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TRACHEOSTOMAPLASTY: A SURGICAL METHOD FOR IMPROVING RETENTION OF AN INTRALUMINAL STOMA BUTTON FOR HANDS-FREE TRACHEOESOPHAGEAL SPEECH

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Abstract

Background—We describe a minimally invasive surgical technique, tracheostomaplasty, to overcome anatomical deformities of the stoma that preclude successful retention of a stoma button for hands free tracheoesophageal (TE) speech.

Methods—We conducted a retrospective analysis of 21 patients who underwent tracheostomaplasty after laryngectomy to accommodate an intraluminal valve attachment for hands-free TE speech.

Results—Sixteen men and 5 women (median age, 65 years; median follow-up, 27.7 months) underwent tracheostomaplasty; 6 patients developed a mild cellulitis that required therapy and 5 patients required a minor revision surgery. At last follow-up, 15 (71%) patients successfully achieved hands-free TE speech using an intraluminal stoma button. Three patients only retained the intraluminal device to facilitate digital occlusion. Tracheostomaplasty failed in 3 patients because of granulation tissue formation or stomal stenosis.

Conclusions—Tracheostomaplasty is a successful technique to improve intraluminal retention of a stoma button for hands-free TE speech in laryngectomy patients.

Keywords

laryngectomy; Barton–Mayo button; hands-free tracheoesophageal speech; outcome; complications

Losing the ability to communicate orally has a dramatic effect on the quality of life of patients who undergo a total laryngectomy.¹ Tracheoesophageal (TE) voice restoration has become a common choice for vocal rehabilitation because it provides voice quality and fluency that are comparable to those of normal laryngeal speech.^{2,3} TE speech is achieved using a unidirectional valve that diverts expiratory airflow toward the pharyngoesophagus and, at the same time, protects the airway during swallowing. Sound is produced by the vibration of the hypopharyngeal mucosa and is then modulated into words by the articulators in the oral cavity.⁴ TE speakers can shunt air from the trachea into the esophagus by either manual occlusion of the stoma or the use of a hands-free speaking valve. The latter eliminates the inconvenience and lack of hygiene associated with manual occlusion.⁴

The Barton–Mayo button (BMB, or the Mayo Clinic Tracheostoma Button; InHealth Technologies, Carpinteria, CA) was introduced in 1988 for intraluminal attachment of a hands-free speaking valve.⁵ Use of a stoma button, such as the BMB, is a very appealing alternative to most TE speakers because it eliminates the need for peristomal adhesives. More recently introduced intraluminal devices, such as the Provox LaryButton (Atos Medical AB, Hörby, Sweden), function similarly to the BMB and can be used interchangeably by laryngectomized TE speakers.

For any intraluminal stoma button to function as an adequate attachment for a hands-free speaking valve,⁶ the stoma must meet several anatomic criteria. First, the stoma must have a relatively circular shape, with an adequate lip of cicatrix around the entire perimeter. This allows for the continuous support and snug fit of the button's shaft to prevent air leakage and dislodgement during TE speech. Second, the TE puncture must be located at least 10 to 15 mm below the mucocutaneous junction to avoid blockage of the puncture site by the button's shaft. Third, soft tissues around the stoma must be flat for adequate retention of the device; in some patients, use of the button can be limited by the presence of peristomal scars or prominent sternocleidomastoid muscle heads. Finally, the stoma must be located in a superficial plane (ie, at the level of the surrounding skin), leaving enough space for the external part of the button, which has a greater diameter than that of the shaft, to avoid contact with other structures. Retrosternal placement of a stoma can produce a funnel-shaped deformity of the peristomal skin that impedes adequate insertion of the button.

