Fiberoptic Examination of the Pharyngoesophageal Segment in Tracheoesophageal Speakers

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Objective: To describe a novel use of flexible fiberoptic endoscopy to examine the pharyngoesophageal segment, upper esophagus, and distal end of the tracheoesophageal prosthesis in patients who have undergone a total laryngectomy and a tracheoesophageal puncture.

Methods: Five patients with poor-quality or no tracheoesophageal voice were evaluated by a speech pathologist and an otolaryngologist. A flexible endoscope interfaced with a video monitoring device was introduced transnasally and passed through the pharyngoesophageal segment. Examination of the anatomical relationship between the prosthesis and the esophageal mucosa was conducted while the subjects attempted to phonate. Treatments were then initiated based on the endoscopic findings.

Conclusion: Flexible endoscopy is a safe, cost-effective, diagnostic tool for evaluating laryngectomees suffering from poor-quality tracheoesophageal voice.


Tracheoesophageal puncture (TEP) has been used for more than 20 years as an effective surgical voice restoration technique after total laryngectomy. After a fistula tract is created between the esophagus and trachea, a 1-way prosthetic valve is placed into the tract that enables pulmonary airflow from the trachea to enter the esophagus, while preventing the backflow of food and fluids from the esophagus into the trachea.1 It is a relatively simple procedure to perform, and in most cases patients achieve good to excellent voice quality and speech production after appropriate instruction on the use of the prosthesis.2,3 In a small percentage of cases, effective tracheoesophageal voicing is not achieved. Often, the problem results from spasm of the pharyngoesophageal segment (PES), with a resultant inability to initiate and/or sustain airflow for voicing. Occasionally, poor voice outcomes may result from improper fit of the prosthesis or from the erosive effects of Candida colonization,4 which may stiffen the valve of the prosthesis and inhibit the airflow dynamics that are required for voice production. Redundant esophageal mucosa and unusually narrow luminal dimensions may also be culpable in patients who fail to produce acceptable tracheoesophageal voice, and in some cases these tissue abnormalities may encroach on the prosthesis valve itself and restrict airflow. It has been suggested that the use of endoscopy to visualize the tracheoesophageal prosthesis can help verify the correct placement of the prosthesis within the esophagus.5 We have discovered that visualization of this valve within the esophagus can help in the differential diagnosis of prosthesis-related tracheoesophageal voicing difficulties. Such findings have prompted a variety of minor prosthesis modifications, which in turn have resulted in improved tracheoesophageal voice quality. We describe 5 patients who underwent TEP but who were unable to produce effective voice despite proper prosthesis fitting and adequate training. The unique method of evaluation and treatment is detailed in each case.

REPORT OF CASES

CASE 1

A 76-year-old man who underwent a total laryngectomy and primary TEP at an outside institution presented to our voice center 2 months after surgery. His chief complaint was that he had difficulty initiating and sustaining sufficient airflow to produce voice. He also complained of intermittent leakage of esophageal contents through the esophagus during meals and occasionally at rest. He was examined and found to have a 2.6-cm, 16F, low-pressure Blom-Singer voice prosthesis (InHealth Technologies, Carpinteria, Calif). The TEP tract was measured, and it was determined that the existing prosthesis was too long. The patient was subsequently fitted with a smaller, appropri-
SUBJECTS AND METHODS

Five patients with poor-quality or no tracheoesophageal voice served as subjects for this study: 4 underwent secondary TEP, and 1 underwent a TEP procedure at the time of laryngectomy. Routine clinical evaluations were performed by a speech pathologist (M.L.S.) with more than 20 years of experience in such cases to assess the site and size of the TEP, fit of the prosthesis, and probability of PES spasm, as well as to find out whether each patient was using proper technique to generate tracheoesophageal voice. If no obvious abnormalities were identified, flexible endoscopy was performed.

