaxation exercises* sometimes can be helpful. Once patients get the feeling for fluency of the air and realize that they should press less strong instead of harder during voicing, conservative speech therapy training might overcome this problem. We reserve the invasive methods, i.e. *chemical denervation with Botulinum toxin* as the first choice and *constrictor pharyngeus myotomy* as the second choice, for failures of speech therapy only.

### Chemical denervation of constrictor pharyngeus muscles with Botulinum toxin

#### Introduction and physiologic effects:

Botulinum toxin is an endotoxin produced by the microorganism *Clostridium botulinum*. The disease Botulism is known since the 18th century and the bacteria causing it is isolated in the beginning of the 20th century.

The endotoxin blocks the acetylcholine release at the neuromuscular junction and is rapidly (in 30-60 minutes) taken up by contracting muscles. Clinical onset of the symptoms begins in 24-48 hours. The endotoxin causes a permanent denervation of the muscles with atrophy starting after 2 weeks. The nerve endings, however, always regenerate, a process that takes several months. Therefore, the duration of the effect is mostly not more than 3-6 months.

Botulinum toxin has a wide range of clinical applications in the head and neck region, such as blepharospasm, cervical and laryngeal dystonia, hemifacial spasm, strabismus, and more recently also for hypertonicity/spasm of the PE segment. Botulinum toxin is commercially available in 2 products: Botox (Allergan) and Dysport (Speywood) (the latter is 4 times less active). The effect is measured in MU (mouse units), where 1 MU = LD50 for Swiss Webster female mice. The LD50 for humans is approximately 2500-3000 MU. The single dose limit is 400 MU, and no serious reactions or adverse events are reported with this dose, but in clinical practice much lower doses are applied. Contraindications are: pregnancy, lactation, pre-existing neuromuscular diseases (myasthenia gravis, Eaton-Lambert syndrome, ALS), and simultaneous use of drugs, affecting neuromuscular junctions, such as amino-glycosides.

#### Application in PE segment hypertonicity:<sup>2-5</sup>

The dose of Botox advised mostly is 50-100 MU (4 times as much in case Dysport is used), which is considerably higher than in most other indications in the head and neck region. The toxin is easily inactivated, which means that the vial, which contains 100 MU, should be kept in the refrigerator until use. The toxin is reconstituted in 2 to 4 cc normal saline and should be used within 6 hours after reconstitution.

First, the position of the hypertonic bar of the PE segment should be determined. This can be achieved best by videofluoroscopy, which should be carried out in the same body posture wherein the injection will be performed afterwards. The upper and lower border of the hypertonic bar of the PE segment is marked in a resting position, using lead beads, taped on the skin.

Next, the Botox solution can be injected unilaterally at the upper and lower marking site and halfway. We use 100 MU in a tuberculin syringe, injecting carefully between the carotid artery and the pharyngeal wall (it should be kept in mind that the carotid artery often is displaced medially after total laryngectomy). The needle is advanced onto the prevertebral fascia and then withdrawn 1 cm and Botox is injected at the 3 spots already mentioned. Alternatively, the procedure is carried out under EMG guidance, using a hollow 27 gauge EMG needle. However, it is advisable also in this case to mark the hypertonic bar of the PE segment in order to be more certain of the correct injection site.

The effect of the Botox treatment can be noticed in 24 hours, and, interestingly enough, if a positive effect is obtained, it can last much longer than the normal physiologic effect, which persists, as already mentioned, between 3 and 6 months. It is not unusual that a single injection is sufficient to achieve a permanent effect.

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4. Zormeier MM, Meleca RJ, Simpson ML, Dworkin JP, Klein R, Gross M, Mathog RH: Botulinum toxin injection to improve tracheoesophageal speech after total laryngectomy. *Otolaryngol Head Neck Surg* 1999; 120: 314-319.
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### ***Surgical constrictor pharyngeus myotomy***

The surgical technique is as follows: a vertical paramedian skin incision is made on the side of the hemithyroidectomy and or neck dissection (figure below to the left). Care is taken not to damage the carotid artery, which in most patients is displaced medially. The pharynx is dissected free carefully (figure right). If nerve branches of the plexus pharyngeus are seen, they should be severed. A meticulous paramedian myotomy is then performed, cutting the last muscle fiber, without entering the pharyngeal lumen.



This is greatly facilitated by the introduction of a cuffed anesthesia tube into the pharynx, prior to the surgical procedure. By inflating the balloon of this tube and moving the tube slightly up and down, it can be easily seen whether the last muscle fibers have been cut. The figure below to the left is showing the inflated balloon after the complete myotomy and the figure to the right the situation with the deflated balloon. The full length of the constrictor pharyngeus muscle should be myotomized. Especially high up at the base of tongue no muscle fibers should be forgotten. The wound is closed in layers, after leaving a small diameter suction drain behind. The result of this procedure can be judged usually already on the first postoperative day.



## **Fistula closure**

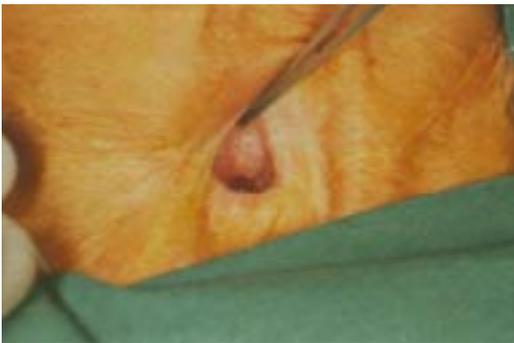
### **Indications**

Closure of the TE-fistula can be indicated when there are problems such as widening of the fistula causing leakage around the prosthesis, not responding to temporary removal of the device, prolapse and/or infection of the TE-fistula, spontaneous extrusion of the prosthesis, postoperative wound infection problems around the stoma, severe hypopharyngeal stenosis or a too low or high position of the TE-fistula.

If the fistula exists longer than 6 months surgical closure is mostly needed. If the fistula is present less than 6 months or in patients with spontaneous extrusion of the prosthesis or infection of the fistula tract, spontaneous closure can be expected.

### **Surgical technique**

The aim of the surgical procedure is to close the fistula in layers and to strengthen the posterior tracheal party wall. If the stoma needs revision, this can be accomplished at the same time (see the following chapter on stoma revision).



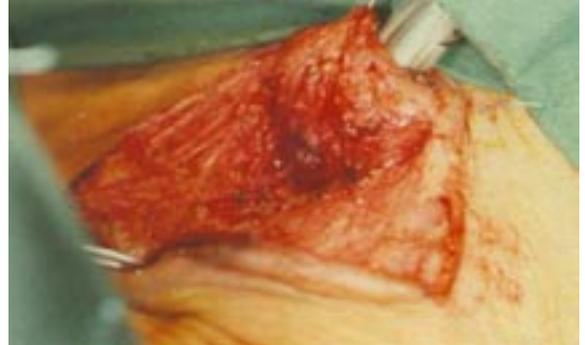
The figure to the left is showing a case of a hypertrophic, too low situated fistula, which caused persistent leakage around the prosthesis. An incision is made horizontally on either side of the stoma, and curved posterior to encompass the posterior line of the stoma and a superiorly based skin and platysma flap is created (see figure right).



The figure above to the left shows the posterior tracheal wall is dissected away from the esophagus, revealing the fistula tract (figure above to the right). The TE-fistula is then completely dissected free to enable a hemostat being passed underneath (figure below to the left). The fistula is opened and cut completely (figure below to the right).



The esophageal stump is closed with inverting vicryl sutures (figure below left). A second muscular layer is sutured to reinforce the esophageal wall. If needed, the sternal head of the sternocleidomastoid muscle can be dissected from the sternum to create a superiorly based muscle flap, which can be easily interposed between the esophagus and the trachea. Even if this additional layer is not needed, it is advisable to take this opportunity to cut the sternal heads of the sternocleidomastoid muscles. This has the advantage that the stoma area will be flatter after this procedure, which makes the use of stoma appliances, such as an HME or automatic stoma valve, easier, as already described earlier in the chapters on total laryngectomy and tracheostoma construction. Next the tracheal wall is sutured in one layer (figures below right).



Finally, the skin is closed in one layer (figure below to the left). No wound drains or dressings are required generally. The figure below to the right is showing the final situation at the end of the procedure. A secondary tracheal puncture can be carried out after complete healing of the stoma, mostly after 6 weeks.



# **Stoma Revision\***

## ***Introduction***

The construction of a stable tracheostoma during laryngectomy is essential for successful prosthetic voice rehabilitation. A tracheostoma should be large enough to make the use of a cannula superfluous, but small enough to be easily occluded by the patient for speech production. In addition to this there are several other properties, which the stoma should possess in order to facilitate speech rehabilitation. This chapter seeks to examine the major surgical considerations in constructing, maintaining or reconstructing the stoma to this end.

Stenosis of the tracheostoma after laryngectomy can be a frustrating complication, which may occur shortly after the operation or after several months. Stoma stenosis has no accepted definition, but the incidence in the literature varies between 4% and 41%.<sup>1-3</sup> Montgomery<sup>4</sup> has classified stenosis into three types: vertical-slit, concentric and inferior-shelf type. This may have some merit, although most of the cases of stenosis cannot be classified strictly into one type or another. Some authors consider a stoma stenotic when a cannula is needed.<sup>5</sup> There is some rationale for the concept that a stoma with a cross-sectional area less than that of the glottis at rest may be considered too narrow.<sup>6</sup> Severe stenosis may not only interfere with the clearing of secretions or crusts from the trachea leading to airway obstruction, but is also troublesome in relation to prosthetic voice rehabilitation. The effects of stenosis may be aggravated by the use of non-indwelling prostheses, since they protrude from the tracheoesophageal (TE) fistula through the stoma. This problem can be avoided with the application of indwelling voice prostheses. The effectiveness of these prostheses has improved considerably over the last few years due to new designs and materials.<sup>7-9</sup> Nevertheless, these prostheses still have to be replaced regularly.

Generally, the replacement procedure can be accomplished safely and simply in an out-patient clinic setting. However, stenosis may complicate this so that general anesthesia may be required. In addition, if a cannula has to be worn, it can be more difficult or sometimes impossible to achieve a seal over the stoma, thus resulting in air escape, which interferes with speech quality. Also the use of external speech valves and the use of heat moisture exchangers<sup>10,11</sup> may be more complicated, or impossible. Reconstruction of a stenotic stoma is therefore a procedure, which might be necessary even if the patient has no complaints of retention of secretions or breathing problems, but desires prosthetic voice rehabilitation.

## ***Surgical techniques of tracheostoma reconstruction***

The simplest method of widening the stoma is the dilatation of the stenosis by the use of cannulas and buttons. However, this is usually only a temporary solution as it does not remove the stenotic scar tissue and may aggravate it.

## ***General principles***

Various more or less elaborate techniques have been described to reconstruct a stenotic tracheostoma. Previous radiotherapy does not preclude reconstruction, but can make surgery more difficult. Excision of the stenotic scar tissue is the first step, which has to be performed to prevent recurrent stenosis. Excess subcutaneous tissue and fat have to be excised as well as overhanging skin flaps. If necessary, the remaining thyroid lobe has to be lateralized if it is bulging into the stoma borders.

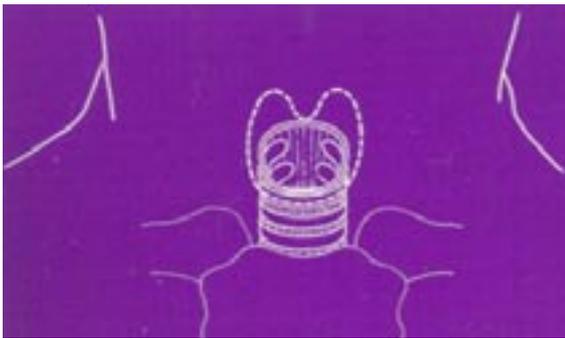
Sometimes it is also necessary to resect the sternal heads of the sternocleidomastoid muscles if they deepen the lateral walls of the tracheostoma, and when one has already been removed as part of a neck dissection, the opposite sternal head should be cut to obtain a symmetrical surface. Apart from these common steps, the reconstructions can be classified into three categories. In each category minor variations have been described but the principles are essentially the same within each group.

### Category 1

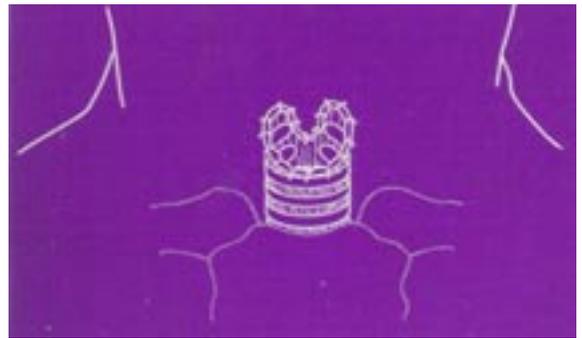
The first technique consists of removing the stenotic part of the stoma with about a centimeter of skin and simple suture of the skin to the tracheal wall. This so-called 'doughnut method' is probably the oldest method.<sup>4</sup> It has the disadvantage that it does not interrupt the line of circular wound healing which is prone to recurrent stenosis. Most of the variations of this technique consist of the creation of lateral traction of the walls in an attempt to prevent a new stenosis.<sup>12</sup> Some also advocate the use of radial incisions with subsequent dilatation with cannulas.<sup>12</sup> We believe this latter method to be more likely to cause recurrent stenosis, since lack of primary wound healing may lead to more fibrosis.

### Category 2

The second group of reconstructions consists of inserting a cutaneous flap in the dorsal part of the upper trachea.<sup>1,4,13,14</sup> Not only does this result in widening of the diameter of the stoma but it also causes an interruption of the circle of scar tissue, thereby decreasing the risk of a new stenosis (figures below). Several modifications have been described but they all have in common the use of a posterior skin flap.<sup>2,5,15,16</sup>



a). Incision circumventing the stoma. An incision is also made through the tracheal mucosa, and vertically in the back wall of the trachea (not shown on the diagram).

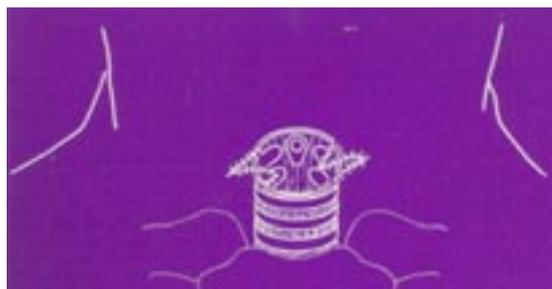


b). After suturing the skin incision to the trachea, note that the posterior skin flap has been insinuated into the posterior vertical incision, thus precluding the placement of a prosthesis in this position.



This technique usually succeeds in increasing the diameter of the stoma, but it can interfere with prosthetic voice rehabilitation, since the dorsal part of the tracheostoma becomes covered with skin. That part of the tracheostoma is the location of the tracheoesophageal (TE) fistula and thus the voice prosthesis. Therefore, if a prosthesis is already in situ, it may have to be removed and reinserted at a later date. Consequently, the patient loses his voice for at least several weeks. Furthermore, the thickness of the skin might complicate the insertion of a new prosthesis. The common wall of trachea and esophagus may become too thick for the current types of prostheses.

**Category 2 technique, involving a posterior skin flap in the stoma.**



**Category 3 techniques, involving two lateral plasties. In the posterior tracheal wall a Provox voice prosthesis is shown.**

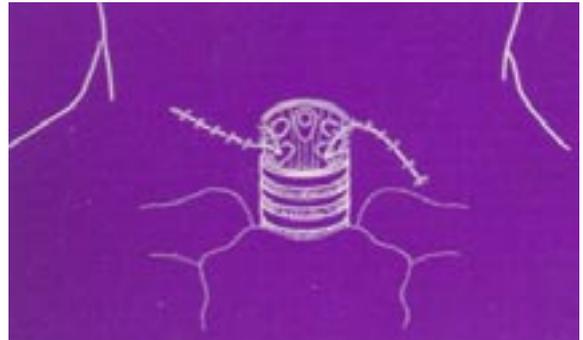
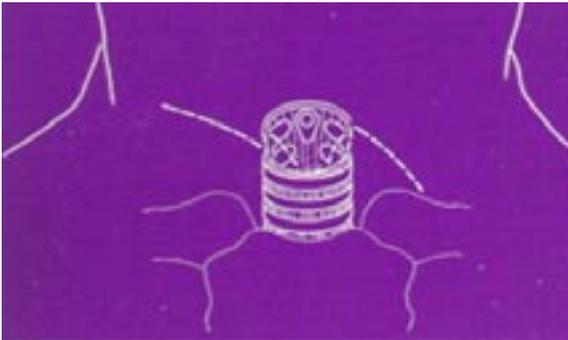
- a) Incision for lateral Z-plasty
- b) Interposition of the flaps
- c) After suturing.

### Category 3

The last technique, which we call the lateral flap technique, also consists in interrupting the line of circular scar contracture by inserting two cutaneous flaps in the lateral walls of the stoma<sup>4,12</sup> by using a double Z-plasty (figures to the left). A modification consists of a superiorly-based bilateral skin flap, which is rotated into the lateral walls of the trachea.<sup>14</sup>

Another modification which we prefer is the so-called “fish-mouth technique”. It consists in the splitting of the first two tracheal rings at 3- and 9-o’clock positions, where after two laterally-based V-Y flaps are inserted into the split tracheal walls (figures below).<sup>17</sup> Essentially these methods are based on the same principles as the dorsal flap, i.e. interruption of the line of a circular scarring. However, they do not have the potential disadvantage of interfering with the location of the voice prosthesis.

**Category 3 techniques, involving lateral V-Y plasties. In the posterior tracheal wall a Provox voice prosthesis is shown.**



a) The incision, which is also extended along the posterior border of the stoma

b) The insertion of the lateral V-Y flaps into the “fish-mouth” created by making incisions at 3- and 9- o’clock in the trachea.



One year after the procedure. The scar of the V-Y flap can still be seen to the right of the stoma.

These techniques can also be used when combining the reconstruction of the stoma with a closure of a TE fistula. In this case, after removal of the voice prosthesis and closure of the fistula, the posterior tracheal wall may be strengthened by interposing other tissue, usually muscle, between the trachea and esophagus. The aim of such a procedure is to achieve a stoma with a proper diameter with a strengthened posterior tracheal wall (figure left). A secondary tracheoesophageal puncture can be performed after complete healing of the reconstructed stoma, after approximately six weeks.

### Comments

The etiology of tracheostoma stenosis may be related to one or more of the following factors: 1. Incorrect stoma construction at the time of laryngectomy.

2. Excessive scar tissue due to infection or fistula near the stoma or repeated trauma by cannulas.

3. Absent or defective tracheal rings at the stoma. (Stoma recurrence of carcinoma is regarded as having a totally different etiology and therefore not part of this discussion.)

The first reason is probably the most important. Preventive measures at the time of the surgery and in the direct postoperative period are the most valuable tools in the maintenance of a tracheostoma with an appropriate size and can avoid multiple reconstruction procedures. In our experience the best results are obtained when it is possible to create the stoma in the inferior skin flap, using a separate fenestra in the skin as described in the chapter on primary puncture (page 18).

Once a stoma has started to form fibrous tissue leading to stenosis, it is extremely difficult to arrest this process, and such a patient may be condemned to the use of a stoma button or cannula for all or much of the time. A reconstruction of the tracheostoma should then be considered. As mentioned above, stoma revision may also be a part of a tracheoesophageal (TE) fistula closure after which a stable fistula can be created after secondary puncture. The same procedure might be considered in certain patients, who have recurrent problems with granulation tissue, thickening of the wall, and resultant inward displacement and even “disappearance” of the prosthesis<sup>8</sup> as well as chronic widening of the TE fistula.