Because of the specific stomal morphology required for a snug fit, use of an intraluminal stoma button is not always achievable after total laryngectomy. Regardless of the stomal construction technique, few tracheostomas are circular, and it is very difficult to predict the formation of a prominent circumferential lip around the stomal edge. For this reason, the reported success of these devices ranges from 25% to 66% in different series.^{4,6}

BMBs can be customized to improve the fit in patients with minor tracheostomal deformities, and we have developed several modifications to the BMB that allow for a snug fit even in the presence of an inadequate stomal morphology.⁷ However, in the presence of multiple or severe stomal deformities, button customization alone usually fails to provide the fit required for retention of a hands-free speaking valve. In an attempt to improve the quality of life of these patients, 1 of us (G.P.R.) developed a single-stage surgical technique to correct stomal deformities that preclude the use of an adequately fitting BMB. This

minimally invasive technique, termed a “tracheostomaplasty,” involves revising an existing stoma using peristomal skin combined with fascial or tendon grafts to provide a permanent perennal retention surface for an intraluminal stoma button. The 2-fold purpose of this study was (1) to describe the technique of tracheostomaplasty in detail and (2) to present our experience with the technique in 21 patients who desired hands-free speech but were unable to wear a BMB.

PATIENTS AND METHODS

Data Collection

This retrospective study was approved by the Institutional Review Board of The University of Texas M. D. Anderson Cancer Center (Houston, TX), and a waiver of consent was obtained. We prospectively collected data on all 21 patients who underwent a tracheostomaplasty at our institution between January 2001, when the procedure was first introduced, and December 2006, when all patients in the study had a follow-up examination at least 6 months from the procedure. The criteria for selection of the study population were that the patient had a tracheostomy with a functional TE puncture, and that the peristomal skin appeared relatively healthy, especially after radiation therapy. Patients were excluded from this procedure if they had significant radiation-associated skin damage, if they had significant cardiopulmonary disease, or insufficient respiratory reserve to produce TE speech. In addition to the prospectively collected data, the electronic medical records of these patients were reviewed to retrieve information on demographics, tumor histology and stage, previous surgical treatment, adjuvant therapy, pre- and postoperative speech parameters, surgical complications, and reasons for additional procedures. The length of follow-up was calculated from the date of the last surgical procedure to the date of last contact with the patient.

Statistical Analysis

The endpoint of our analysis was the ability of a patient to use an intraluminal stoma button for hands-free TE speech for 6 consecutive hours. Thus, we compared patients who were able to achieve this endpoint with those patients who could not achieve this endpoint. Proportional variables were compared using the chi-square test or Fisher exact test, as appropriate, and continuous variables were compared using the Student's *t* test. All analyses were 2-tailed, and values of $p < .05$ were considered significant; otherwise, actual *p* values are shown. Statistical analysis was performed using SPSS Statistics version 17.0 software (SPSS Inc., Chicago, IL).

Rationale for Tracheostomaplasty

The main objectives for developing this surgical procedure were: (1) to create a neostoma by using the peristomal skin but without revising the mucocutaneous junction; (2) to create a neostoma with a diameter that meets the airway demands of most individuals; (3) to use autologous grafts to provide long-term support for the neostoma and, at the same time, minimize the complications associated with other types of grafts; (4) to avoid unnecessary manipulation of the peristomal soft tissues by using minimally invasive techniques; and (5)

to limit the use of local skin flaps to patients in whom they are strictly necessary. Every step of the surgical technique was designed to minimize the risk of stenosis of the neostoma.

Morphometric studies of the human larynx estimate the mean maximum glottic width at 12 mm and the mean area for the posterior (respiratory) glottis at 101 mm² in men.^{8,9} Based on this information, we selected a #12 BMB for calibration of the neostoma. This device has an internal diameter of 13.5 mm and a cross-sectional area of 143 mm², which should suffice for the airway requirements of most individuals.

Description of Tracheostomaplasty Technique

Intravenously administered antibiotics were given to the patient in the holding room. The patient was placed on the operating table in a supine position. After general anesthesia was induced through a size 6 reinforced endotracheal tube placed in the tracheostomy, the patient's neck, chest, and 1 thigh were prepared with an antimicrobial solution, and were draped in a sterile fashion. The balloon of the endotracheal tube was fully inflated, and the peristomal skin and upper walls of the tracheostomy were cleaned with povidone/iodine solution. Excess povidone/iodine solution was suctioned to prevent aspiration.