To evaluate the status of the tracheoesophageal prosthesis within the esophageal lumen, a flexible fiberoptic scope (Rhino-Laryngofiberscope Type P3; Olympus America Inc, Melville, NY) interfaced with a videocassette recorder (Diamond Pro Professional Video Cassette Recorder BV2000, Mitsubishi Electronics America Inc, Torrance, Calif) and camera (Mitsubishi Electronics America Inc) was introduced transnasally and passed through the PES. The anatomical relationship between the distal end of the prosthesis and the walls of the esophagus was then examined. After the examination, the patient was instructed to phonate by occluding the tracheostoma with a finger to shunt pulmonary air through the prosthesis and into the esophagus. Valve activity and prosthesis function were evaluated and photodocumented to determine the extent to which the prosthesis itself might be responsible for the faulty voice output. Treatments were then initiated based on the results of the investigation. The problems encountered and the management techniques used for our patients are described below.

At least sized 2.2-cm, 20F, indwelling Blom-Singer prosthesis. Despite refitting of the prosthesis, the patient continued to have difficulty generating a fluent tracheoesophageal voice. He also continued to struggle with transient aspiration symptoms. At this point, the decision was made to try to visualize the prosthesis within the esophagus using the previously described flexible endoscopy technique. This examination revealed the prosthesis to be entering the esophagus at an awkward angle within the esophageal lumen, perhaps as a sequel to the unusual direction of the TEP tract. Such positioning caused the valve of the device to be partially impacted against the esophageal wall (Figure 1). Examination of good tracheoesophageal speakers has shown us that speech and voice performance are most proficient when the distal end of the prosthesis rests, without obstruction, perpendicular to the anterior esophageal wall (Figure 2). The unusual angle of the prosthesis in the current case resulted in at least intermittent pressure on the esophageal retention collar and valve mechanism. This pinching effect caused transient resistance to airflow during speech efforts, as well as incomplete closure of the valve during swallowing. To correct these problems, an additional Silastic collar was molded to the original esophageal retention collar of the prosthesis to provide an improved and more stable platform within the esophagus. Improved stability was accomplished using nonreinforced silicone sheeting (Pharm Elast 20-20 Silicone Sheet; SF Medical, Hudson, Mass) and adhesive silicone (Type 1A, MED 1137; Nusil Technologies, Carpinteria, Calif) (Figure 3). The desired result was to stiffen and expand the existing collar and to prevent it from becoming embedded in the esophageal wall. Consequently, the angle of the prosthesis within the esophagus more closely resembled the aforementioned benchmark for proficient speech production and airway protection. After reinsertion of this modified device, the patient was able to generate more fluent tracheoesophageal voice and speech. He also exhibited no further esophageal leakage through the tracheoesophageal prosthesis.

CASE 2

A 64-year-old man underwent a total laryngectomy and right radical neck dissection. A TEP was performed 2 years after surgery, and the patient was fitted with a 2.2-cm, 20F, low-pressure Blom-Singer prosthesis. His initial voice production was of good overall quality; however, he experienced difficulties with aspiration through the prosthesis.
The leakage persisted despite replacement of the prosthesis with a second device of the same size. Fiberoptic endoscopy revealed that the prosthesis was entering the esophagus at the junction of the anterior and posterior walls (Figure 4). This caused the retention collar of the prosthesis to become crimped by the surrounding esophageal mucosa, resulting in inadvertent opening of the prosthetic valve, with leakage into the trachea. To prevent crimping of the voice prosthesis, a larger Silastic collar was attached to the anterior side of the esophageal retention collar with materials that were similar to those described in case 1. This augmentation served to both stiffen the retention collar and flatten out the esophageal wall, thus stopping further leakage and aspiration (Figure 5).