### **Conclusions**

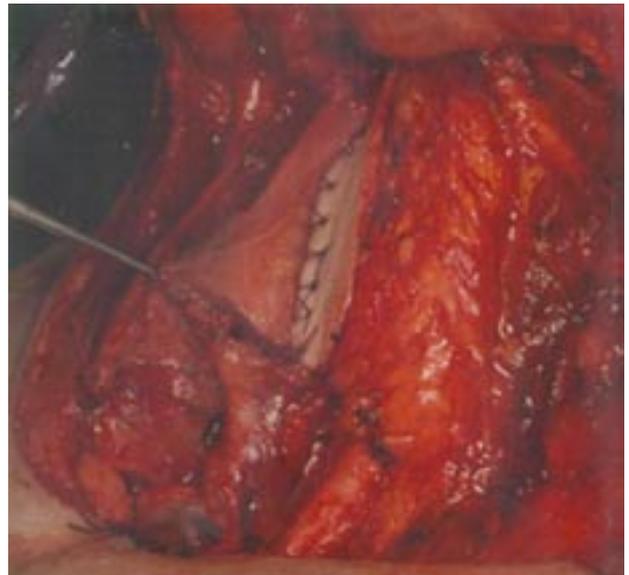
In the light of the current wide-spread use of voice prostheses after laryngectomy, we believe that tracheostoma construction and reconstruction should be planned in consideration with prosthetic voice rehabilitation. If the voice prosthesis is successful, we advocate the use of the lateral flap techniques in the reconstruction of tracheostoma stenosis. In that way the prosthetic speech production is uninterrupted. If the stoma stenosis occurs together with TE fistula problems, temporary closure of the fistula might be considered in the same procedure.

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## Pharyngeal reconstruction and prosthetic voice rehabilitation<sup>1</sup>

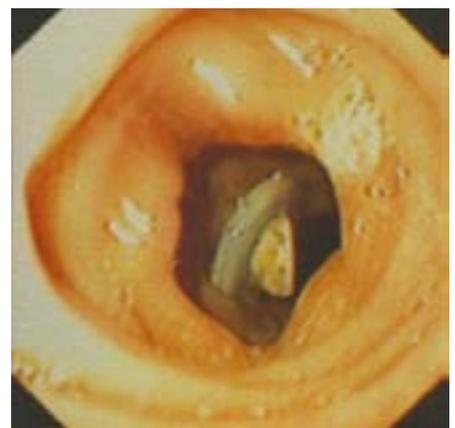
Voice rehabilitation after (sub)total laryngopharyngectomy with or without esophagectomy traditionally only has been possible with an electrolarynx. Reconstruction of the pharyngeal defect after subtotal pharyngectomy, with only a small strip of mucosa left, can best be achieved with a **pectoralis major myocutaneous (PM) flap** (figure right). The barium swallow of this reconstruction is shown in the figure below.



We have the experience that primary insertion of a Provox or Provox2 voice prosthesis after the application of a PM-flap results in a relatively good voice which is comparable to that after a standard

operation. We, therefore, prefer this method of reconstruction over the removal of the remaining mucosa strip and reconstruction of the pharynx with a free revascularized jejunum flap. The advantages of the PM-flap over the free jejunum flap are obvious: the PM-flap is readily available, is easily harvested, and requires little extra operation time; if constructed properly, there is little chance of stenosis; no abdominal surgery and no special microsurgical expertise are needed.

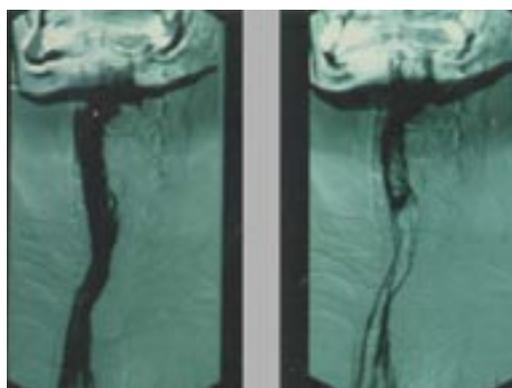
If, however, a total pharyngectomy has to be performed, the **free revascularized jejunum** reconstruction appears to be very reliable, and combined with a primary insertion of a voice prosthesis results in a fair voice in all patients, in whom we have used this type of reconstruction. The figure below to the left shows the jejunum flap after microvascular anastomosis; the figure below in the middle shows the barium swallow, 12 days postoperatively; the figure below to the right shows a voice prosthesis in the esophagus, just below the jejunum segment) The voice, however, is sometimes blocked by the autonomous peristalsis of the jejunum segment and sounds “wet” due to the continuous production of secretions. From a prosthetic voice rehabilitation point of view, the jejunum cannot be considered the ideal reconstruction method anymore.



Compared to a gastric pull-up operation (if a total esophagectomy is not indicated) the jejunum flap has some advantages: no need for esophagectomy, less abdominal trauma, no intra-thoracic trauma, no postoperative dumping syndrome, and primary prosthetic voice rehabilitation is possible. Alternatives are the use of a **revascularized tubed radial fore arm flap** or a **revascularized tubed greater curvature of the stomach**.



If the total laryngopharyngectomy has to be combined with total esophagectomy, reconstruction with a **gastric pull-up procedure** is our method of choice. A relevant observation in this respect is the improved vocalization by using a **greater curvature tube** instead of the complete stomach. The figure to the left shows an intra-operative picture of the tubed stomach pull-up in the neck and below to the right the postoperative barium swallow; note the excellent diameter of the tube, which is comparable to the normal esophageal diameter; the figure to the left shows a Provox voice prosthesis in situ in the lumen of a tubed stomach). The voice obtained with the tubed stomach clearly has a better intelligibility and loudness. Other advantages of a greater curvature tube over a complete gastric pull-up are: the transposition through the esophageal bed is less difficult, and there is less intra-thoracic cardio-pulmonary compression, and dumping.



The use of a **tubed free radial forearm flap or revascularized tubed greater curvature of the stomach** instead of a jejunum, which we recently have applied, also shows promising results. An example of the latter is shown below.



It is our experience that prosthetic vocal rehabilitation after extensive pharyngeal reconstruction is possible in virtually all patients and should be aimed for.

It can be concluded that in pharyngeal reconstruction, besides oncological and technical arguments, the possibility of applying primary instead of secondary prosthetic voice rehabilitation and the quality of the resulting voice should also play a role in the choice of the reconstruction method.

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# Replacement of the voice prosthesis

## Indications

A voice prosthesis is not a permanent implant, and needs periodic replacement. Indications for replacement can be divided in ‘**prosthesis-related**’, and ‘**fistula-related**’.

**Prosthesis-related** indications are leakage through the valve and obstruction. The most common indication (74%) for replacement of the Provox (1) and Provox2 voice prostheses is prosthesis-related, i.e. incompetence of the valve due to candida overgrowth, causing leakage of fluids through the valve. Obstruction of the prosthesis, leading to total blockage of the prosthesis and/or excessive pressure to obtain adequate speech, is a rare prosthesis-related indication for replacement (3%). If obstruction occurs, cleaning of the prosthesis by suction, preferably under endoscopic control, should be tried before replacement is undertaken. Inspection of the prosthesis can easily be carried out with a rigid 30<sup>0</sup> nasopharyngoscope or a flexible laryngoscope. In this way, inspection of the valve is possible and cleaning of distinct areas of the prosthesis is feasible. This often solves the problem without the need for replacement.

**Fistula-related** indications comprise of leakage around the prosthesis, hypertrophy and/or infection of the fistula, or spontaneous loss of the device. These indications form less than a quarter of the reasons for replacement. The majority of these indications are formed by leakage around the device, where a too long prosthesis causes a pistoning effect, by which fluids are squeezed around the device during drinking. In most cases, downsizing the prosthesis by inserting a shorter device solves this problem. It should be realized, that subsiding of surgical edema and tissue reaction is a natural course of events, especially with indwelling prostheses, which are not handled by the patients themselves (less trauma to the fistula); this means that during follow-up often a shorter prosthesis is sufficient.

This phenomenon is not considered to be an adverse event, in contrast to all other fistula-related indications, which will be discussed in the Troubleshoot section below.

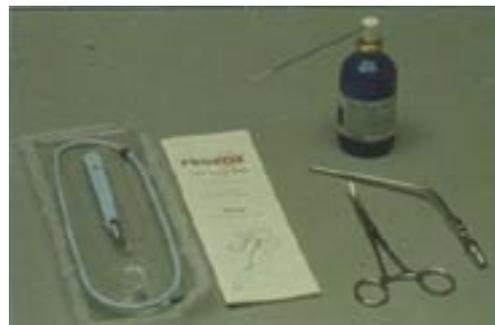
The mean device life of the Provox (1) and Provox2 voice prostheses in the Netherlands is approximately 5 months, but individual variations can be considerable. Shorter (4-6 weeks) and much longer durations of use (up to 10 years) have been observed. This has resulted in the Netherlands Cancer Institute in a median device life of 3 months.

For a complete overview of the long-term aspects of prosthetic vocal rehabilitation using the Provox System, we refer to the following paper: *OpdeCoul B, Hilgers FJM, Balm AJM, Tan IB, van Tinteren H, van den Hoogen FJA. A decade of postlaryngectomy vocal rehabilitation in 318 patients: a single institution's experience with consistent application of indwelling voice prostheses (Provox). Arch Otolaryngol Head Neck Surg 2000; 126: 1320-1328.*

## Replacement procedures

Replacement of both the original Provox (figure right) and the Provox2 voice prosthesis should be carried out by a medical professional trained in the procedure. A good view on the tracheostoma using a headlight is mandatory and a suction system is very helpful. Use a good metal suction tube. One or two curved non-toothed hemostats should be at hand.

With the original Provox prosthesis good assistance during replacement in the outpatient office, preferably by a trained nurse, is recommended. The replacement of the Provox2 prosthesis is considerably easier and can be carried out without assistance.



### Choosing the right prosthesis length



*The Provox prosthesis is replaced under local anaesthesia (10% lidocaine spray) as an outpatient procedure. Occasionally, the procedure may be carried out under general anaesthesia upon determination of the physician, for instance in case of a stenosis of the PE-segment.*



Care should be taken to replace the prosthesis with one of the correct length, in order to ensure proper function and to avoid undesirable side effects. A slightly too long prosthesis is not problematic, whereas a very tight fitting device might cause edema, which makes the prosthesis rapidly being 'too short'. During follow-up, the thickness of the trachea wall might change, due to subsiding of surgical or radiation edema, or due to infection, making the fistula tract shorter (left figure see also videoclip on cd-rom) or longer, respectively.



Therefore, never replace the prosthesis automatically with one of the same size. Always check first if the length is still correct by grasping the flange of the prosthesis with a hemostat and slightly pulling it outward (right figure). Judge the distance between the flange and the tracheal mucosa, and if this is less than 2-3 mm, the same length can be chosen. In case of a greater distance, the prosthesis length should be chosen accordingly, but it has to be kept in mind that only rarely more than one size down should be used.



In case the tracheal flange shows some deformation, this might indicate that the prosthesis is too short and a longer version should be used. Use of a prosthesis with a longer shaft should also be considered if the tracheal mucosa shows a tendency to become hypertrophic and to bulge over the tracheal flange.

In case of doubt, the Provox measure can be used to establish the actual length of the TE-fistula (in case of a 20-23 Fr. diameter prosthesis; figure right, see also videoclip on cd-rom).

In case of doubt, the Provox measure can be used to establish the actual length of the TE-fistula (in case of a 20-23 Fr. diameter prosthesis; figure right, see also videoclip on cd-rom).

### **Provox2 voice prosthesis**

Replacement of the Provox2 voice prosthesis is carried out with a disposable insertion tool (a loading tube and an inserter) for the anterograde insertion of the voice prosthesis directly through the stoma into the TE-fistula. This 'second generation' device has been adapted for anterograde insertion by having softer flanges (the esophageal flange being the more rigid one), and more curved junctions between the flanges and the shaft. This allows easier insertion in the loading tube and facilitates removal out of the TE fistula tract with a hemostat. The diameter of the shaft has not been changed, but the thickness of the esophageal flange is decreased from 1.6 mm to 1.5 mm, and of the tracheal flange from 1.6 mm to 1.3 mm. The size (=distance between the flanges) of the prosthesis is marked on the tracheal flange, to facilitate identification of the length of the prosthesis in situ. Sizes are 4.5, 6, 8, 10, 12.5, and 15 mm. To prevent accidental loss during its insertion, the Provox2 prosthesis has a security string, which extends in the axis of the flange and can also serve as the introduction string, if the voice prosthesis is inserted in the traditional retrograde manner through the pharynx. The possibility to replace this prosthesis both in an anterograde and in a retrograde manner makes the Provox2 prosthesis the most versatile prosthetic device presently available. The anterograde replacement procedure appears to be easily accomplished not only by Otolaryngologists, but also by other medical professionals, such as speech pathologists and oncology nurses (see videoclip on CD-rom).

Local anesthesia is seldom necessary. In some patients, the procedure may cause slight coughing reflexes, which might be dampened with a 4 or 10% lidocain spray into the trachea. Local anesthesia in the pharynx is not needed.

**Loading of the Provox2 voice prosthesis into the insertion tool:** the insertion tool consists of an inserter and a loading tube. The inserter has 2 mark-lines: number 1 is the line indicating the correct position of the prosthesis in the loading tube; number 2 is the line indicating that the esophageal flange is unfolded just outside the tip of the loading tube.

The safety string of the voice prosthesis is inserted into a slit of the inserter, and pulled in place to secure its position. Thereafter, the prosthesis is placed on top of the inserter (figure 1).

Next, the esophageal flange of the voice prosthesis is squeezed between thumb and index finger and hooked into the loading tube ensuring that the esophageal flange is folded forward (figure 2). The thumb of the other hand should push down and forward the flange, which is still protruding from the slit of the loading tube (figure 3). This flange has to be kept down firmly within the tube, while pushing the inserter forward until mark-line 1 is reached. Now the prosthesis is in the correct position for insertion (figure 4).



Fig 1



Fig 2



Fig 3



Fig 4

Fig 5



**Replacement of the Provox2 prosthesis:** the old Provox2 prosthesis is removed from the TE-fistula by pulling out the device with a non-toothed hemostat (see video at the end of this chapter). (In case a 'Provox1' prosthesis has to be removed, the Provox guide wire may be used for retro-grade transoral removal, as described below).

Alternatively, up to the clinician's discretion, the tracheal flange might be grasped with a hemostat and cut off, and the remainder of the device is pushed into the esophagus, allowing for natural passage through the intestinal tract. The patient's clinical history of abdominal diseases should hereby be taken into account.

The loading tube is inserted into the TE-fistula (figure 5) until the back wall of the esophagus is slightly touched. Then, with the loading tube kept in this position with one hand, the inserter, grasped between thumb and index finger of the other hand, is pushed forward until mark-line 2 is reached. The thumb should be used as an additional stopper, to keep the tracheal flange inside the loading tube at this time. In this position the forward folded esophageal flange is unfolded in the lumen of the esophagus.

Fig 6



Next, the complete insertion tool, this is the loading tube **and** the inserter together, is pulled back, anchoring the esophageal flange on the anterior esophageal wall. Then, the loading tube can be slid backwards, keeping the inserter in place, allowing the tracheal flange of the voice prosthesis to unfold properly (figure 6). Sometimes, this happens immediately. In other cases, the tracheal flange has to be unfolded deliberately, either by turning the inserter with the prosthesis around its axis, or by turning and pulling this flange into position with a non-toothed hemostat.

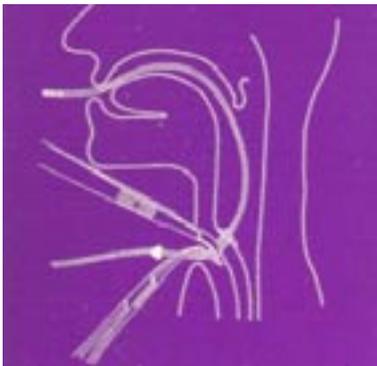
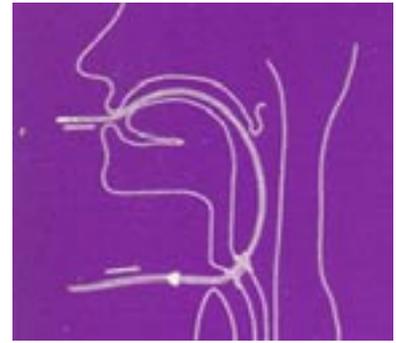
Fig 7



The proper position of the voice prosthesis can be checked easily by rotating and exerting slight traction on the tracheal flange, after which the safety string of the prosthesis can be cut off with a small pair of scissors, or a scalpel (figure 7). The Provox2 voice prosthesis is then ready for use.

## Replacement of the Provox (1) voice prosthesis

1) Obtain satisfactory local anesthesia of the trachea and oropharynx with lidocain 10% spray. Some experienced patients might prefer replacement of the prosthesis without local anesthesia, since the lidocain spray causes the same or sometimes even more irritation than the rapid replacement procedure itself. Introduce the guidewire through the old prosthesis and push it upward through the pharynx and out of the mouth. Often it is easy to grab the guidewire in the pharynx with a finger. Sometimes the introduction of the guidewire needs special attention. This is particularly true for the low positioned prosthesis. Grasping the tracheal flange with a non-toothed hemostat and changing the position of the prosthesis in a more upright direction, can facilitate the proper movement of the wire into the pharynx. In the rare event that the wire is trapped at the base of the tongue or tonsil, a tongue depressor and hemostat are useful in freeing the guidewire.



2) Grasp the tracheal flange of the prosthesis with a curved non-toothed hemostat, cut this off from the prosthesis with the disposable scalpel, included in the package, and remove it over the guidewire



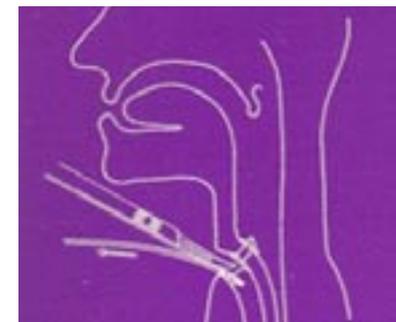
3) Remove the esophageal remnant of the prosthesis transorally with a push and pull action of the disposable guide wire that has a 8 mm stop halfway its length for this purpose.



4) Attach the new Provox voice prosthesis to the connector of the guidewire and secure it in its slid with a gentle pull of the introduction string of the prosthesis. Pull the wire the prosthesis towards the existing TE-fistula and ask the patient to swallow the new prosthesis.



5) Introduce the prosthesis into the TE-fistula. Because of the oval shape and flexibility of the tracheal flange the prosthesis can be introduced easily into the fistula, mostly with the help of the curved non-toothed hemostat. Finally, the introduction string is cut off with the disposable scalpel.