CASE 3

A 50-year-old man who underwent a total laryngectomy followed by a TEP 1 month later was fitted with a 1.4-cm, 20F, low-pressure Blom-Singer voice prosthesis. The TEP tract was located near the mucocutaneous junction of the tracheostoma, which made it difficult for the patient to avoid digital occlusion of the airflow port during voicing. He was ultimately able to manage this problem. He next presented 3 years after surgery with complaints of progressive difficulties in voicing. Granulation tissue had developed around the tracheostoma, near the unusually high-placed tracheoesophageal prosthesis. When the patient attempted to speak, he was intentionally tipping the voice prosthesis superiorly to achieve the airflow necessary to generate voice, while trying to avoid occluding the airflow port. The constant manipulation of the prosthesis and the subsequent irritation of the surrounding mucosa most likely led to the development of granulation tissue. To improve the high TEP position, a decision was made to remove the prosthesis and to have the patient undergo a second TEP procedure. A second TEP was performed, and fitting was accomplished using a 1.8-cm, 20F, low-pressure Blom-Singer prosthesis. However, after the fitting, the patient had difficulty initiating and sustaining airflow and voice. Attempts with open-tract voicing (removing the prosthesis) resulted in a substantial improvement in voice production, which indicated that the problems were prosthesis related. Measurement of the TEP tract revealed that the tracheoesophageal prosthesis was coming into contact with the posterior esophageal wall during voicing attempts. Further investigation using a flexible endoscope confirmed our initial suspicions; direct contact of the prosthesis against the posterior esophageal wall prevented the valve of the prosthesis from opening and obstructed airflow (Figure 6). Also, endoscopy revealed an abnormally small anterior to posterior diameter of the esophageal lumen. To solve this problem, the patient was fitted with a 1.8-cm, 20F, ultra-low-pressure prosthesis (Bivona Medical Technologies, Gary, Ind) (Figure 7). This device is specially designed with a hood over the distal esophageal end of the prosthesis, with a side-located airflow passage into the esophagus. The valve door is contained within the barrel of the prosthesis and opens into a side area where contact with the posterior esophageal wall will not obstruct airflow. The patient now has good-quality tracheoesophageal voicing.

CASE 4

A 76-year-old man underwent a total laryngectomy and secondary TEP with postoperative voice therapy at an outside institution. He subsequently presented to our center and was found to have a 2.2-cm, 16F, duckbill Blom-Singer prosthesis in place. The TEP tract was noted to...
be located at the mucocutaneous junction, with the prosthesis projecting abnormally into the tracheal airway. The patient also complained that there was leakage of esophageal contents around the prosthesis when he was drinking liquids. Measurement of the TEP tract indicated the correct fit to be 1.8 cm; however, this fitting resulted in digital occlusion of the airflow port during phonation attempts owing to the unusual location of the original TEP site. The patient was advised to allow the present tract to close and then to have a second TEP to create a more optimally positioned tract. Despite this recommendation, he refused to undergo another operation and requested some type of alternative treatment. He was therefore fitted with a 1.8-cm, 20F, low-pressure Blom-Singer prosthesis to further decrease expiratory pressures needed to initiate and sustain airflow for voicing. To prevent digital occlusion of the airflow tract, a tracheostoma valve housing was fashioned with a digital occlusion reducer and positioned over the stoma site. These adjustments enabled him to achieve good-quality tracheoesophageal voice.

Several years later, the patient presented with complaints of increased difficulty in initiating and sustaining airflow for voice production. Examination revealed that the prosthesis was the appropriate size. Flexible endoscopy showed that the distal end of the prosthesis was buried in a mound of granulation tissue on the anterior esophageal wall (Figure 8). To stabilize the prosthesis within the esophagus, an additional larger Silastic collar was attached to the existing esophageal retention collar. Stability was accomplished using nonreinforced silicone sheeting (Pharm Elast 20), as described previously. This modification created a stiffer and larger retention collar, allowing the prosthesis to be stabilized (Figure 9). It also resulted in reduction of expiratory pressures during phonatory efforts, providing an improved platform for the prosthesis. The results were excellent.