6) The prosthesis in situ after removal of the introduction string, ready for speech. Preferably, the long end of the tracheal flange points downward in the trachea

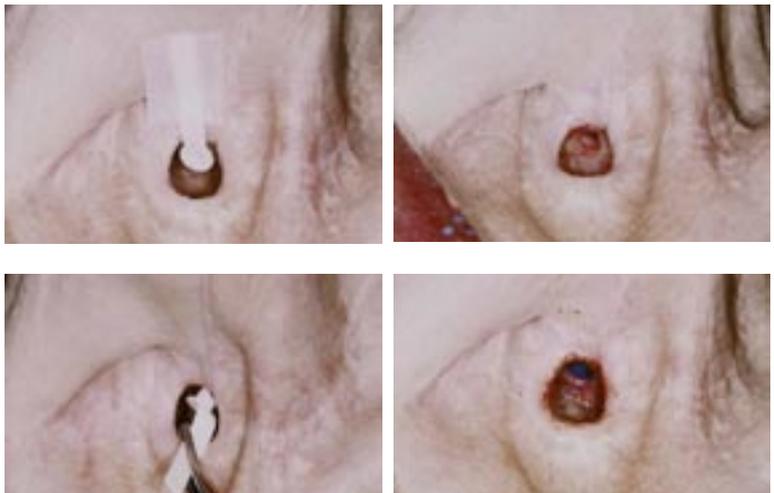
## **Replacement of other voice prostheses by Provox**

The Provox (1) and Provox2 voice prostheses can replace other voice prostheses, designed for use in a TE-fistula. In general, no problems are encountered with this replacement, as long as the length and the diameter of the TE-fistula are comparable with the dimensions of the Provox TE-fistula. The following rules for indwelling prostheses, such as Groningen and Blom-Singer devices, and non-indwelling prostheses, such as Blom-Singer or Bivona voice prostheses, can be of practical value:

### **Other indwelling voice prosthesis:**

if the TE-fistula is in the correct position no special measures have to be taken for replacement.

**Non-indwelling voice prosthesis:** because of the smaller diameter of these prostheses (16-20Fr), slight dilatation of the TE-fistula with the special Provox dilator after removal of the prosthesis may be needed. An example of a replacement of a Blom-Singer 16 Fr prosthesis for a Provox2 8mm prosthesis is shown in the pictures to the right. Due to the tapered end of the loading tube, no dilatation is needed in prostheses up to 8 mm of length. In the longer devices dilatation with the Provox dilator is strongly recommended. In these cases, the first introduction of the Provox or Provox2 device may sometimes be more easily accomplished under general anesthesia.



## **Additional remarks in conjunction with prosthesis replacement**

Patients should be advised not to eat shortly before replacement of the prosthesis. Replacement on an empty stomach prevents vomiting during the procedure.

Patients should be instructed to clean the prosthesis with the special Provox cleaning brush and/or the Provox Flush. Because of the unobstructed lumen of the prosthesis, patients are often also able to clean the device by forced expectoration with the stoma closed, and should be instructed to do so.

The oval shape of the tracheal flange is helpful in determining the optimal position of the prosthesis. The oval end should point downwards, in which position the oblique esophageal 'chimney' is cranial and 'protecting' the valve.

Occasionally, mild leakage through or around the prosthesis may occur in the first weeks after introduction of a new prosthesis. This is often temporarily and no reason for immediate replacement of the prosthesis.

# Troubleshooting in (indwelling) prosthetic voice rehabilitation

An essential aspect of prosthetic vocal rehabilitation is that from time to time patients using (any) voice prostheses may experience problems that require special attention of their medical professional to ensure long-term use of their device. Since a voice prosthesis is not a permanent implant, it needs occasional replacement, either by the patient him/her self in case of a non-indwelling device, or by a medical professional in case of an indwelling prosthesis. The reasons to replace the voice prosthesis can be either device-related or fistula-related. The main reason for replacement is device-related, i.e. leakage through the voice prosthesis. Less frequent are fistula-related reasons, such as local infection, atrophy of the party wall, or increased resistance during voicing. This troubleshooting section will pay attention to all typical problems and adverse events that may interfere with optimal prosthetic voice rehabilitation. Proper attention for and solution of these issues will determine the ultimate success rate of this presently optimal method of vocal rehabilitation after total laryngectomy.

**It is important to verify at each clinic visit the status of the prosthetic device, and if there are any problems, to establish their exact nature.**

The following list of 10 points should be kept in mind when a patient needs replacement of his/her Provox (2) device:

- 1. Determine the indication for replacement (leakage through or around, infection of the TE-fistula tract, etc.)**
- 2. Determine the required length of the new prosthesis (never automatically replace the existing device with one of the same size)**
3. Prepare the prosthesis for insertion (attaché the prosthesis to the inserter, fold the esophageal flange forward in the loading tube and advance the inserter to mark line 1)
4. Remove the old prosthesis with a non-toothed hemostat, and ask the patient to keep his/her mouth open (this prevents swallowing and thus aspiration) until the prosthesis is replaced
5. Insert the loading tube into the TE-fistula and advance the tube towards the posterior esophageal wall, making sure that the tip is inside the lumen of the esophagus
6. Advance the inserter until mark line 2 is level with the backside of the loading tube, using the thumb as a 'stopper'
7. Pull back the inserter and the loading tube together, anchoring the esophageal flange on the anterior esophageal wall
8. Remove the loading tube, unfolding the tracheal flange (if necessary use one or two hemostats in case the tracheal flange is still in the TE-fistula, or in case of 'overshooting')
9. Ensure proper retention of the prosthesis by rotation and/or up and down movement of the prosthesis on the inserter
10. Cut the security string of the prosthesis and rotate the prosthesis into its optimal position with the cut edge pointing caudally.

Points 1 and 2 are important for any replacement procedure of any voice prosthesis, the other points are obviously relevant for Provox2 only. Nevertheless, the most common mistakes are made against Points 1 and 2. For instance, if the leakage problem is not identified as leakage around the prosthesis, simple replacement with a device of the same length is not helping much. If, due to a local infection and overgrowth of the mucosa in the esophageal lumen, the prosthesis is pushed outward/extruded, not identifying this problem and replacement with a shorter device will increase the problem. Fortunately, the problems and solutions discussed here are relatively rare and are mostly easily manageable, if recognized in time (1, 2).

**Definition problems/adverse events:** all 'fistula-related' indications for replacements, except leakage around the prosthesis, if downsizing can solve this. (Subsiding of surgical edema and tissue reaction is a natural course of events, especially with indwelling voice prostheses, which are not handled by the patients themselves (little trauma to the fistula); this means that during follow-up often a shorter prosthesis is sufficient).

Problems or adverse events are mostly minor and their treatment is generally not too difficult. As a rule of thumb one can say, that in daily practice two-thirds of the patients have no problems what so ever, and they consume approximately one-third of the total time, spent on prosthetic voice rehabilitation. These patients only visit the outpatient clinic once in a while for replacement of the prosthesis when it becomes incompetent and shows mild leakage of fluids. The other one-third of the patients occasionally has problems, which need special attention and they consume the other two-thirds of the total time, spent on prosthetic voice rehabilitation. However, this concerns only 11% of the replacements, which means that the patients in this category usually have non-problematic replacements(2). If this one-third of the patients is treated properly, success rates up to 90% can be expected. It should be noted, that the **influence of radiotherapy** on the final outcome of the voice rehabilitation seems to be minor. There is no increase in immediate postoperative complications, but a temporary deterioration of the voice during postoperative irradiation must be reached. Furthermore, we found a decrease in device life and an increase in fistula-related complications in radiated patients, but these have rarely prevented the application of this prosthetic rehabilitation method in this patient category.

## Device-related replacement issues

**Leakage through the prosthesis** may occur in association with candida overgrowth or displacement of the radiopaque ring (valve seat). Endoscopic examination should be performed to determine whether either of these phenomena has occurred. Dislodgment of the radiopaque ring is an indication for replacement of the prosthesis and also for thorough examination of the patient to make sure that the dislodged ring not has been aspirated. If so, it should be removed immediately from the tracheobronchial tree with appropriate bronchoscopy equipment. If the radiopaque ring has not been dislodged, and if cleaning of the prosthesis does not resolve the leakage through it, the cause is usually candida overgrowth and replacement of the prosthesis is indicated.

### **Candida overgrowth**

Candida overgrowth of the prosthesis is a phenomenon occurring in almost all patients. A typical example is shown in the figure to the right. As long as there is no leakage through the prosthesis caused by candida deposits, there is no reason for special action. The mere presence of candida by itself is not a reason for replacement of the prosthesis. However, if frequent replacements of the prosthesis are needed due to candida overgrowth, some form of treatment with antifungal agents might be considered (3-6). We prefer to use mycostatin oral solution, which also should be applied topically with the cleaning brush directly into the prosthesis. In some patients an improved device life was observed with this method.



The upper figure to the left shows an example of a prosthesis “treated” with mycostatin during 5 months, only applied with the brush. Only on top of the prosthesis, not reached with the brush, excessive candida vegetations are present. The valve became incompetent because of a small candida deposit on the free edge of the valve. The next figure shows an endoscopic view of a voice prosthesis with candida deposits just prior to replacement. Also a combination of oral and local application of Diflucan or Trisporal is an option. Mycostatin is given two to three times daily (500.000 U, 5 ml). Diflucan (50 mg, 5 ml) or Trisporal (100 mg, 10 ml) suspensions are given once daily. All these medications should be applied with a swish and swallow action, and in addition applied into the prosthesis, using the brush.



**Problem:** *the patient needs very frequent replacements due to leakage through the prosthesis, e.g. every 3-4 weeks.*

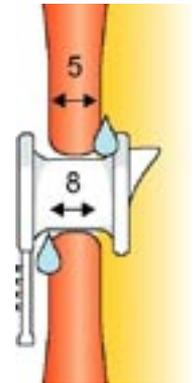
This very short device-life in the vast majority of cases is caused by rapid overgrowth of candida, leading to incompetence of the valve mechanism. Aside from prescription of anti-candida medication, as

described above, there is laboratory and clinical evidence that dietary changes might influence the device-life of a voice prosthesis (7-10). Although biofilm formation is the first step to candida adherence and growth on the silicon material of the device, it seems that the consumption of probiotic dietary products can decrease the ‘candida burden’ in the pharynx and esophagus. It can be worthwhile to ask the patient about their dietary habits, and suggest changes in case rapid candida overgrowth seems the cause of a short device life. There is also anecdotal evidence that diminishing the consumption of ‘candida or yeast rich food’, such as beer and certain cheeses might decrease this problem as well.

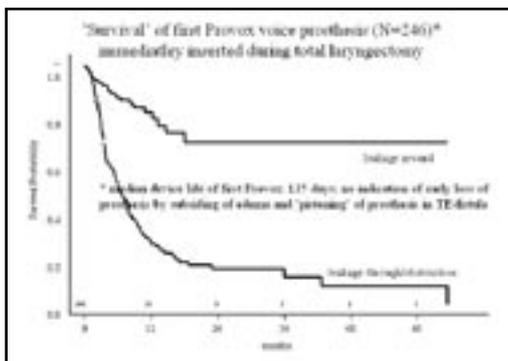
## Fistula-related issues and problems

**Issue:** *the patient experiences leakage around the prosthesis and the prosthesis is too long.*

After primary or secondary TEP, subsiding of the inevitable surgical edema and tissue reaction is a natural course of events, especially with indwelling voice prostheses, which are not handled by the patients themselves (little trauma to the fistula). This means that during follow-up gradually the prosthesis might become too long (see figure right). If in the mean time no replacement for leakage through the prosthesis was necessary, this might result in a 'pistoning' of the prosthesis during swallowing, whereby fluids are squeezed around the prosthesis, leading to aspiration and coughing (see figure right and animation on the CD-rom). This problem often can be solved easily by inserting a shorter prosthesis. From our experience it is probably better not to downsize more than one size, because a too tight fit might cause swelling and edema, making the device quickly too short, whereas a slightly too long device is much less problematic.



**Issue:** *does the immediate insertion of a Provox voice prosthesis during primary or secondary TEP lead to replacement of many prostheses for leakage around the device*



The gradual subsiding of the surgical edema and tissue reactions, which eventually leads to a decreased length of the TE fistula tract, is a process that

in most patients takes many months. This means that in most patients leakage through the device is still the main indication to replace the first voice prosthesis. This can be deduced from the survival/device-life curve (see graph left), which



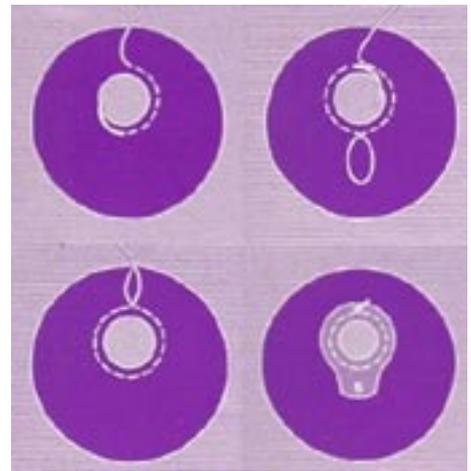
shows the fate of 246 Provox voice prostheses inserted during primary TEP at the time of laryngectomy (an immediate postoperative picture is shown to the right). This survival/device-life curve is based on our data, published by Op de Coul et al. 1999. As can be seen, the vast majority of prostheses are replaced for leakage through the prosthesis, while replacement for leakage around is much less frequently needed. Interestingly enough, the median device life of the first prosthesis is clearly longer than that of the following devices in this series (135 versus 89 days).

**Problem:** *the patient has leakage around the prosthesis and the shortest (4.5 mm) prosthesis is already in situ.* Atrophy of the tracheoesophageal party wall is a problem that is encountered with all the presently available voice prosthesis systems. This is a real fistula, i.e. tissue-related and not a device-related problem. Most probably, this atrophy is mainly a side effect of radiotherapy.

Immediately after replacement, a slight leakage around the prosthesis may occur for some hours or a few days, but this may well be decreasing spontaneously. Therefore, a short observation time is advisable. However, if this leakage does not decrease spontaneously, there are several solutions for this atrophy problem.

The traditional option is temporary (often several days) removal of the prosthesis and insertion of a cuffed trachea cannula and/or nasogastric feeding tube to allow for shrinkage of the fistula. Obviously, this is uncomfortable for the patient, and may require hospitalization of the patient. Therefore, we prefer an instant and for the patient more comfortable solution, which is the application of a purse string suture around the fistula tract, using an atraumatic absorbable 3.0 vicryl suture.

The procedure is shown schematically in upper figure. First the old prosthesis is removed and the suture is inserted submucosally at 12 o'clock at a distance of 1-2 mm of the fistula edge (top-left). The needle is curved around the fistula tract, coming out at 6 o'clock. The needle is inserted again and curved upward submucosally to 12 o'clock again (top-right). Then, the new prosthesis is inserted and the suture is carefully tied, causing the fistula wall to be tightened around the prosthesis (bottom left and right). The middle and lower figure show a typical case pre and post suture placement. The suture should not be removed, but left for spontaneous absorption. This has an augmentation effect on the fistula wall, curing the problem. A short course of a broad-spectrum antibiotic treatment should be given to prevent local infection. If leakage around the prosthesis is intractable to more conservative surgical measures, surgical closure of the fistula and subsequent re-puncture may be necessary (*see chapter Surgical procedures*).



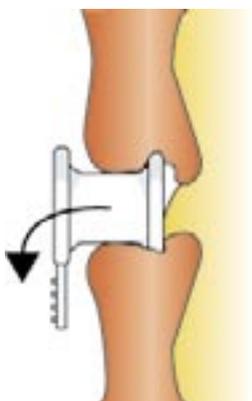
**Problem:** *there are signs of local infection (redness, tenderness, granulation), but the prosthesis still seems of the right size and is functioning properly.*

In most cases of local infection there is also edema and granulation tissue formation, present. However, if these latter phenomena are not occurring, treatment with broad-spectrum antibiotics with or without corticosteroids can be adequate to control this infection. An example of an infection can be seen in the top figure, with the result of antibiotic treatment after 2 weeks in the lower figure. However it is of utmost importance to verify that the prosthesis really is of the right size/length, since undue pressure of the prosthesis on the mucosa of the party wall will further increase the infectious edema. Upsizing of the prosthesis is then required.



**Problem:** *there are signs of local infection (redness, tenderness, granulation), the prosthesis is displaced (drawn inwards or pushed outwards), and the voice is sub-optimal*

In most cases of infection around the prosthesis, granulation formation and/or edema will occur to the extent that the fistula tract becomes longer. As a result, the prosthesis may be drawn inwards and disappear under the tracheal mucosa, or conversely, the prosthesis may be pushed forward out of the fistula tract due to overgrowth of the mucosa on the esophageal side of the TE-fistula. This last phenomenon is the most common course of events in case of infection and is schematically shown in the animation on the CD-rom and the figure to the left.



Such an infection is noticed by the patient because of a slight increased effort in voicing. The figure shows an example of such a case of excess tissue formation on the esophageal side, which prolapsed slightly after removal of the prosthesis. A

spseudodiverticulum is the result, which should not be considered as a separation of the party wall, as often is assumed. Temporary replacement of the prosthesis with a longer version is then advisable. Treatment with broad-spectrum antibiotics with or without corticosteroids is often adequate to control this infection. If the infection is not cured by this treatment with the prosthesis in situ, the prosthesis should be removed and further healing should be awaited. If by this process the fistula tract closes spontaneously, secondary re-puncture for insertion of a new prosthesis may be required (*see chapter Surgical procedures*).



**Problem:** *the prosthesis is extruding from the fistula tract.*



**Reminder:**  
a "too long" prosthesis  
with an increased effort  
in voicing might be a  
"too short" prosthesis.



Protrusion of the prosthesis and subsequent spontaneous extrusion is sometimes observed during an infection of the TE-fistula. This phenomenon has been also observed sometimes after (too) rapid downsizing of the prosthesis. Removal of the prosthesis is mandatory to avoid dislodgment into the trachea. Often the fistula tract is still patent and it is possible to ‘salvage’ the fistula and thus the voice by inserting a proper length device, either anterograde or retrograde. The figures show such a situation, in which the TEP could be salvaged: top spontaneous extrusion; middle fistula tract after removal of prosthesis; below-left insertion of a longer device; below-right the well-healed fistula after 10 months, when the patient came for his next replacement for leakage through the device. If this is not possible, the fistula tract may close spontaneously secondary to the removal of the prosthesis and resolution of the infection, for which antibiotic treatment might be needed. Secondary re-puncturing is then necessary in order to re-establish the prosthetic voice.

**Problem:** *granulation tissue is interfering with the voice prosthesis.*



Formation of granulation tissue around the TE-fistula has been reported at a rate of approximately 5%. Mostly this is seen in conjunction with a local infection and treatment of such an infection will result in spontaneous disappearance of the granulation, as shown above. If this is not the case or if immediate treatment is required in order to improve the voice, some sort of cauterization (electro-, chemo-, laser) of the area of the granulation may be considered. In conjunction with this, treatment with a broad-spectrum antibiotic is advisable. The figures right give an example of this: above prior to NdYAG laser excision, below the situation after 2 weeks. There is some circumstantial evidence of a causal relation between local infection

and/or granulation tissue formation at the TEP site and gastro-esophageal reflux. Therefore, it could be beneficial in treatment of refractory cases, to prescribe anti-reflux medication in order to break a 'vicious circle'.

**Problem:** *hypertrophic tissue has developed in the TEP area, interfering with the voice prosthesis position and/or function.*

This phenomenon may sometimes occur when the prosthesis is relatively short, leading to bulging of the tracheal mucosa over the tracheal flange. This excess tissue can often be removed by using a laser (CO<sub>2</sub> or NdYAG), without having to remove the voice prosthesis. Alternatively, a longer prosthesis can be used.



The top figure shows a mild form of hypertrophic scarring. There is excess tissue formation that pushes the prosthesis outwards. This tissue also can be removed with the NdYAG laser (or with ordinary cauterization equipment, of course). The result 2 weeks after this treatment can be seen in the lower figure.



Another example is shown in the lower 3 figures. The first picture shows the excess tissue, the next the situation after diomed laser removal and replacement of the vice prosthesis, and on the last picture the removed tissue is shown.



**Problem:** *voicing is increasingly difficult, and/or after replacement the voice does not improve.*

There are 2 reasons for this problem. The first reason is that prosthesis might have become too long due to the gradual subsiding of the edema of the party wall. During digital occlusion of the stoma, the too long prosthesis might then be pushed into the esophageal back wall, by which the flow of air is obstructed, leading to a strained voice. Additionally, this might cause edema of the back wall, escalating the problem. Furthermore, these patients also might complain of a foreign body feeling and/or a decreased passage of solids. This problem is easily detected when rule number 2 of the replacement procedure is correctly executed: by pulling with a hemostat on the tracheal flange, the proper length of the prosthesis should be established (as shown in the figure right). A good, additional method to detect that the too long prosthesis is the problem, is to let the patient voice without the prosthesis in situ: if the too long prosthesis is the problem, voicing will be easier without the device in situ. In this situation downsizing is the obvious solution.

The other reason for this problem is 'overgrowth' of the prosthesis with esophageal mucosa, which has not been identified at the time of

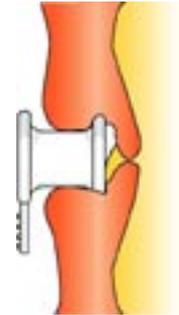


replacement (see also ‘separation of the party wall’). It is of utmost importance that the esophageal flange of the prosthesis is really situated in the esophageal lumen. This can be verified by carrying out a flexible endoscopy, but this might not always be available and is also seldom necessary. The best way to ensure that the esophageal flange is in the esophageal lumen, in case of doubt, is to ‘overshoot’ the prosthesis into the lumen of the esophagus and then pull the device in place with the help of one or two hemostats. Another option is to use the traditional retrograde method, which always ensures proper positioning of the esophageal flange. Although this latter procedure is seldom needed in daily practice, it should be kept in mind as a problem solver.



**Problem:** *anterograde insertion is difficult due to local infection.*

A good option in such a case is to use the traditional retrograde method, an example of which is shown to the right) which always ensures proper positioning of the esophageal flange. Although this latter procedure is seldom needed in daily practice, it should be kept in mind as a problem solver. Therefore, a separate disposable guide wire should always be at hand.

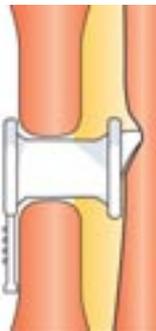


**Problem:** *the voice sounds strenuous and speaking requires too much effort*

Hypertonicity is the main cause of increased effort in voicing. This phenomenon becomes obvious mostly immediately after (primary or secondary) insertion of the voice prosthesis, but also may become apparent at a later date, e.g. after the end of post-operative radiotherapy. The solutions are described in the sections hypertonicity, speech therapy, and videofluoroscopy. Here it suffices to mention that proper speech therapy should be attempted, before advancing to the more invasive options of Botox injection or myotomy. However, treatment of hypertonicity is very worthwhile and rewarding.

**Problem:** *there seems to be a ‘separation of the party wall’*

A real separation of the party wall is a phenomenon that we have never seen in conjunction with the application of indwelling devices. Due to the retrograde primary or secondary insertion technique, the party wall is not at risk for separation during the surgical procedure. Furthermore, due to the fact that the first replacement is mostly only necessary after several months, by then, the party wall is stabilized and the fistula tract is well established. Therefore, if there seems to be a separation of the party wall, this is generally secondary to local infection, edema and overgrowth of esophageal mucosa (as simulated in the animation on the Cd-rom and the figure to the left). This results in a pseudo-diverticulum as can schematically be seen in the animation. Often the prosthesis is also pushed outward and therefore seems too long (see also Problem: *there are signs of local infection etc.*). If this ‘separation’ is noted, the obvious solution is to insert a longer device, bridging the whole TEP tract. We have observed that by this approach the pseudo-diverticulum disappears. However, the next replacement should be carried out with even more attention than normal, in order to avoid reoccurrence of this problem.



**Problem:** *voicing is blocked by finger pressure on the stoma/voice prosthesis*

If the prosthesis is too long, the patient might press the device with his finger into the back wall of the esophagus, thereby partly or even completely blocking the airflow (as simulated on the figure to the left and on the CD-rom). Aside from causing a voicing problem, this ultimately might lead to damage and/or necrosis of the back wall of the esophagus, which potentially is a serious complication. This problem can be encountered e.g. after an infectious episode, for which a longer device was inserted. After subsiding of the infection granulation and edema, the prosthesis will be too long. If this does not result in leakage around the device, this too long prosthesis might stay in situ for a prolonged period of time, ultimately causing the problem discussed here. Another cause might be the constant pressure of a cannula onto the voice prosthesis, pushing the prosthesis into the back wall of the esophagus.

In the first example, the obvious solution is replacement of the device with one of the proper size. In the second example, if insertion of a shorter prosthesis is not an option, it should be tried to lower the pressure onto the voice prosthesis by decreasing the diameter of the cannula or try to avoid the use of a cannula completely, e.g. carrying out a stoma plasty. Also, the use of an automatic speaking valve like the FreeHands HME can solve this problem, by taking away the digital pressure on the voice prosthesis.

**Problem:** *there is an elevated intra-tracheal pressure, c.q. effort needed for voicing*

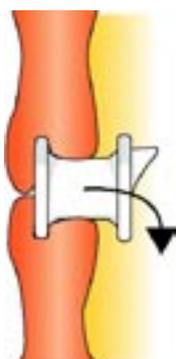
Reasons for this are hypertonicity of the neoglottis, a too long prosthesis (see previous page), esophageal mucosa overgrowth, radiotherapy edema. See the different sections for the solution.

**Problem:** *during and after removal of the prosthesis some bleeding is noticeable*

Slight bleeding from the edges of the TE-fistula may occur during replacement of the prosthesis. This is mostly the result of removal of the old device and not of the insertion of the new prosthesis. This bleeding will normally cease spontaneously. Patients undergoing anticoagulant therapy should be carefully evaluated for the risk of hemorrhage prior to placement or replacement of the prosthesis. It is also advisable to reassure the patient that the traces of blood they might notice in the sputum in the first few days after replacement of the prosthesis are not worrisome and no sign of a pulmonary malignancy. Obviously, if they keep seeing these traces of blood they should be encouraged to make an earlier clinic appointment in order to establish whether some form of diagnostic imaging is needed.

**Problem:** *the voice prosthesis has disappeared and seems to be ingested*

Accidental ingestion of the Provox or Provox2 voice prosthesis or other components of the Provox voice rehabilitation system may occur. Possible causes could be a local infection of the TE-fistula or the constant pressure of a trachea cannula, causing gradual overgrowth of tracheal mucosa. The figure on the left



(and the animation on the CD-rom) shows a possible course of events. In case of disappearance of the prosthesis, verify whether the device is indeed ingested and is not just hidden in the fistula under the mucosa. As with any other foreign body, the symptoms caused by ingestion depend largely on the size, location, degree of obstruction (if any), and the length of time it has been present. The ingested component in the lower esophagus may be removed by esophagoscopy or observed for a short period of time. The object may pass spontaneously into the stomach; in that case most foreign bodies usually pass the intestinal tract. Surgical removal of foreign bodies in the intestinal tract must be considered if bowel obstruction occurs, bleeding is present, perforation occurs, or if the object fails

to pass through the intestinal tract. In case a reinsertion of the voice prosthesis is considered, proper measures should be taken to avoid reoccurrence of the ingestion (see leakage around the voice prosthesis).

**Problem:** *the voice prosthesis has disappeared and seems to be aspirated*

Aspiration of the prosthesis, once properly inserted in the fistula, is very unlikely, due to the rigidity of the esophageal flange. However, in case of an atrophy of the party wall and widening of the TEP tract (an example right), accidental aspiration of a voice prosthesis is a potential problem. If a Provox or Provox2 voice prosthesis (or any other component of the Provox voice rehabilitation system) is aspirated, immediate symptoms may include gagging, coughing, choking, or wheezing. As with any other foreign body, complications from aspiration of a component may be caused by an obstruction or infection, and may include pneumonia, atelectasis, bronchitis, lung abscess, bronchopulmonary fistula and asthma. If the patient can speak or breathe, coughing may dislodge the foreign body without the need for emergency action. Partial airway obstruction or complete airway obstruction requires immediate intervention for removal of the object. In case a reinsertion of the voice prosthesis is considered, proper measures should be taken to avoid reoccurrence of the aspiration (see leakage around the voice prosthesis).



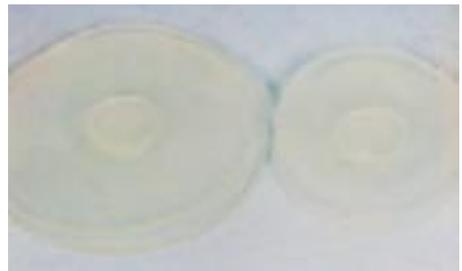
**Problem:** *the TE fistula is too wide to hold a voice prosthesis and surgery is not an option anymore*

A rare example of such a situation is shown in the top figure. The patient was in an end stage of a second primary cancer (non-small lung carcinoma) and severely cachectic. The solution was blocking the TE fistula with a nasal septal button, which was cut into shape (top left figure). In the next figure the situation after anterograde insertion of the nasal septal button is shown. In this way the intractable aspiration was stopped and the patient could tolerate liquids again.



**Problem:** *the patient has a stenosis of the neopharynx*

A stenosis of the neopharynx (mostly influencing swallowing more than voicing) does not interfere with the anterograde replacement of a voice prosthesis, but obviously can be a problem in a retrograde replacement procedure. If a neopharyngeal stenosis is suspected or known, and retrograde replacement is necessary, this is preferably carried out under general anesthesia with concurrent dilatation of the PE-segment. If the stenosis is less prominent, dilatation under local anesthesia and subsequently the required retrograde replacement of the prosthesis may still be possible. Although with the anterograde replacement of a Provox2 prosthesis a pharyngeal stenosis is not causing replacement problems, its dilatation might still be necessary for other (swallowing) reasons.



**Problem:** *due to a small stoma anterograde replacement is difficult*

In experienced hands the replacement procedure is quick enough to allow a short blockage of the stoma without 'choking' the patient. Also, if the diameter of the stoma is so small that the loading tube is completely obstructing it, the patient probably should wear a trachea cannula, like the LaryTube, anyway. This should dilate the stoma well enough to allow replacement of the prosthesis. Otherwise a stoma plasty could be indicated. Another option is to use the traditional retrograde replacement method with the guide wire.

**Problem:** *the patient has a deep stoma interfering with the application of peristomal devices*

Although a deep stoma (an example is shown left), if not very narrow, is seldom interfering with replacement of a voice prosthesis, it can be a problem for proper peristomal attachment of an HME or automatic speaking valve. To avoid a deep stoma in the first place, we advise to cut the sternal head of both sternocleidomastoid muscles. If this problem is observed later, this cutting of the SCM muscle can be done for instance in conjunction with a stoma plasty.



**Problem:** *the TE fistula is positioned deep down in the trachea, making the replacement more troublesome*

The correct position of the TE-fistula is of great importance. The center of the fistula should be approximately 5 mm below the mucocutaneous junction of the trachea. The figure to the right shows such an ideally situated prosthesis. A much lower position (as shown in the lower figure) can induce problems for the patient in cleaning of the prosthesis, might make replacement more cumbersome and could be the cause for easy leakage of fluids through the prosthesis. If any of these problems interfere with optimal function of the prosthetic voice rehabilitation, closure of the fistula and secondary puncture at a later date could be beneficial.



**Problem:** *the TE fistula is migrated upwards outside the trachea, making voicing problematic*

This is an extremely rare problem in an indwelling voice prosthesis system like Provox. This is probably due to the lack of any tension upwards, unlike non-indwelling prostheses. If any 'migration' occurs, this is most probably downward migration, an example of which is shown on the previous page. The top figure is only one of two cases of upward migration we have ever seen with indwelling prostheses. In this case, the patient underwent a gastric pull-up procedure with reconstruction of the neck skin with a PM flap with split skin coverage. Although everything healed well, over a course of more than 5 years the situation shown developed. The patient was still able to achieve airtight stoma occlusion by using the Provox HME adhesive to cover the voice prosthesis area together with the tracheostoma. However, at a certain point this became too problematic and, therefore, the fistula tract was closed with a local skin rotation flap. After 6 weeks, a new secondary TEP was carried out with the result shown in the lower figure. At "11 o'clock" the closed TEP scar still can be noticed.

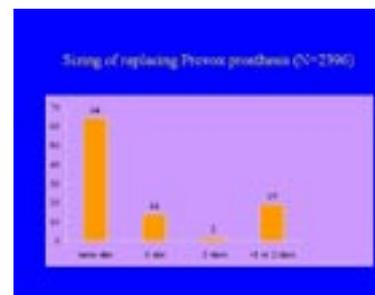


**Problem:** *during retrograde insertion the guide-wire gets stuck in the neoglottis*

During the retrograde replacement of the Provox prosthesis, the guide-wire may become entrapped in the pharyngeal mucosal wall. By applying a smooth introduction movement and slight pressure, the guide wire will generally bend near the tip and still slide upward through the pharynx.



**Issue:** *How much should I downsize in case of shortening of the fistula tract*  
 In case the natural subsiding of edema requires downsizing the prosthesis, it is advisable to downsize not more than one length. It is mostly sufficient to downsize only one size/length, e.g. from 12.5 to 10 mm, or from 8 to 6 mm. Downsizing two sizes might result in a 'perfect' fit and initially might look good, but if some edema develops, the device might rapidly become too short. Furthermore, the system has a good tolerance and a slightly too long prosthesis causes less trouble than a tight fitting one. As can be seen from the graph to the left (from Op de Coul et al. 1999) downsizing more than one size is rarely indicated and in fact should be discouraged for the above mentioned reason.



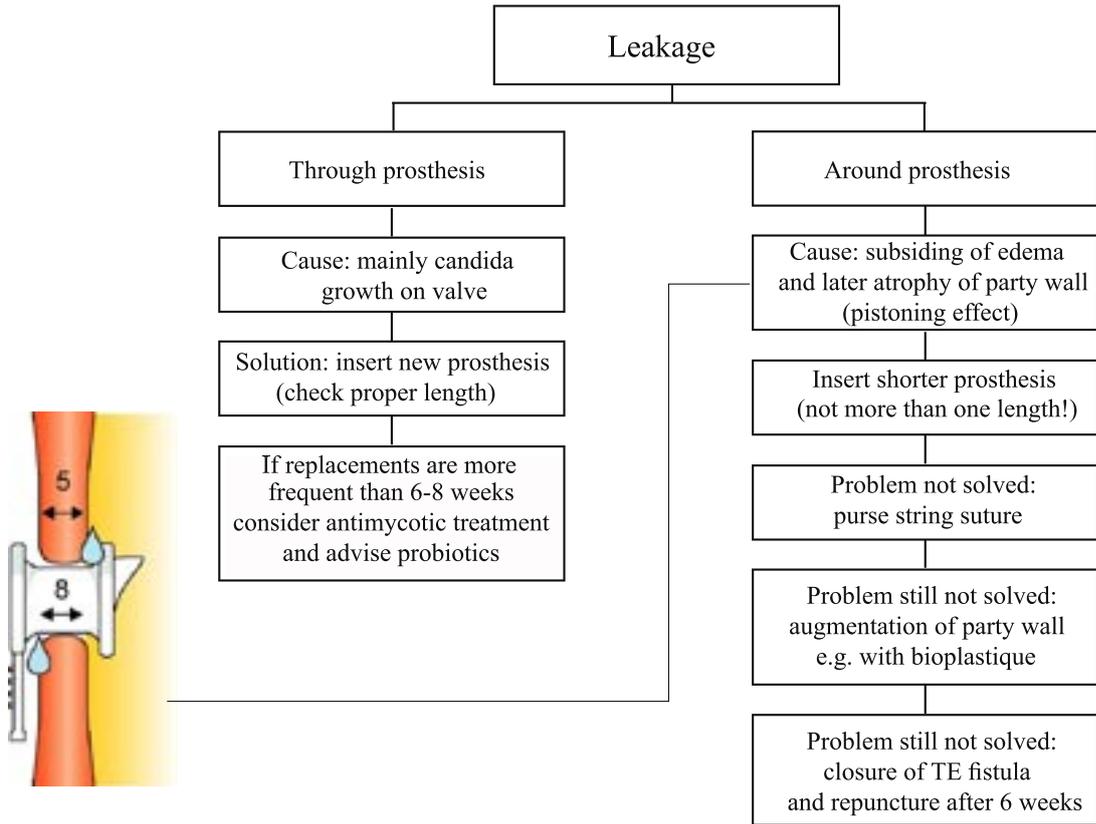
**Issue:** *can I remove the old prosthesis by pushing the device into the esophagus and let nature take its course*  
 Although it has been common practice for many medical professionals to push the prosthesis through into the esophagus, allowing the device to travel through the intestinal tract, some caution should be given here. Although this rarely has caused problems, some incidences have been reported that are worthwhile mentioning. In our Institute we have had a patient in whom the prosthesis caused esophageal obstruction, because it became trapped onto a till then undetected esophageal carcinoma. There are also reports on a case of sub-acute bowel obstruction in a patient with a history of abdominal surgery. Finally, there is a report on a case of acute appendicitis, in which the voice prosthesis was found in the resection specimen of the appendix. These examples have to be kept in mind if the choice is made to push the prosthesis through the TEP fistula into the esophagus.