CASE 5

A 79-year-old man underwent a total laryngectomy with a secondary TEP. He was fitted with a 1.8-cm, 20F, low-pressure, indwelling Blom-Singer voice prosthesis and was able to produce reasonably good voice with this device. One year after surgery, he presented with complaints of difficulties in initiating and sustaining airflow for voicing. Measurement of the TEP tract verified that the prosthesis was the proper length. When the prosthesis was
removed, the patient generated significantly improved voicing through the open tract, which indicated that the problem was prosthesis related. Fiberoptic endoscopy revealed that the esophageal retention collar was seated within a craterlike defect in the anterior esophageal wall (Figure 10). Although the patient was refitted with a larger prosthesis, the distal portion of the prosthesis continued to retract into the defect. To solve this problem, an additionalSilastic collar was attached to the existing esophageal retention collar, as previously described. The additional width of the retention collar prevented the indwelling prosthesis from being displaced into the depression in the anterior esophageal wall. After a 6-month period, the mucosal crater healed around the prosthesis barrel, and the patient was able to return to a standard 2.2-cm, 20F, indwelling Blom-Singer voice prosthesis.

Preservation of voice and swallowing function after total laryngectomy is a vital concern of the patient and a challenge for the rehabilitation team. In the distant past, total laryngectomies had 2 choices for voice rehabilitation. They either learned how to develop esophageal voice skills that often required extensive speech therapy or used an artificial larynx, which resulted in functional but poorer-quality voice and speech characteristics. The TEP surgical voice restoration technique developed by Singer and Blom dramatically improved functional voice and speech outcomes for total laryngectomies. This procedure can be performed primarily at the time of the laryngectomy, or at a later date as a secondary approach. To date, the TEP alternative has been widely accepted internationally, and it may be considered the “gold standard” for speech rehabilitation, particularly for those laryngectomies who are reluctant to use an artificial larynx or to learn esophageal speech to communicate verbally.

Although the TEP technique provides good to excellent voice quality in the majority of cases, speech pathologists and otolaryngologists are sometimes confronted with patients who struggle with poor voice output and control; in some cases, little or no usable voice is obtained. This group of patients poses a therapeutic challenge for even the most experienced speech pathologist because of the complexity of problems that may be responsible for the voicing difficulty. The lack of a clear understanding of the cause of poor voice production can lead to an incorrect diagnosis, resulting in unnecessary, costly, and unsuccessful treatments. At our institution, an algorithm has been developed to help guide the speech pathologist and otolaryngologist during the diagnostic evaluation of such patients (Figure 11).

Common causes of poor tracheoesophageal voicing include: (1) problems related to the proximal (tracheal) or distal (esophageal lumen) ends of the tracheoesophageal prosthesis and/or (2) abnormalities associated with the PES and upper esophagus, such as spasm, stenosis, mucosal irregularities, and persistent or recurrent carcinoma. Time since the onset of voice difficulties after the TEP procedure and the rate of progression of voice dysfunction can aid in developing a differential diagnosis. Those patients who fail to produce good quality voice after being initially fitted with a prosthesis will usually demonstrate problems related to (1) the technique being used to produce voice, (2) the size or fit of the prosthesis, or (3) spasm, stenosis, or mucosal abnormalities of the PES and upper esophagus. Patients who have enjoyed good quality voicing but who eventually develop phonatory difficulties will commonly have obstruction of the proximal or distal ends of the prosthesis as a result of crusting, mucous collection, or Candida colonization. Less commonly, they may demonstrate abnormalities associated with the PES and upper esophagus, such as stenosis, mucosal irregularities, or recurrent carcinoma.