### **Voicing problems:**

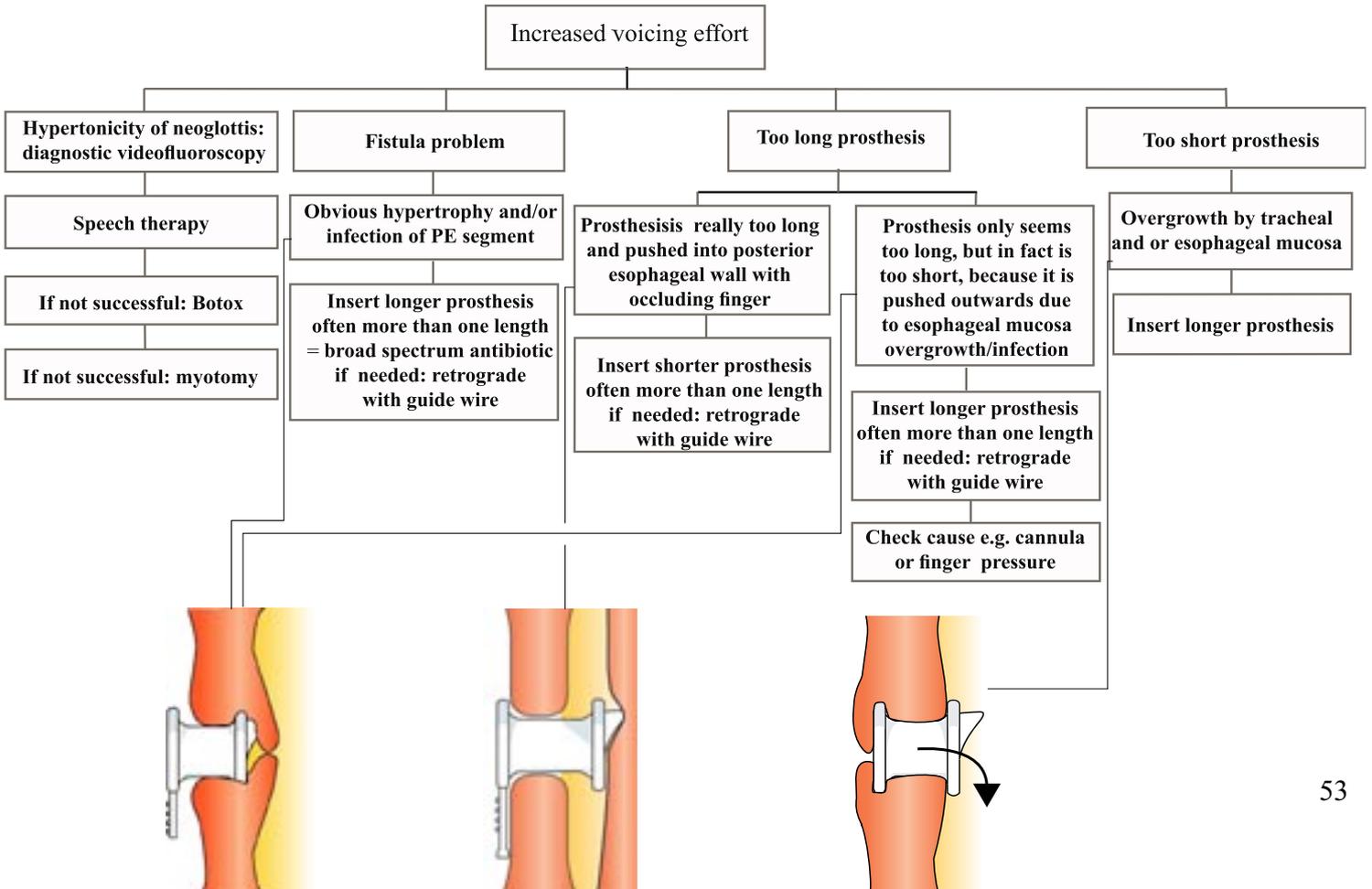
**see Speech Pathology chapter, section Problem solving.**

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**Troubleshoot-algorithm for leakage as main complaint**



**Troubleshoot-algorithm for increased voicing effort as main complaint**



# Voice and Speech Therapy

## Introduction

Sizing of replacing voice Tracheoesophageal and esophageal voice production have in common that the PE segment is the sound source, but they do differ in the air supply to this source. Conventional esophageal voice is obtained by injecting relatively small amounts of air (60-80 ml) from the mouth into the esophagus and redirecting this column of air upwards through the PE segment. Prosthetic voice production, however, like normal laryngeal voicing, is pulmonary driven. Much like the vocal fold mucosa in laryngeal voicing, the PE segment mucosa is vibrating and mucosal waves can be seen with high-speed digital imaging during such voicing (Van As et al., 1999). Speech and voice therapy in TEP prosthetic speakers, therefore, resembles normal laryngeal voice training.

## Preoperative counseling

In all clinics in The Netherlands, that serve laryngectomized patients, preoperative counseling by the speech pathologist is customary. Basic preoperative counseling involves explaining the basic principles of vocal rehabilitation as well as related aspects. For example, possible interfering factors such as problems with hearing, reading, writing, and visual acuity are addressed. The patient's manual dexterity is assessed. Also, in most clinics, it is common to involve a laryngectomized visitor in the counseling of the patient prior to the laryngectomy; this is often done to familiarize him/her with the postoperative situation and to demonstrate the possibilities of voice rehabilitation and other aspects of postlaryngectomy life. Several authors have stressed the relevance of this approach in laryngectomy rehabilitation (Mohide, Archibald, Tew, Young, & Haines, 1992; Stam, Koopmans, & Methieson, 1991).

## Outline of voice therapy

Approximately 10 days after surgery when the esophagus and the surrounding tissues, especially the tracheostoma, are sufficiently healed and the nasogastric tube has been removed, or the same day in the case of secondary TEP puncture, voice training can start. Since the indwelling voice prosthesis is already in place, no time is lost by fitting the device. The first therapy session begins with a short recapitulation of the preoperative information (e.g., explaining the changes in the anatomy and the basic principles of the vocal rehabilitation) and an inspection of the prosthesis to make sure it is not obstructed. Next, the patient is instructed to breathe in gently and to open the mouth and produce a /ha/ sound. In these first voicing attempts the speech pathologist should digitally occlude the stoma for the patient. In most cases, the voice will come through after one or just a few attempts. Usually the best results are obtained when starting with exclamations like "ha" and "hi". With the fricative /h/ it is easier to start the airflow before phonation than with an isolated vowel. If the voice does not occur easily, the patient is asked to shout. A stronger airflow in this situation helps to initiate the voice. After the first several voicing attempts, the patient can be encouraged to lengthen the vowels and to start with short statements or phrases/sentences of two and three syllables (e.g., "Hello", "Hi there", "How are you", etc.). Furthermore, the laryngectomized patient can now try to occlude the stoma together with the speech pathologist, and then by him/herself.

## Important basic principles in voice rehabilitation in prosthetic speech

In the beginning, voice therapy should focus on four general issues: airtight stoma occlusion, upright body position, abdominal breathing, and breath-voice coordination.

The acquisition of an airtight occlusion of the tracheostoma during phonation is important. In case the stoma is not yet well healed or is too large in relation to the patient's finger size, airtight digital occlusion might pose a problem at this stage. The availability of special, valved-HME's nowadays may eliminate this problem to a great extent (Ackerstaff, Hilgers, Balm, & Tan, 1998; Van As, Hilgers, Koopmans-van Beinum, & Ackerstaff, 1998). The pictures and video clip show an example of this (11 days) postoperative situation. These devices are often provided to patients shortly after surgery. As alternative method, a gauze covered small balloon could be used to achieve airtight occlusion of the stoma. As a reaction



to non-airtight stoma occlusion, the patient may exert too much pressure on the stoma, hence, forcing the prosthesis against the posterior pharyngeal wall and obstructing airflow. Another unfavorable side effect of non-airtight stoma closure is the occurrence of disturbing stoma noise. In order to obtain a good occlusion with only a light pressure on the stoma, the patient is advised to bring the stoma, or the body weight towards the finger, instead of pressing the finger onto the stoma. An additional advantage of using a valved-HME is that the pressure placed on the stoma is more evenly distributed.

An upright, relaxed body position is important for a good breath support. The back should be straight and the head bend forward just a little to avoid tension in the neck region around the stoma. Therefore, practicing while seated on a chair is preferred over sitting in bed early in therapy.

A calm, abdominal breathing pattern, gentle abdominal inhalation before phonation and an easy, unforced expiration is necessary to obtain a good and relaxed voice. We advise observing the breathing pattern of the patient before starting breathing exercises, since some patients already use a good abdominal breathing pattern. In these patients, the therapist's role is to make them aware of their abdominal breathing, whereas in those with a thoracic breathing pattern, breathing-exercises should be integrated in the speech therapy program.

Good breath-voice coordination and timing of stoma occlusion are important factors, since stoma noise may occur when the patient closes the stoma too late at the beginning of a sentence, or releases finger

pressure too early at the end of a sentence.

When short sentences are formed easily and fluently, exercises are extended by trying longer phrases starting with any initial vowel or consonant. Speech becomes more fluent by using meaningful sentences, instead of just a list of words.

## **Some points of attention for the ‘finishing touch’**

When the patient has acquired easy phonation, more specific exercises addressing fluency, loudness, intonation, stress and pitch modulation, articulation, and speech rate are provided, in order to obtain an optimal voice and intelligible speech. After all, intelligible speech is the most important aspect when it comes to communication with the environment.

### ***Fluency***

The voice is pulmonary driven and consequently tracheoesophageal speech can be as fluent as normal speech. Some training in extending maximum phonation time and phrase length can be helpful to reach normal phrase length. By counting as long as possible on one intake of breath, the patient becomes more aware of his vocal capacities. Paragraph reading and focusing on using the natural pauses for inhalation can be helpful in achieving natural speech.

### ***Prosody***

Training in enlarging pitch and loudness ranges and achieving insight in the capacities of the voice when it comes to pitch and loudness is an important aspect of improving naturalness and liveliness of tracheoesophageal speech. Singing is often used as an instrument to extend the possibilities and control over pitch and loudness.

### ***Speech rate***

Speech rate is often very personal and usually not easy to change. However, when the speech rate is too fast and negatively influences speech intelligibility it is important to slow it down.

### ***Intelligibility***

Achieving intelligible speech, with an optimal voice quality as close to normal voice as possible, is the ultimate goal of voice rehabilitation. Therefore, it is important not only to address voice quality but also intelligibility. Specific articulation exercises, for instance for voiced-voiceless distinction can be necessary.

In general, functional speech is obtained within a very short time, often already during the first therapy session. Most patients will leave the hospital with intelligible speech after only a few days of practice. After discharge from the hospital, the voice and speech therapy is continued on an outpatient basis, until an optimal result has been achieved.

## **General aspects of patient instruction**

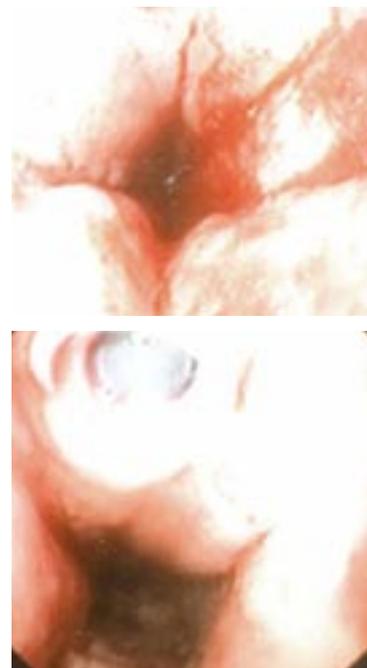
Instruction should be given to patients about daily cleaning of the TEP voice prosthesis with a brush or flushing unit. Occluding the stoma and producing a loud sound also cleans the TEP voice prosthesis. The patient should be aware of the fact that the prosthesis will stay cleaner by speaking regularly. Patients should be provided with a proper explanation about the fact that at a given time the valve of the prosthesis will become incompetent and that leakage of liquids can occur. The first reaction should be to properly clean the prosthesis with a brush or flush. If this does not solve the problem, replacement probably is indicated. However, temporary control of leakage through the prosthesis can be obtained by using a special plug if the patient is unable or unwilling to make an appointment at short notice with the clinician, for instance during weekends or holidays. The patient should be instructed how to use this plug during the consumption of liquids (solid food rarely causes problems).

Patients are always given the opportunity and are encouraged to learn esophageal speech as well. In contrast to the situation in the USA, in the Netherlands electrolarynx use is limited to patients failing both prosthetic and esophageal voice. However, the use of an electrolarynx as an alternative alaryngeal communication and, thus, as a back-up method, deserves more attention.

In our institute, the use of an automatic speaking valve for hands-free speech is encouraged only after the patient has mastered all daily practical aspects of prosthetic speech and has developed a fluent, not too strained voice. It appears to be important that the patient has enough dexterity to handle these devices comfortably (Van den Hoogen, Meeuwis, Oudes, Janssen, & Manni, 1996). In daily practice, success rates are still relatively low with less than a quarter of the patients achieving a full-day unrestricted use, which is comparable to the results reported by Van den Hoogen et al (1996) However, results with the novel automatic speaking valve Provox FreeHands HME are not available yet, since this device has been developed and introduced only recently. For the practical aspects of the use of the Provox FreeHands HME, see the following chapter.

## **Problem solving**

Unsatisfactory voice rehabilitation results may occur due to one or more problems on several different levels (i.e., oral structures, PE segment, voice prosthesis, tracheostoma, and trachea). Furthermore, the patient may have problems with respiration or posture. Two other specific kinds of problems are combined or intermittent use of esophageal along with TE speech, and voice problems during radiotherapy. With respect to the latter problem, an example is shown to the left: the top figure shows an endoscopic view of the PE segment and the next figure the view at the level of the voice prosthesis in a patient, who needed a gastroscopy in the 5<sup>th</sup> week of his radiotherapy. As can be seen, there is no problem at the level of the voice prosthesis, but there is distinct redness and edema in the PE segment itself, which explains why the voice often deteriorates during radiation. However, it is important to encourage the patient to continue to use the prosthetic voice and to reassure him/her that the voice most likely will regain its original quality soon after completion of the radiation. If occlusion of the stoma during radiation is a problem due to skin irritation and soreness and the HME adhesive can not be used, the use of a Larytube cannula can solve this problem, enabling prosthetic voicing.



In case of doubt about the cause of a problem the use of diagnostic videofluoroscopy of speech and swallowing is an excellent tool for visualization of the anatomy and function of the PE segment (McIvor et al., 1990; Van As et al 2001). Table 1 presents an overview of the different problems, the levels/areas at which they exist, and possible solutions for resolution.

Table 1. Overview of different problems encountered in surgical prosthetic voice and speech rehabilitation, the levels/areas at which they exist, and possible solutions.

<b>Level/area</b>	<b>Problem</b>	<b>Possible solutions</b>
Oral structures	Decreased intelligibility	Articulation exercises
PE segment	Strained voice due to stricture or hypertonicity  Breathy voice due to hypotonicity or reconstruction	If speech therapy fails, discuss with ENT-specialist need for dilation, myotomy, or Botox, etc. Apply digital pressure on the neck, adjust head position, decrease airflow, lower pitch
Voice prosthesis	Internal obstruction External obstruction due to overgrowth of mucosa. External obstruction by esophageal back wall	Clean with brush, flush, or suction Increase length of device Shorten device, exert less digital pressure, use HME
Stoma	Difficult occlusion due to irregular, still painful, or too large a stoma Difficulty in 'finding' the stoma with the finger	Use small balloon covered with gauze, or valved HME Practice in front of mirror
Trachea	Excessive phlegm production interfering with voicing	Inhalation therapy, apply HME
Respiration	Forced, too strong, or too weak an expiration causing voicing problems	Abdominal respiration exercises, training with 'chant-talk technique'
Posture	A 'collapsed' body position causing poor voice and a short phonation time Incorrect head position causing muscular tension and a strained voice	Correction of body position/posture Relaxation exercises, correction of head position
Confusing esophageal and tracheoesophageal voice	Short phonation time, identical with or without stoma occlusion	Explain problem to patient, lengthen the vowels, use 'chant-talk technique', breathing exercises
Radiotherapy	Decrease in voice quality during radiotherapy	Reassure patient and <b>continue</b> speech therapy



### **Narrow Stoma**

A special point of interest is the combination of a trachea cannula like Larytube with the use of a voice prosthesis in patients with a narrow stoma. Often patients can voice without any problem with this cannula in situ, because the narrow stoma often makes airtight occlusion easy, whereas there is sufficient air passage along the cannula towards the voice prosthesis to enable comfortable voicing. If, however, not sufficient air is directed towards the voice prosthesis, it is advisable to use a fenestrated version of the cannula. If the standard fenestrations are not ideally situated in front of the prosthesis, these can be custom made in a non-fenestrated cannula with a simple punch (which is available with the Larytube system). It is not advisable to make one large hole in the cannula, because this might get trapped behind the tracheal flange of the voice prosthesis during removal of the cannula with obvious problematic consequences.



### **Conclusion**

There is no “one-right method” for prosthetic speech therapy. The training should be flexible and adapted to each individual laryngectomee. Only a good cooperation between the ENT-specialist, speech therapist and other members of the multidisciplinary team leads to successful restoration of the voice.

# Hands-free tracheoesophageal speech with the Provox FreeHands HME

## Introduction

Handsfree tracheoesophageal speech contributes to a more natural way of speaking after total laryngectomy. Instead of using a finger for manual occlusion, the valve closes automatically on exhalation and allows air from the lungs to pass through the voice prosthesis into the esophagus where the voice sound is originated. Since the patient does not need the use of one hand for speaking anymore with an automatic speaking valve, the handicap is less noticeable to others, speech appears to be more natural and both hands are free during speaking. Unfortunately, not all laryngectomized patients are able to achieve handsfree speech due to several reasons. The Provox FreeHands HME has some specific features (see animation on the Cd-rom) that might be helpful in increasing the percentage of patients that is able to use handsfree speech. This chapter will address all issues that should be considered when fitting a Provox FreeHands HME in order to achieve optimal results for handsfree speech.

## Provox FreeHands HME automatic speaking valve



This device consists of a disposable HME cassette as its indispensable core with a reusable multi-magnet automatic speaking valve on top. The HME can be secured to the bottom of the speaking valve to ensure proper retention in the housing of the adhesive attached to the peristomal skin and is removed by ‘cracking’ the cassette when it needs changing (at least every 24 hours). The HME is deliberately placed underneath the valve to ensure protection of the valve against mucus contamination in case the patient coughs up phlegm.

The reusable automatic speaking valve contains a silicone membrane, which can occlude the side opening of the device and has a magnet at its tip. The valve has two positions. In the ‘talk’ position the membrane can move freely; in the ‘walk’ position (achieved by rotating the device 75° in the housing) the membrane magnet locks against an eccentrically placed pin, preventing closure of the membrane during physical exertion. This membrane magnet, in combination with a second magnet near the side opening, keeps the membrane closed during speech, facilitating voicing with a low trachea pressure. Furthermore, on top of the device there is a cough-relief valve, which is hinged with elastic silicone bands. This valve opens during coughing, to release the pressure built up in the trachea and to diminish the possibility of the adhesive coming loose. The cough-relief valve is closed by means of magnets, which allow adjustment of its opening pressure by varying the distance between the magnets. Preferably, the Speech-Language Pathologist (SLP) makes this adjustment for the patient (using the special screwdriver that comes with the system), to achieve a sufficiently high gradient between the pressures needed for closure of the speaking valve and for opening of the cough-relief valve. For adhesion to the skin, patients can use the adhesives for the Provox HME system, or a special cannula (LaryTube; Atos Medical AB, Sweden). Three types of easily exchangeable, color-coded membranes are available: white (most flexible), green (least flexible), and blue (intermediate flexibility). Together with the SLP, the patient selects the most comfortable and efficient membrane for voicing. In our development study group, 6 patients chose the white membrane, 9 the blue one, and none selected the green version. <sup>1</sup>

The airflow resistance of the HME is adapted to its combination with the automatic valve, which has some airflow resistance of its own. A special container is provided for cleaning the device (overnight) with a standard denture cleanser.

## Attachment of the valve

In order to attach the automatic speaking valve in front of the stoma, two methods can be used: peristomal attachment and intratracheal fixation. Most clinicians prefer to try peristomal attachment as a first option, since intratracheal fixation might cause damage to the mucosa in the tracheostoma and when used in a wrong way it might dislocate the voice prosthesis. Below both methods of attachment are described.

### **Peristomal attachment**

There are different types of housings and adhesives available for peristomal attachment. The adhesives that are used for the Provox HME (FlexiDerm, Regular, OptiDerm) can be used for FreeHands as well. For patients needing extra support in the region around the stoma or with a deep stoma it is advised to use the more solid Provox FreeHands XtraBase adhesive. Especially in patients with a deep stoma one needs to be aware of the fact that when using a FlexiDerm adhesive, it should be in contact with the skin otherwise air might pass through the adhesive. In addition to the adhesive, silicone might be used in order to strengthen the seal. Preparation of the skin is an important factor in achieving a good seal. Below the steps that should be taken in order to achieve a good seal are listed:

- If necessary remove glue from the skin with a remover pad
- Clean skin with water and soap and make sure it is oil-free and dry
- Apply Skin Prep in order to protect the skin
- Apply a thin layer of silicone glue on the skin (and the adhesive) around the stoma and let dry for 3 to 4 (or even 10) minutes
- Put the adhesive on the skin, as close to the stoma as possible, make sure it contacts the skin everywhere and that there are no air bubbles in between the adhesive and the skin. Line the lower end of the housing up with the lower border of the stoma if possible, in order to reduce the amount of mucous that might enter between the adhesive and the skin.
- Let the adhesive base plate dry (or only talk with a regular HME) for the first 30 minutes and then start using the FreeHands automatic speaking valve.

The video on the CD-rom (figure left) shows a patient preparing his stoma in a well controlled way.



### **Intratracheal fixation**

Intratracheal fixation can be achieved by means of a (fenestrated) cannula with a neck strap (LaryTube Standard or LaryTube Fenestrated), or a cannula combined with an adhesive (LaryTube with Blue Ring). When using a cannula in combination with FreeHands, a clinician should properly size the cannula to fit into the tracheostoma without leaving space between the cannula and the tracheal mucosa, in order to avoid air leakage around the cannula. When using a LaryTube with a neck strap the strap should be fitted tight enough to hold the backpressure during speaking. Using a LaryTube with a Blue Ring in combination with an adhesive might help in some patients that are having problems with maintaining the seal of the adhesive due to back pressure or due to mucous entering between the skin and the adhesive.

Another method of tracheal fixation, which does not require the use of a neck strap or adhesive, is the Barton-Mayo button. This device is trapped into the tracheostoma. This device can be used when the tracheostoma has a so-called 'lip' or 'rim' that keeps the Barton-Mayo button in place. It is usually preferred to insert it directly behind the 'lip' and in front of the voice prosthesis. In some patients, when the location of the voice prosthesis does not allow insertion right behind the stoma 'lip' it is inserted behind the voice prosthesis and the button is fenestrated to allow passage of air through the voice prosthesis. The latter is not preferred since it may cause dislocation of the voice prosthesis during insertion or removal of the button.

There are some issues that should be taken care of when applying intratracheal fixation. They are listed below.

- It is important to give proper explanation to the patient about inserting the device into the stoma and taking it out, without damaging the tracheal mucosa or dislocating the voice prosthesis. Practice a couple of times together with the patient and provide written instruction. For inserting the button the use of a forceps is advised. Fold the tracheal end of the device once and then again and use the forceps from the inside to keep it folded. Then insert into tracheostoma, release the forceps to unfold the device again.
- If the patient is complaining about a sore stoma or when there is a slight bleeding of the mucosa, try to gradually build up the use of the device (day 1 – 1 hour, day 2 – 2 hrs, etc)
- If the patient is using anti-coagulant medication and complains about bleeding of the stoma, stop using it immediately
- These intratracheal devices usually enlarge the tracheostoma, never increase the diameter of the device; instead allow shrinkage of the stoma during the night or for some days until the device fits again.
- The material of the Barton-Mayo button might become looser after sometime and cause air-leakage between the button and the FreeHands valve. Metal rings are available to keep the fit tight enough.

## Assembling and disassembling the HME

The HME and the automatic speaking valve are two separate parts that should be assembled and disassembled by the patient (see video clip on the CD-rom). Proper instruction to the patient and practicing is needed in order to avoid damage to the automatic speaking valve.

## Choosing the membrane

The FreeHands Starter kit contains three different membranes; light (white), medium (blue), and strong (green). The valve comes with the blue membrane and most patients are found to be comfortable with this membrane. When fitting the FreeHands it is advised to try to speak with the other membranes as well in order to select the optimal membrane for the patient. The white membrane closes at a lower air pressure than the blue membrane and the green one closes at a higher air pressure. During excessive breathing the air pressure might equal the pressure needed for closing the membrane. Therefore, the membrane that might seem optimal for voicing might be less optimal for breathing in some patients. It is advised to check with the patient when exhalation starts to close the valve. Check not only in rest, but also during slight physical activity. When the patient is aware of this, he or she is usually capable of controlling exhalation in order to avoid inadvertent closure of the membrane. For increased exhalation during physical exertion it is advised to use the ‘walk’ position of the device (see [walk and talk position](#)). The video clip on the CD-rom enlightens this part of the fitting procedure.

## Proper adjustment of the cough-relief valve

Adjustment of the cough-relief valve should be optimized for both coughing and voicing (see video clip on the CD-rom). Insert the valve in the housing and ask the patient to cough. The cough-relief valve should open easily and with the least possible noise. When the valve is adjusted stronger the noise resembles more of a clicking sound caused by the magnets and when the valve is adjusted lighter that sound is softer. In between those extremes the noise resembles more of a ‘fluttering’ sound that is usually not liked very much by the patient. Obviously, the weaker the adjustment of the cough-relief valve the lower the pressure exerted on the seal when coughing and consequently, the longer the seal of the adhesive. After adjustment of the cough-relief valve it might appear that the valve is adjusted



too weak for voicing. In that case the patient experiences that the valve opens when attempting to speak or when attempting to speak louder. Depending on the wishes of the patient the strength of the cough-relief valve could be increased slightly to avoid this problem. However, in some patients it might be advantageous to have the cough-relief valve opening at lower pressures in order to prolong the seal of the adhesive. For speaking louder or shouting the patient can support the cough-relief valve with his finger.

### **Using the walk and talk position**

By turning the valve a quarter counter-clockwise it is turned from the 'talk' (right figure) to the 'walk' (Off=right figure) position (see video clip on the CD-rom). When turning, inside the valve a magnetic pin is rotated towards the magnet at the end of the membrane. Thereby, the membrane is trapped and it will not close on exhalation. Explain this feature to the patient and show the patient how he or she can see in what position the valve is. It also should be mentioned, that physical exertion with the valve in talk position can lead to a slightly increased airflow resistance, even if the valve does not close completely. It is advised to insert the valve in the housing for speaking adjusted in the talk position. Practice a couple of times how to adjust the valve when placed in the housing.



### **Use of the cleaning container**

Maintenance of the valve is enabled by the use of a special cleaning container and denture cleansing tablets, as can be seen in the video clip on the CD-rom. Detailed instruction about the use of this container is written in the manual. The clinician should practice the use of this cleaning container with the patient in order to avoid damage to the valve caused by improper use of the cleaning container.



## **Speech therapy. What to practice to optimize hands-free speech**

Achieving hands-free speech is usually not just a matter of putting on a valve and starting to speak. In order to achieve optimal results, optimal seal of the housing and optimal voice quality and speech intelligibility, proper instruction and training of the patient is required. In addition to proper explanation and adjustment of the valve, some therapeutic considerations are mentioned in this section.

### ***Closure of the membrane***

Usually, the membrane closes immediately in reaction to the increased airflow when the patient attempts to speak. However, some patients tend to close the membrane first and then start to speak. This causes the impression of a slight delay and sometimes the closure of the membrane can be heard. When this is the case, it is advised to practice simultaneous closure of the membrane and start of voicing by making the patient aware of this behavior, focusing on breath support, and practice with phonation of /h/-vowel combinations and vowel onsets, followed by normal sentences.

Also, the phenomenon of a delay between closure of the membrane and start of speaking is more often seen when the patient has just started using the handsfree device. The patient then is ‘thinking’ too much about closing the valve. Usually it already helps not to think and speak more automatically.

### ***Breath-support/breath-voice coordination***

Some patients experience problems maintaining voice sound and timing voice on- and off-set when using an automatic valve. In order to improve those features, training of breath-support by means of abdominal breathing and training of breath (closure of membrane) – voice coordination provides the patient with a better control over his or her voice production.

### ***Phrase length, speech rate, maximum phonation time***

Both phrase length and speech rate are important factors for natural sounding, intelligible speech. Phrase length is dependent on the maximum phonation time of the patient and therefore this term is included in this section as well. Exercises to increase maximum phonation time (both on vowels and running speech) increase possibilities to vary phrase length and give the patient insight in his or her skills. Both a too long and too short phrase length may appear unnatural. Focusing on the natural pauses is therefore important. Speech rate should not decrease or increase as a consequence of the use of an automatic speech valve and only should be adjusted when it is influencing intelligibility in a negative way.

### ***Pitch, loudness, intonation***

In order to avoid monotonous, expressionless speech, it is important to practice pitch and loudness changes (singing) and intonation (questions, remarks) when using the automatic speaking valve. Learning what is possible to do with the voice when the valve is in place is important.

### ***Shouting***

In order to avoid the cough-relief valve from opening when attempting to shout, it is advised to teach the patient to support the cough-relief valve by finger when shouting.

### ***Decrease backpressure***

Backpressure is the main reason for the seal of the adhesive to break and is therefore an important issue to address during speech therapy. High backpressure may be caused by hypertonicity of the neoglottis, but it might also be a result of the patient unconsciously attempting to speak too loud. In the latter case it is worthwhile to practice speaking at a softer tone and lower pitch. Usually auditory feedback and explanation to the patient is helpful. It can be helpful to use the valve as its own feedback mechanism. By adjusting the cough-relief valve to open at lower pressure, the cough relief valve will open when the patients is speaking with too much pressure. Also a manometer, monitoring the tracheal pressure during speaking, can be used to practice to speak with less pressure.

### ***Hypertonicity/spasm of the neoglottis***

In case of hypertonicity of the neoglottis (characterized by a strained, strangled voice sound) the patient might not be able to lower the backpressure since more pressure is needed to produce voice. Evaluation of the neoglottis by means of videofluoroscopy is necessary to diagnose hypertonicity or spasm. Hypertonicity can be solved by means of Botox injections or secondary myotomy.

### ***Hypotonicity of the neoglottis***

In case of hypotonicity of the neoglottis (characterized by a breathy, whispery, aphonic voice sound) might become more obvious when using a handsfree device. When using digital occlusion of the stoma the finger pressure sometimes supports the esophagus and approximates the esophageal walls in order to create a voice sound. When those patients start using a handsfree device, voice quality might decrease. Applying digital pressure on the esophagus usually helps, but then speech is not handsfree anymore. To keep speech handsfree, consider using a custom made pressure band or using a Dan Kelly pressure band. In some patients, speaking softer and at a lower pitch improves voice quality and sometimes a slight change of head position causes approximation of the esophageal walls and thereby improves voice quality.

### ***Confusing handsfree TE-speech with esophageal speech***

Patients who are using both tracheoesophageal speech and esophageal speech are used to switch to esophageal speech when speaking handsfree. In those cases focusing on abdominal breathing, and start voicing on a vowel or /h/-sound (avoiding air injection or inhalation) is usually helpful.

## **Troubleshooting**

### ***No voice sound***

- Membrane does not close
  - Try white membrane.
  - Practice abdominal breath support, especially at onset of phonation.
- No complete seal of adhesive
  - Apply new adhesive, consider use of Barton-Mayo button.

### ***Weak/whispery/aphonic voice***

Probably caused by hypotonicity of the neoglottis, try applying digital pressure, change of head position, custom-made or Dan Kelly pressure band.

### ***Air leakage under membrane***

When a slight leakage of air is heard during voicing, and the seal of the adhesive is intact, the origin of the air leak should be checked. Mostly this can be found out easily by feeling with a finger. In some cases the origin might be detected at the edge of the membrane. When the membrane is slightly tilted, air can leak sideways. The main cause for the membrane being tilted is that it is pushed too far down into the valve housing, when inserting it. When changing a membrane this should be carried out effortlessly and the membrane should not be pushed too far in.

### ***Air escaping underneath cough-relief valve***

This might happen when the patient is giving too high pressure for speaking. In that case one hears air blowing underneath the cough-relief valve, the valve opens sometimes during speaking, or the valve makes a whistling noise. First check whether the valve is in its strongest position. When the problem still exists in the strongest position try to teach the patient to speak softer and with lower pressure. Usually the patient manages to keep the cough-relief valve closed during speech within a couple of days; the cough-relief valve serves as a 'feedback' mechanism to lower the pressure. In case of severe hypertonicity or spasm it should be considered to treat the hypertonicity.

### ***Shortness of breath***

Especially when using the white membrane closure of the membrane is already initiated at a very low expiratory airflow. In some patients the membrane also closes on increased exhalation during physical activity. This causes shortness of breath. Explain proper use of the walk and talk position and practice its use. Also let the patient experience the strength of exhalation that causes closure of the valve and teach the patient how to control it to prevent closure of the valve.

### ***Cough-relief valve opens when patient is speaking loud***

For speaking loud or shouting it is preferred to support the cough-relief valve with a finger. This decreases the pressure on the seal of the adhesive. Depending on the wish of the patient, the strength of coughing and the ability to maintain a long seal the cough-relief valve can also be adjusted to a stronger position.

### ***Seal of the adhesive does not last long***

Complete and airtight seal of the adhesive/housing of the valve is one of the most important factors for successful use of the device. On average a seal of 6 to 8 hours can be considered satisfactory. If, despite applying the suggestions mentioned below, length of seal cannot be improved, it is advised to consider the use of an intratracheal device such as a LaryTube or Barton-Mayo button.

### ***Factors to be considered if airtight seal of the adhesive is unsatisfactory:***

- Lower the pressure used for speaking
- By lowering the pressure used for speaking the pressure exerted on the adhesive during speech is decreased. This can usually (except of course when the neoglottis is hypertonic) be achieved by asking the patient to speak softer and with a lower pitch. Using a manometer measuring the pressure at the trachea during speech during voicing might help to give the patient feedback in order to achieve lower pressure. Also, adjusting the cough-relief valve to a lower opening pressure could be considered to help the patient achieving a lower tracheal pressure during speech.
- Support the adhesive when coughing or remove the valve when a cough is coming up.
- After coughing carefully remove mucous in order to avoid mucous breaking the seal.
- Avoid using remover or alcohol that is containing oil.
- Support the neck with a pressure band (e.g. custom made or Dan Kelly band), a tie or stoma cover when the skin is moving outward due to back pressure during speaking.

### **Problems with intratracheal fixation**

- Tracheostoma enlarges after using some time
  - Never use a larger button or cannula. Allow the stoma to shrink overnight or during a couple of days, by wearing an adhesive and HME.
- Bleeding of tracheostoma
  - Stop using the device. After the stoma is healed try to increase the length of use of the device gradually. When even short periods of using cause bleeding or when bleeding maintained for a long time after removing the device, stop using it.
  - Observe how patient is putting the device into the stoma and taking it out. Give proper instruction to avoid damage of tracheostoma or voice prosthesis
- Air escaping between button and FreeHands HME.
  - When using the Barton-Mayo button, after some time the material of the button weakens and air starts to leak between the button and the FreeHands HME. In that case a metal ring can be used to support the button.

### **Too much noise of cough relief valve when coughing**

The cough relief valve usually makes the least noise when adjusted weak. This is, however, not the same for each patient and mainly dependent on the airflow produced when coughing. When the patient is complaining about too much noise when coughing, usually because it produces a ‘fluttering’ sound, a weaker or stronger adjustment could solve the problem.



### **Conclusion**

The Provox FreeHands HME is a novel automatic speaking valve, which combines a heat and moisture exchanger as its indispensable core with a sophisticated multimagnet valve system for more comfortable voicing, cough relief and physical exertion. These features probably will enable more patients to benefit from handsfree speech and in the same time improve their compromised pulmonary status. Nevertheless, maintaining a perfect airtight seal is still the most important aspect of successful handsfree speech, which indicates, as described above, that along with the other aspects of patient instruction, this issue should get the highest possible attention. But if successful one could say: *‘Handsfree speech is the cherry on the rehabilitation pie.’*

### **Reference:**

1. Hilgers FJM, Ackerstaff AH, van As CJ, Balm AJM, van den Brekel MWM, Tan IB. Development and clinical assessment of a Heat and Moisture Exchanger with a multi-magnet automatic tracheostoma valve (Provox FreeHands HME) for vocal and pulmonary rehabilitation after total laryngectomy. Acta Otolaryngol (Stockh), 2003;123:91-99.

# Research of voice- and speech quality after total laryngectomy

Studying voice and speech quality is of importance for evaluation of voice rehabilitation. Judgment of voice and speech quality needs to be multi-dimensional. In a study by van As et al. (2001) such a multidimensional protocol is proposed. The protocol consists of perceptual evaluations, acoustic analyses, maximum phonation time, videofluoroscopy, and the Voice Handicap Index (Jacobsen, et al. 1997). Depending on the goal of the investigation, one or more parts of the protocol can be carried out. For the Speech Language Pathologist perceptual evaluations are most important and clinically relevant. Complementing acoustic analyses can be considered a valuable (objective) adjunct to perceptual evaluations. The use of a quality of life questionnaire such as the Voice Handicap Index is recommended to gain insight in how the voice affects the quality of life. Videofluoroscopy recordings (video recording of X-ray during swallowing and phonation) are suitable for judging the anatomy and morphology of the neoglottis. (Van As, et al. 2001). Usually, videofluoroscopy recordings are used for diagnosis and evaluation of swallowing and/or speech problems such as hypertonicity and spasm of the neoglottis.

## Perceptual evaluations

Depending on the goal of the evaluations, they can be carried out either by naive listeners or by experienced SLPs who are trained for doing these perceptual evaluations. Results have shown that a minimal basic subset of 4 perceptual scales covers the two underlying perceptual dimension (voice quality and pitch) found for the naive raters sufficiently, and that for the SLPs a minimal basic subset of 8 perceptual scales is sufficient to cover the 4 underlying perceptual dimensions (voice quality, tonicity, pitch, and tempo) found for them. (Van As, 2001). The perceptual scales used, consist of semantic bipolar 7-point scales. The instruction given to the listeners is to choose the extreme scale ends (1 or 7) when the term is very much applicable to the voice quality, to choose one interval more towards the middle (2 or 6) when the term is moderately applicable, one interval more to the middle (3 or 5) when the term is a little applicable, and the middle (4) when both terms are equally or neither one of the terms is applicable.

### The subset for the naive listeners is:

Ugly	_ _ _ _ _ _ _	Beautiful
Deviant	_ _ _ _ _ _ _	Normal
Low	_ _ _ _ _ _ _	High
Deep	_ _ _ _ _ _ _	Shrill

### The subset for the SLP is:

Ugly	_ _ _ _ _ _ _	Beautiful
Deviant	_ _ _ _ _ _ _	Normal
Breathy	_ _ _ _ _ _ _	Not breathy
Hypotonic	_ _ _ _ _ _ _	Not hypotonic
Low	_ _ _ _ _ _ _	High
Deep	_ _ _ _ _ _ _	Shrill
Slow	_ _ _ _ _ _ _	Quick
Dragging	_ _ _ _ _ _ _	Brisk

Also a number of other perceptual scales such as bubbly-not bubbly, unsteady-steady, weak-powerful, and monotonous-melodious are suitable for perceptual evaluation of tracheoesophageal speech. These scales can be added to the minimal subset, depending on the purpose of the perceptual evaluations. Apart from the perceptual scale judgments, it is also advised to judge the overall voice quality as good, reasonable, or poor. A good voice is defined as “almost similar to normal voice”, a poor voice is defined as “very deviant from normal voice”, and reasonable voice is defined as “somewhere in between both extremes”.