A thorough history and complete physical examination are vital in the initial workup, because the findings will establish the diagnosis in the majority of cases. The initial examination should assess whether the patient is using proper technique for voice production. Next, the tracheo-
esophageal prosthesis should be inspected in situ for (1) collection of mucus or crusts within its lumen that may result in airflow obstruction (for patients with an established TEP tract and prosthesis), (2) abnormal TEP tract angulations that may lead to dysfunction of the prosthesis, or (3) unusual position of the prosthesis within the tracheostoma owing to irregular size or shape of the stoma. If no abnormalities are noted, or if voice fails to improve after cleaning of the device, the prosthesis should be removed to assess the integrity of the valve mechanism, to see if there is *Candida* colonization, to measure the length of the TEP tract to verify proper prosthesis size and fit, and to replace the prosthesis if necessary. If no improvement in voicing is obtained after these maneuvers, the prosthesis should again be removed and the patient should be taught how to voice through the open TEP tract using the usual finger-to-stoma valving technique. To facilitate this effort, the examiner can position a catheter through the open tract and blow air through the tube to insufflate the esophagus to induce passive PES vibrations and vocalization. The patient can then convert these sounds into speech activity. Improvement in voice quality with open-tract voicing, or with the trans-tracheoesophageal tract insufflation technique, is suggestive of a prosthesis-related problem, likely at its proximal or distal end. If no improvement is noted with the open-tract voicing or insufflation techniques, other causes for poor tracheoesophageal speech ability related to the PES and upper esophagus should be entertained. Ancillary tests such as the modified barium swallow study, esophagram, or esophagoscopy with the patient under general anesthesia can aid in providing a diagnosis. Similarly, in-office fiberoptic endoscopy with the patient performing phonatory tasks can provide excellent visualization of the PES and upper esophagus to help differentiate these disorders, as well as provide a dynamic evaluation of the distal end of the prosthesis and its relationship to surrounding soft tissue structures.

In the present investigation, 5 patients presented with poor-quality tracheoesophageal voice, and 5 of the 7 patients had symptoms of aspiration through the tracheoesophageal prosthesis. Examination of the TEP tract, tracheoesophageal prosthesis, and tracheostoma failed to provide an explanation for the voice or aspiration difficulties, therefore prompting use of fiberoptic videendoscopy of the PES, upper esophageal region, and distal end of the tracheoesophageal prosthesis to help provide a diagnosis. This examination revealed abnormalities involving the distal aspect of the tracheoesophageal prosthesis and its anatomical relationship to surrounding soft tissues in all our patients. Fiberoptic observation was pivotal in determining the cause of the abnormal symptoms, thus allowing implementation of prompt and effective treatments. None of our patients complained of discomfort during or suffered complications after the endoscopic examination. Management required simple modifications in the design of the prosthesis to overcome valve crimping and prosthesis compression to prevent aspiration and to improve airflow dynamics for better PES vibration and voice production. Without the aid of fiberoptic endoscopic visualization, an accurate diagnosis would not have been made, therefore delaying the necessary prosthesis adjustments needed to correct the underlying tracheoesophageal speech difficulties.

**CONCLUSIONS**

During tracheoesophageal voicing, the upper esophagus and PES are insufflated by pulmonary-driven airflow through the tracheoesophageal prosthesis. This phenomenon enables use of fiberoptic endoscopy to provide unobstructed visualization of the luminal side of the prosthesis and its relationship to surrounding structures. If abnormalities are identified, customized prosthesis alterations can be performed to improve tracheoesophageal voice quality. Alternative modifications are addressed in the current case presentations. These individuals benefited from such intervention in that their speech characteristics markedly improved and aspiration symptoms subsided after treatment. Importantly, none of the patients complained of discomfort from the endoscopic technique, and there were no reported complications.

The present investigation was supported by an algorithm that we routinely incorporate to assist in the differential diagnosis and treatment of total laryngectomees suffering from poor-quality tracheoesophageal voice, aspiration symptoms, and/or dysphagia, notwithstanding adequate speech therapy. Otolaryngologists in the office setting can easily perform the flexible videendoscopic procedure. Combined with a thorough clinical evaluation, this technique is relatively simple to perform, safe, and cost-effective. The greatest utility of this evaluation approach is realized when the otolaryngologist and speech pathologist work closely together to determine when such an appraisal is warranted and what therapeutic measures can be used to alleviate the underlying problem.

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**REFERENCES**