Although perceptual evaluations are straightforward and clinically relevant it also has some disadvantages. They are subjective, time-consuming, and listeners might differ in their opinion. Acoustic analysis does solve some of these problems, but also has some major disadvantages in analyzing tracheoesophageal voice.

## Acoustic analyses

Acoustic analysis is an instrument that is often used for objective evaluation of voice quality. The parameters used for the evaluation of voice quality often consist of fundamental frequency, perturbation and noise measures. There are numerous software programs available for acoustic analyses. Performing acoustic analyses in tracheoesophageal speech is more difficult in tracheoesophageal voice than in normal voice. The problems are caused by the irregularity of the voice. These irregularities are sometimes very severe and cause errors in the pitch-extraction (see figure 1). It is therefore important to check the results of pitch-extraction by means of visual inspection of the pitch markers placed by the program.

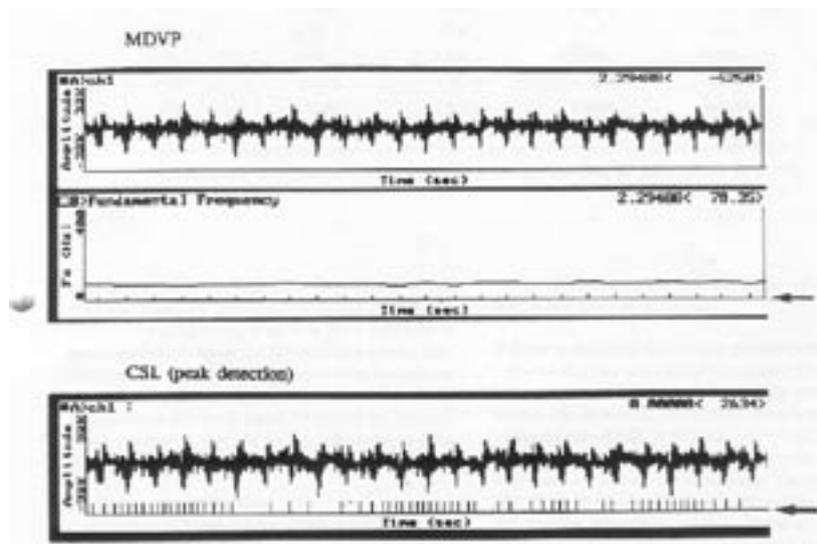
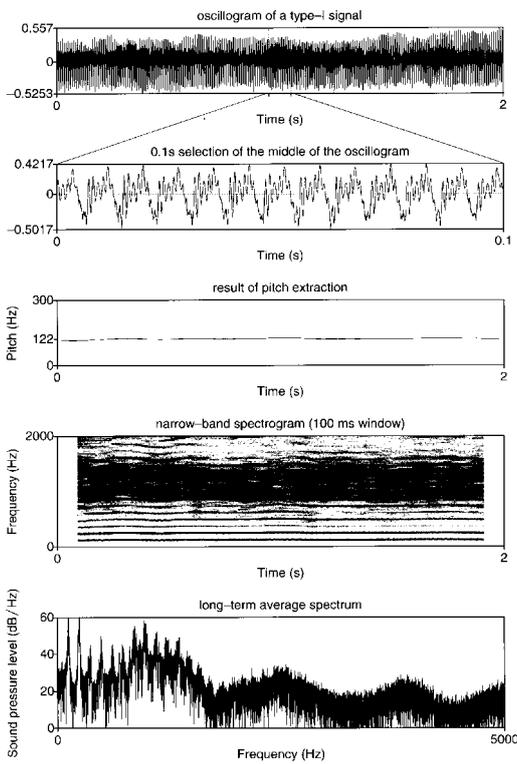


Figure 1. Pitch-extraction results of a sustained /a/ of a tracheoesophageal speaker using the Computerized Speech Lab with CSL software (bottom) and the Multi Dimensional Voice Program software (top). The pitch-markers (see arrows at the right hand side) are correctly placed with MDVP and not with CSL.

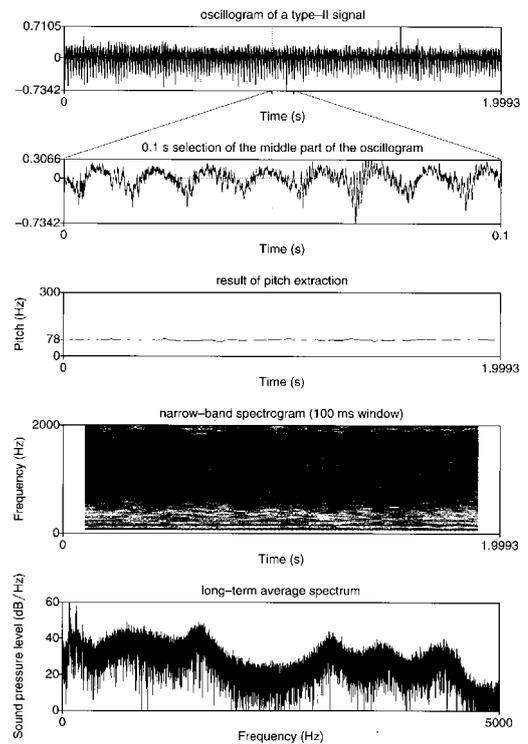
In order to obtain a first impression of voice quality, provide information to other clinicians, and prepare for further acoustic analyses, acoustic signal typing is a useful instrument. These acoustic signal types are based on a narrow-band spectrogram displaying the harmonics in the voice signal. Van As et al. describe an acoustic signal typing system that can be used to group voice samples of tracheoesophageal speech can be categorized into four different signal types. (Van As 2001). In figure 2, these four signal types and the criteria for their use are shown.

Research shows that these signal types are related to the overall judgment of voice quality as good, reasonable, or poor, which makes them useful as an adjunct to perceptual evaluation. Apart from these signal types, also objective acoustic measures can be calculated. The following 6 measures have shown to be relevant in relation to voice quality: fundamental frequency, standard deviation of fundamental frequency, percentage of voiced, harmonics-to-noise ratio, glottal-to-noise ratio, and band energy difference. For a detailed description of these parameters see Van As (Van As 2001).

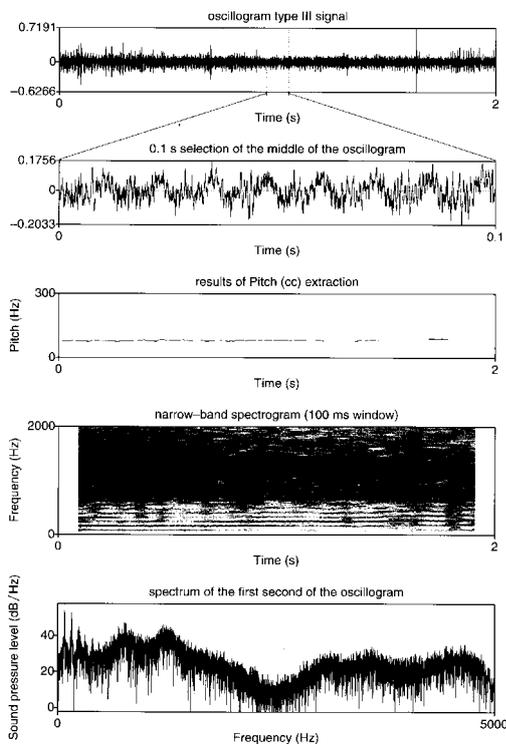
Figure 2. Categorization of tracheoesophageal voice quality into 4 different signal types, based on the narrow-band spectrogram. For clarification each figure shows the entire 2 second at the top, followed by a 0.1 s selection from the middle of the vowel, the curve of pitch extraction, the narrow-band (100 ms) spectrogram, and the long-term average spectrum.



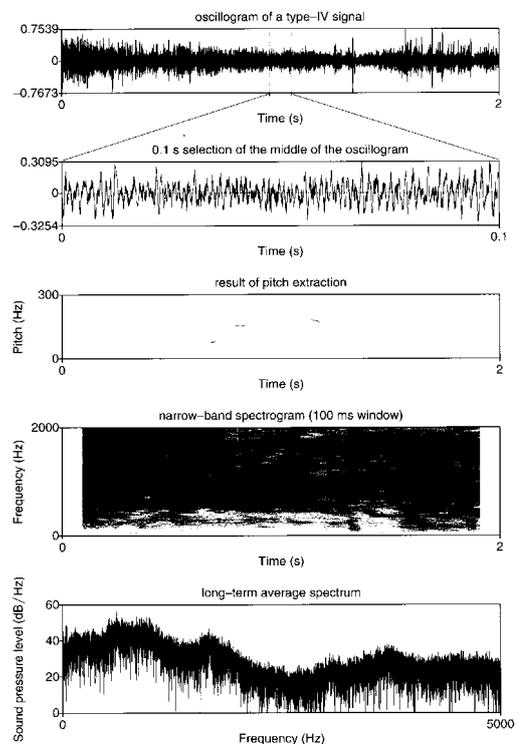
Type I. Stable & Harmonic



Type II. Stable & At least 1 harmonic



Type III. Unstable or Partly harmonic



Type IV. Barely harmonic

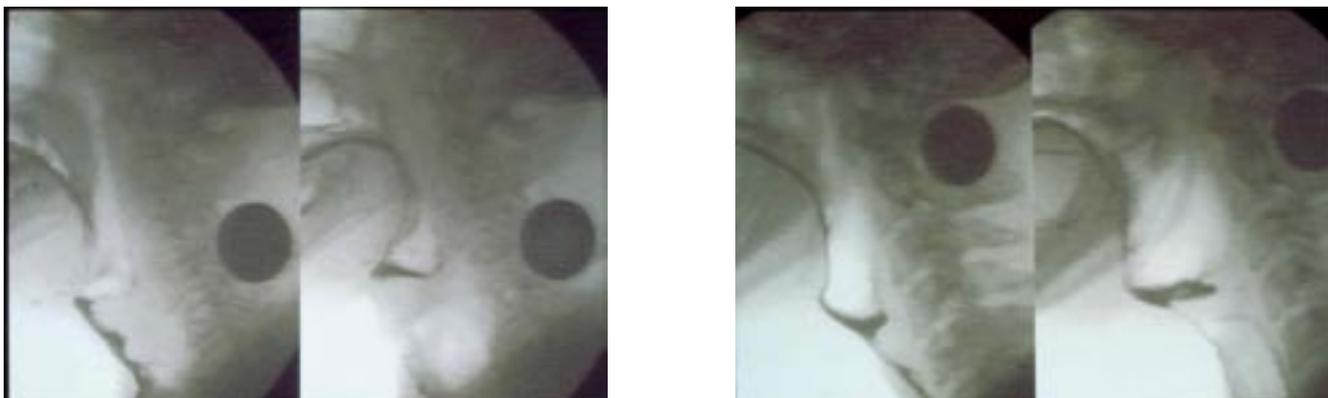
## Maximum phonation time

In addition to the objective acoustic measures, also maximum phonation time is a relevant measure in relation to voice quality. Maximum phonation time is found to be longer in patients in whom the overall voice quality is better and short maximum phonations times were related to less fluent and less intelligible speech.

## Videofluoroscopy

Videofluoroscopy is a clinical evaluation method that is used in most clinics on a regular basis for diagnosis of problems with voice production or swallowing after total laryngectomy. Van As et al (2001) describe a standardized protocol for the assessment of these recordings. This protocol not only consists of visual assessments but also contains objective quantitative measures of the neoglottis. Their study also investigated the relation between the evaluation of the videofluoroscopy recordings in relations to perceptual evaluation, acoustic analyses, and maximum phonation time, in order to reveal which aspects are important to judge in relation to voice quality.

As a result of these studies, a set of parameters has been selected that are relevant to assess in videofluoroscopy recordings. These parameters are: visual assessment of the presence of a neoglottic bar (yes/no), regurgitation of barium during phonation (yes/no), tonicity of the neoglottis during phonation (hypotonic, normotonic, hypertonic, spasm, stricture) and quantitative measures in mm (in digitalized images of rest and phonation) of the minimal neoglottic distance at rest and during phonation, the surface area of the neoglottic bar at rest and during phonation, the prominence of the neoglottic bar at rest and during phonation, and the increase of the maximal sub-neoglottal distance from rest to phonation.



Above are two examples of videofluoroscopic images (a case of hypertrophy to the left and a case of hypotrophy to the right; by clicking on the images the accompanying /aa/ sound can be heard). Each image shows the situation at rest on the left side and the situation during voicing on the right. Note that during voicing in the hypertrophic case the subneoglottic area is widely extended, whereas in the hypotonic case no contact can be seen between the neoglottic bar and the anterior pharyngeal wall.

## Summary

To summarize, a clinical investigation protocol should contain:

- A perceptual judgment of a trained speech-pathologist of the overall voice quality (good-reasonable-poor) and a judgment of the subset of the 8 perceptual semantic bipolar 7-point scales (deviant-normal, ugly-beautiful, breathy-not breathy, hypotonic-not hypotonic, low-high, deep-shrill, slow-quick, and dragging-brisk) based on read-aloud text;
- Acoustic signal typing based on a narrow-band spectrogram (100 ms analysis window) of a 2 s voice sample of a sustained /a/ at comfortable pitch and loudness level;
- Calculation by an experienced investigator of the following 6 acoustic parameters: median fundamental frequency, standard deviation of fundamental frequency, percentage of voiced, harmonics-to-noise ratio, glottal-to-noise excitation ratio, and band energy difference, on the same 2 s of a sustained /a/ at comfortable pitch and loudness;
- Measuring of maximum phonation time for a sustained /a/;
- Visual assessment by a clinician (ENT-specialist, radiologist, or speech-language pathologist) of the presence of a neoglottic bar during phonation, regurgitation of barium during phonation, and tonicity of the neoglottis during phonation in videofluoroscopy recordings and quantitative measurement of the minimal neoglottic distance at rest and during phonation, the surface area of the neoglottic bar at rest and during phonation, the prominence of the neoglottic bar at rest and during phonation and the increase of the maximal sub-neoglottic distance from rest to phonation in two representative digitalized images (rest and phonation) of videofluoroscopy recordings;

and when available:

- Assessment of the visibility of the neoglottis, the visibility of the origin of the neoglottis, the amount of saliva interfering with neoglottic vibration, the shape of the neoglottis and the regularity of the vibration in digital high-speed imaging recordings (van As, et al. 1999).

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Van As, CJ, Tigges M, Wittenberg T, Op de Coul BMR, Eysholdt U, Hilgers FJM. High-speed digital imaging of the neoglottic vibration after total laryngectomy. *Arch Otolaryngol Head Neck Surg* 1999; 125: 891-897.

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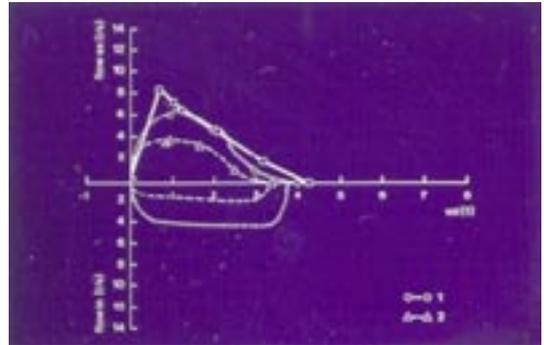
Van As, CJ, Op de Coul, BMR, Van den Hoogen, FJA, Koopmans-van Beinum, FJ, Hilgers, FJM (2001). "Quantitative videofluoroscopy": a new evaluation tool for tracheoesophageal voice production." *Archives of Otolaryngology Head and Neck Surgery* 127: 161-169.

# Pulmonary protection and respiratory rehabilitation

## Introduction

Total laryngectomy results in a wide range of physical and psychosocial sequelae for the patient, including life style changes.<sup>1</sup> The most prominent consequence of this surgical procedure is the loss of the normal voice, which nowadays often will be rehabilitated with a voice prosthesis, in our Institute, as discussed in the previous chapters, since 1988 preferably with the indwelling Provox and more recently with the second generation Provox2 prosthesis. The disconnection of the upper and lower airways also has repercussions for the conditioning - warming, humidifying and filtering - of inhaled air, which is thereby precluded. Consequently, many laryngectomized patients suffer from respiratory problems, of which involuntary coughing, excessive phlegm production, forced expectoration and dyspnea are the most pronounced complaints.<sup>2</sup> These symptoms develop and tend to increase during the first 6 months postoperatively, and probably well beyond that period, but later seem to stabilize. Frequently, there is an increase in respiratory symptoms during the winter. Moreover, these problems can have a serious impact on many aspects of daily life, including increased fatigue and sleeping problems, compromised voice quality, disrupted social contacts, and heightened psychological distress.<sup>2</sup> Although these problems are more or less self evident, the awareness about them amongst medical health care providers has been relatively low in the past.

Furthermore, an objective impairment of the pulmonary function of the laryngectomized patient can be expected as well. Pulmonary function assessment should be performed with an extratracheal device (e.g. Provox HME adhesive, see figure below)<sup>3</sup>. If an intratracheal cuffed-cannula is used, the flow-volume loop suggests lower (incorrect) values (see upperfigure, inner dotted curve). It could be established that the actual measured pulmonary function values of the laryngectomized patients studied are significantly lower than the (age, sex, height and race adjusted) predicted values.<sup>4</sup> Moreover, there seems to be an additional independent adverse effect of the laryngectomy in the older patient group. The above-mentioned differences were more pronounced in the over 65 years of age group.



# Heat and Moisture Exchangers (HME's)

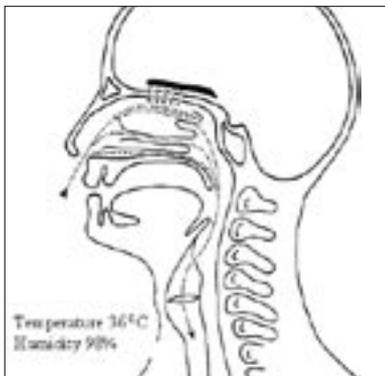
## Treatment aspects

In an attempt to restore some of the lost “nose” functions, the use of heat and moisture exchangers (HME's) was introduced. With such a device it appears possible to reduce the diurnal loss of water through the exhaled air (500 ml) by approximately 60%. In several studies the positive influence of a heat and moisture exchanger (HME) on respiratory problems could be established.<sup>5,6</sup> The study results indicated that the regular use of an HME can lead to a significant improvement of the respiratory and the related psychosocial problems of laryngectomized patients. Significant reductions were found in the mean daily frequency of sputum production, stoma cleaning and forced excretion. Consequently several aspects of daily life, e.g. feelings of fatigue and malaise and sleeping problems, improved. The use of the HME also influenced the voice quality in a positive way. The positive effects of an HME also could be established objectively: a significant improvement over time in the inspiratory flow-volume values has been observed.<sup>6</sup>

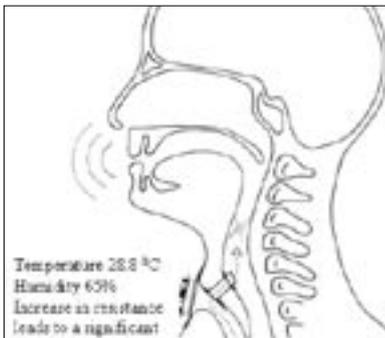
## Prevention aspects

Also a study was performed to investigate whether the use of an HME could prevent the development or reduce the severity of respiratory symptoms by initiating use of the device as soon as possible following total laryngectomy.<sup>7</sup> Comparing the pulmonary complaints in a regular user and a non-regular user group at 3 and 6 months postoperatively, statistically significant group differences over time in the frequency of forced excretion, and stoma cleaning and marginally significant differences in sputum production were observed. A clear trend could be seen, with regular HME users reporting a decline in respiratory symptoms over time as compared with non-regular HME users who reported an increase in these symptoms. These results show that an early start can prevent the development of respiratory symptoms considerably.

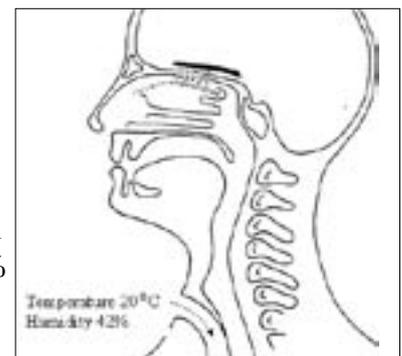
From these and other studies, it can be concluded that, at present, the only effective non-pharmaceutical treatment of pulmonary problems in laryngectomized patients is the regular use of an HME.



This has been substantiated by McRae and Jones, who demonstrated that the application of an HME results in an objective improvement of several important physical parameters.<sup>8</sup> In the normal situation the temperature is 36°C and the relative humidity 98% at the subglottic level (see figure left).



This situation is significantly changed after total laryngectomy. Under room temperature and humidity conditions, they observed an increase of the tracheal temperature from 20° to almost 29°C, and of the relative humidity from 42% to 65% after applying an HME (figure right).



The figures show this schematically. Furthermore, they could demonstrate a significant increase in the tissue oxygenation after reinstalling the breathing resistance by means of a HME, confirming the improvements of the pulmonary physiology (figure left).

Fig 1



Fig 2



Fig 3



Fig 4



Fig 5



## Provox HME

### **Compliance aspects:**

In the above-mentioned clinical trials, however, the compliance with the use of HME's was not always optimal. Between one-third and a half of the patients discontinued using the device. The two most prominent reasons were: 1. Problems related to the adhesive, such as skin irritation, the adhesion to the skin, loosening of the plaster by coughing and/or forced expectoration while clearing the airway, and 2. Problems with voicing: speech problems occur because patients with a voice prosthesis often experienced difficulties in closing the stoma airtight with a finger on top of the HME, which is needed to be able to vocalize adequately.

To reduce, or solve the two above-mentioned problems, a new type of HME (Provox HME) was developed.<sup>9</sup> The development is also based on and stimulated by ideas and suggestions from some of our patients, who participated in earlier studies and therefore had ample experience with the use of an HME. This new device consists of a disposable plastic housing, which is fixed to the peristomal skin (figure 2) by means of a self-adhesive tape. The housing is available with 3 different types of adhesive tape (Regular, FlexiDerm, and OptiDerm), in 2 sizes (round and oval) (figure 1). Regular is a transparent, perforated standard adhesive. FlexiDerm consists of a thin, transparent, flexible material, which is easy to adjust around deep and/or irregular stomas. OptiDerm is a colloid adhesive with hypoallergenic properties and has a light brown color. For the combination with an automatic speaking valve, such as the Provox FreeHands HME, a more stable Adhesive is available (XtraBase).

The actual HME cassette, which is also disposable, contains a heat and moisture exchanging foam, and a speech valve with a spring for airtight digital closure of the HME, and thus the stoma (figure 3,4 and 5). The spring is intended to open the valve after release of the finger pressure. The HME is constructed in such a way that inadvertent obstruction due to clothing or loss of consciousness is prevented to a great extent. There are two versions of the HME with different airflow resistances, i.e. a regular and a low resistance (HiFlow) version.

### ***Improvements in compliance:***

The assessment and evaluation of this new device showed that all patients were clearly positive about the valve used for digital occlusion of the device, and thus the stoma.<sup>9</sup> Voicing was considerably facilitated and the intelligibility improved. The HME cassette could easily be replaced manually, if needed. The median period of time that the adhesive adhered to the skin optimally was one day for the regular adhesive and two days for the other two types of adhesive. Problems experienced in previous studies related to the adhesive tape, such as skin irritation, inadequate adherence and loosening of the plaster by coughing or forced ex- pectoration in order to clear the airway could be solved by the availability of the different adhesives includ- ed in this system. For each individual patient a suitable plaster was available. The fact that these plasters did correctly adhere to the skin for often more than one day was appreciated by most patients.

It could be concluded from our initial study, there was a clear improvement in short-term compliance. In order to investigate long-term compliance, 69 consecutive patients were interviewed by means of a struc- tured questionnaire.<sup>10</sup> The results showed that all patients expressed their satisfaction with the valve used for digital occlusion of the stoma. Sixty-three percent of the patients reported that voicing was facilitated. Subjective intelligibility improved in 55% of the patients. Previous problems with other devices, e.g. plaster adherence, skin irritation, and handling were clearly diminished, increasing the long-term compliance of the patients to 78%.

### ***Improvements in voicing:***

The improved intelligibility and easier stoma occlusion, as reported by the patients using the Provox HME, were recently studied in 21 laryngectomized patients.<sup>11</sup> Two different stoma occlusion conditions, i.e. direct digital occlusion of the stoma (by thumb or finger), and digital occlusion (by finger) via the Provox HME were compared. For both conditions acoustical analyses of voice quality (various pitch, amplitude, tremor and harmonicity measures) were performed on a sustained /a/, the mean maximum phonation time was calculated, and a phonetogram was made to establish the dynamic loudness range. Acoustical analysis was possible in 13 of the 21 voices (for the other voices the pitch was too low or the voice was too aperiodic), but no statistical significant differences were found for any of the acoustical pa- rameters studied. However, the maximum phonation time was significantly longer and the dynamic loud- ness range was significantly larger, under the Provox HME occlusion condition. The maximum phonation time showed a relevant improvement in 57% of the patients, while the dynamic loudness range showed a relevant improvement in 35% of the patients. In total, 75% of the patients benefit of an improvement in one or both of these speech characteristics when using the Provox HME occlusion.

It can be concluded that optimal stoma occlusion by means of a specialized device has a positive influence on two relevant parameters of prosthetic voice production: maximum phonation time and dynamic loudness range.

### **Early post-operative pulmonary hygiene:**



Another advantage with Provox HME is, that the colloid plaster can be used early post-operatively, even with the stitches still in situ (see figures left). In our department we have adopted the custom to apply the Provox HME colloid plaster (OptiDerm) already at the first post-operative day. Since we always try to create a stable tracheostoma, that does not need a tracheostomy cannula to be kept open, this adhesive can easily be glued to the peristomal skin. This makes external humidification superfluous, and appears to be very cost effective. This custom has several other definitive advantages: the patient has optimal stoma protection as early as possible, the need to use suction to clear the trachea from sputum appears to be diminished, noisy external humidification is avoided, the patient gets used to the HME early (no problem with the airflow resistance of the device, because this is lower than the preoperative upper airway resistance), the stoma has a well cared for appearance for the family and other visitors.



If the patient postoperatively needs a cannula in order to keep the stoma sufficiently open, it is still possible to use an HME immediately by applying a LaryTube

cannula, which has a special adapter to hold the HME, as can be seen in the top and middle figure to the right. In this case the HighFlow cassette should be used, because of the airflow resistance of the cannula itself. If there is a need for using a standard tracheostomy tube, the TrachPhone HME can be applied, which also has an adapter for oxygen application, if needed (figure right).



Another advantage of using the Provox HME system immediately post-operatively is found in early voice rehabilitation. In the figures on the previous page an example is given of a patient 12 days postoperatively. Often, patients are somewhat reluctant to start with the speech therapy, because it can be difficult to close the not yet nicely healed 'rounded' stoma, and because the skin still might be somewhat sore. By applying the HME, the patient can start with speech therapy and will be able to properly close the stoma digitally in a hygienic way, without undue pressure on the suture lines.

### **Breathing resistance (Provox HME Cassette Normal versus HiFlow):**

The breathing resistance of the normal Provox HME Cassette is sometimes considered too high by some patients. Especially when the laryngectomy has been carried out already some time ago, the patient might have some problems adjusting to the increased breathing resistance when starting HME use. This might decrease the compliance of the patient (which is less the case, when starting with the HME immediately postoperatively, as mentioned above). Often, a careful explanation of the physiologic benefits of the (partly) restored breathing resistance, along with the more obvious heating and moisturizing benefits, is sufficient to convince the patient. Sometimes, however, the increased breathing resistance is not accepted by a patient. Therefore, a Provox HME Cassette with a lower resistance allowing a higher airflow, called HiFlow, has been created. It can be considered as a starter device, which can be replaced after some weeks by the normal HME Cassette. Also for patients, who are physically still very active, this HME might be used during exercises or sports activities. These patients might use both the Normal and the HiFlow Cassette alternately.



### ***Treatment with inhalation medication in laryngectomized patients***

In patients who still need inhalation medication, the application of such a drug is often problematic. The standard dose inhalers are specially designed for oral use, and the size of the nebulized particles should allow them to 'stay airborne' during transoral, -pharyngeal, and -tracheal passage. Even then, often a considerable amount of the drug will become deposited on the pharyngeal and laryngeal mucosa and not reach the trachea and bronchi, where the medication is supposed to exert its effect. Although there are no data available on the delivery of inhalation medication through the stoma, it is conceivable that in this case the results are even less ideal.

Also, a good hand-breathe coordination, which is a prerequisite for optimal delivery of the drug in oral application, is probably more cumbersome for laryngectomized individuals. Therefore, delivery right out of the dose-inhaler through the stoma, as shown in the top figure, is probably suboptimal. Preliminary data in our clinic suggest that delivery through a spacer (shown in the lower figure; Babyhaler, Glaxo-Wellcome), connected to the peristomal area through a Provox HME adhesive, gives better results. Further clinical studies

are needed to substantiate this, but in the mean time, it seems logic to add a spacer to the prescription of a dose inhaler for laryngectomized patients.

### **Conclusions**

The results of these studies suggest that the use of an HME can effectively reduce the physical and psychosocial problems after total laryngectomy. Continuous use of the HME, both day and night, is advisable to obtain an optimal pulmonary rehabilitative effect. With the availability of the Provox HME early post-operative pulmonary hygiene and voicing is improved. The short and long-term compliance with the use of this HME by laryngectomized patients, not always optimal in the past, is also clearly improved, because digital stoma occlusion is greatly facilitated by its valve mechanism. This device undoubtedly can improve the vocal prosthetic and pulmonary rehabilitation of laryngectomized patients, especially of those individuals who have too limited dexterity to handle a handsfree valve. It should be emphasized that an HME is a medical device. Optimal results can be expected only with better awareness of the medical team of the respiratory symptoms and the related psychosocial problems, and with proper patient education.

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# Rehabilitation of olfaction

## Introduction

Deterioration of the sense of smell seems an inevitable consequence of total laryngectomy<sup>1</sup>. This bothering side effect of the operation is caused by disconnection of the upper and lower airways, which results in breathing through a tracheostoma in the neck, and thereby absence of nasal airflow (see figures; dashed line indicates airflow). Therefore, odor molecules are no longer passively reaching the olfactory epithelium<sup>a</sup>, and patients are effectively anosmic, despite the fact that the olfactory system essentially is intact. Over the years, several studies have established this problem, without finding a solution for this 'nuisance'. Most patients actually seem to accept this problem, probably due to proper counseling prior to the surgery and to the lack of an effective rehabilitation method<sup>1,2</sup>. The absence of complaints about this problem is actually quit surprising in view of the many patients finding their way to the otolaryngology practice in case of a sudden or gradual loss of the sense of smell, which in laryngeal patients apparently is considered to be an unacceptable symptom of what is often suspected to be a sign of a serious underlying illness<sup>3</sup>.

## Clinical research on olfaction after total laryngectomy

In order to prove that the sense of smell essentially is intact if there would be a nasal airflow, the larynx-bypass is a useful instrument<sup>4,7</sup>. This device consists of a mouthpiece, a tube and an attachment possibility of that tube to the stoma (either through an adhesive (right upper figure) or through a cap covering the stoma (right lower

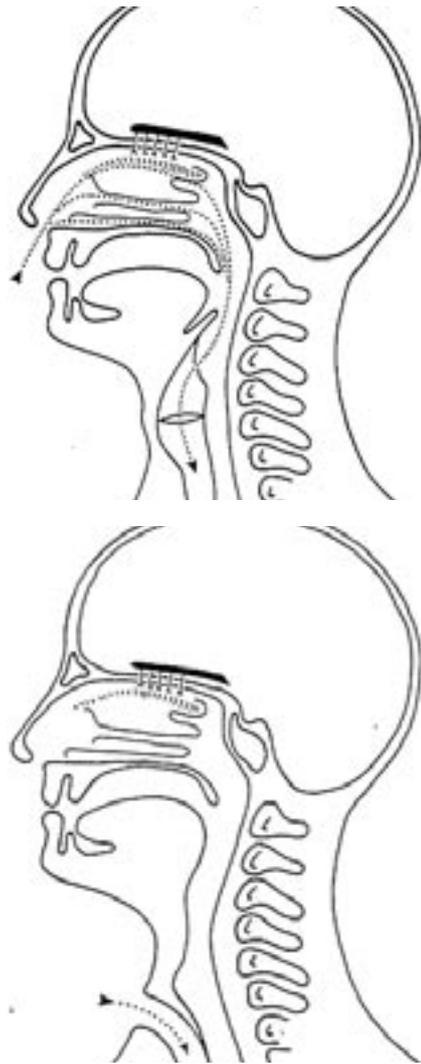


figure)). By connecting the mouth with the stoma and subsequently breathing in through the nose, a nasal airflow is provoked. This allows odor testing, and it could be shown that in most laryngectomized individuals the sense of smell is intact. However, for obvious reasons, this is not a useful instrument to rehabilitate the olfactory acuity in every day life.

Recently, this problem has been studied in depth, and again the magnitude of this problem was established<sup>2</sup>. On the basis of 2 odor tests and standardized questionnaires, it was found that more than two-thirds of a cohort of 63 laryngectomized individuals was effectively anosmic ('non-smellers'). Careful observation of the patients, who scored positive on one or both of the odor tests (the 'smellers'), revealed that these patients used their 'facial muscles' actively significantly more often. Furthermore, most of these patients were using their 'smell technique' unconsciously and had 'discovered' this technique all by themselves. Specific training was not given to them during their postlaryngectomy (vocal and pulmonary) rehabilitation program.



## Clinical research on rehabilitation of olfaction

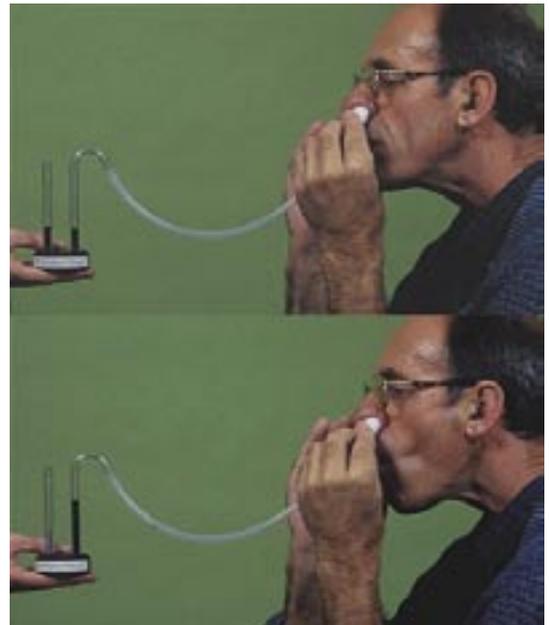
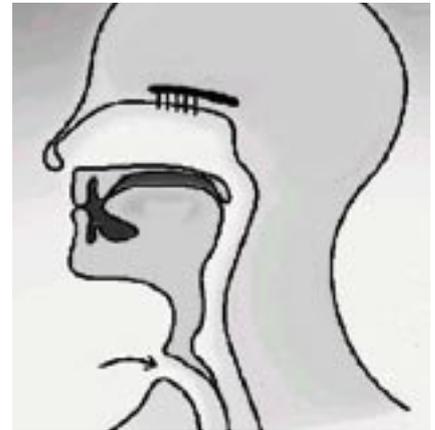
Analyzing the observed movements of the 'facial muscles', we came to the conclusion that some movements actually result in a nasal airflow, which allows the odor molecules to reach the olfactory epithelium again. Refining these observed movements led to the conception of a nasal airflow inducing maneuver (NAIM) or so-called 'polite yawning' technique<sup>8</sup>. This technique induces, basically, a rapid increase in volume of the oral cavity, while keeping the lips closed airtight. The potential vacuum, prompted by the 'expansion' of the oral cavity, has to be filled and the result is an airflow through the nasal cavity (see top figure and animation on CD-rom). By repeating this maneuver rapidly, a 'pumping' effect is created and a sufficient airflow through the nose is established in order to be able to smell again.

This airflow can be visualized by means of a water manometer (see middle figure and video clip on the CD-rom), which gives the patient (and the speech pathologist) an immediate visual feedback about the effectiveness of this maneuver.

The effectiveness of the NAIM was established in an intervention study and subsequently confirmed in a follow-up study<sup>8,9</sup>. Approximately half of the patients were able to smell again after one half-hour training session. Also the 25 percent of the patients in this series, who were already able to smell with a personal technique, indicated an improvement: after the instruction by the speech

pathologist, they were much better able to provoke a nasal airflow and could much better smell 'at will'.

Traditional odor testing methods are time consuming and somewhat difficult for laryngectomized individuals, especially prior to the instruction of the NAIM.<sup>2,8</sup> This testing appears to be somewhat easier when using the Zürcher Geruchstest (see video clip on the CD-rom), recently described by Simmen et al.<sup>10</sup>. The Zürcher Geruchstest contains 8 different odors with a multiple choice illustrated form (3 suggestions per odor). Olfaction is considered to be normal in case the patient identifies 7 or 8 of the odors correctly. Otherwise, the patient is considered to be anosmic or hyposmic. For initial testing of the olfactory acuity and assessing the results of the rehabilitation program, this is a quick (5 minutes) and easy method for patients to apply.<sup>9</sup>



## Considerations on olfaction rehabilitation after total laryngectomy

Rehabilitation of olfaction in laryngectomized individuals clearly belongs to the sphere of activities of the speech pathology profession, and should form an integral part of the postlaryngectomy rehabilitation program. From our studies it becomes clear that more intensified training is needed in many patients, in order to transform the NAIM into an automatism, and to integrate the maneuver in all every-day-life situations. It has to be stressed with the patient, that compensation for the lack of passive smelling is only possible to a certain extent, if the NAIM is applied in every change of environment or situation, e.g. entering a room, approaching other people, etc. This is also an important reason to try to make this maneuver as unobtrusive as possible, and this requires additional speech pathology efforts. In fact, the so-called 'large' movement, where the jaw is lowered substantially in order to increase the volume in the oral cavity, can be transformed into a 'small' movement, in which the position of the jaw is not changed and only the floor of mouth and tongue are lowered. By quick repetition of this 'small' movement, a large enough airflow is provoked to enable smelling again. The 'small' movement can be applied without drawing much attention, and patients who acquire this skill are more likely to use the NAIM regularly.

**In conclusion:** olfaction rehabilitation in laryngectomized individuals should form an integral part of the rehabilitation program, deserving as much attention of the speech pathologist as the other two postlaryngectomy fields of interest, i.e. speech and pulmonary rehabilitation. The nasal airflow inducing maneuver or 'polite yawning' technique forms an excellent 'instrument' for the speech pathologist to address this disturbing problem, resulting in a clear improvement not only in olfaction, but also in taste perception, and thus in an improved quality of life.

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