The first step of the tracheostomaplasty was to harvest the graft from the thigh-donor site. A 4-cm-long incision was designed over the distal lateral thigh parallel to the axis of the limb. The incision was carried down to the tensor fascia lata (TFL) tendon. A 1-cm-wide flap of fascia was incised and placed in the end of a Crawford fascial stripper, carefully pushed forward to remove a total length of fascia about 13 to 15 cm. The graft was defatted, wrapped in a sterile saline-soaked sponge, and placed on a Mayo stand for later use. Pressure was used to obtain hemostasis, and the TFL-donor site was closed.

A subcutaneous tunnel located approximately 1 cm from the edge of the stoma of the tracheostomy was created through 1-cm radial incisions at the 3, 6, and 9 o'clock positions around the stoma (see Figure 1). If necessary, an incision at the 12 o'clock position can be used; however, we tried to avoid placing an incision at this location because of a high risk of wound-healing problems. The skin was incised, and a Jacobson hemostat was used to bluntly dissect in the subcutaneous plane circumferentially around the stoma from 1 incision to the next. A piece of povidone/iodine-soaked umbilical tape was carefully pulled through the subcutaneous tunnel, and was used to help remove fatty tissue on the inner side of the subcutaneous tunnel and, later, to guide the graft through the tunnel.

The TFL graft was then sutured to 1 end of a piece of povidone/iodine-soaked umbilical tape and pulled through the subcutaneous tunnel. After the graft completely encircled the stoma, the umbilical tape was removed and the ends of the graft were held with a hemostat. A small slit was made in 1 end of the TFL graft, and the other end of the graft was pulled through the slit (see Figure 2).

Next, the endotracheal balloon was briefly deflated, a size 12 short BMB (outer diameter, 17 mm) was placed over the end of the size 6 reinforced endotracheal tube, and the balloon was returned to the airway and reinflated (see Figure 3). The shaft of the BMB was used as a guide to set the diameter of the stoma. This was done by pulling the ends of the tendon graft

in opposite directions and cinching the stomal skin in a purse-string fashion. The ends of the graft near the slit were sutured together with multiple interrupted 4-0 polydioxanone sutures placed in a horizontal mattress pattern. Tapered needles were used to avoid cutting the graft. Excess tendon was then cut from the ends of the graft. The wounds were irrigated copiously throughout the procedure with 50,000 units of bacitracin and 500,000 units of polymyxin B per liter of saline irrigation fluid. Hemostasis was obtained, and a size 10 round Blake drain (Johnson & Johnson, Somerville, NJ) was placed in the subcutaneous tunnel circumferentially and allowed to exit from a site several centimeters from the stoma.

The radial incisions were each closed with a buried absorbable 3-0 monofilament suture in the dermis and an interrupted 5-0 chromic suture in the skin. Bacitracin ointment was applied to all incisions. The thigh donor-site incision was covered with a sterile dressing, and the leg was wrapped from the ball of the foot to the upper thigh with a 6-inch-wide elastic wrap (Ace; Becton-Dickinson, Franklin Lakes, NJ). The patient was extubated, a size 8 (outer diameter, 12 mm) Provox LaryTube (Atos Medical AB) was placed to protect the airway, and the patient was taken to recovery for overnight observation. Once the airway was stable and patent, the LaryTube was removed (usually 1 or 2 days after surgery). To allow adequate wound healing and to avoid stomal dilation, patients were instructed to avoid digital occlusion of the stoma or placement of a stoma button in the neostoma for 3 weeks after surgery. All patients had follow-up examinations by a multidisciplinary team of specialists in head and neck surgery, speech pathology, and plastic surgery.

RESULTS

Twenty-one patients underwent tracheostomoplasty: 16 men (76%) and 5 women (24%). The median age was 66 years (range, 49–84 years). Median follow-up was 27.7 months (range, 10–56 months).

In 20 patients, the histology of the primary tumor was squamous cell carcinoma; a laryngectomy had been performed as a primary treatment in 11 of these patients and as a salvage procedure in 9 patients. One patient underwent a primary laryngectomy for a subglottic chondrosarcoma. Fifteen patients (71%) had received radiation therapy. At the time of last contact, 4 patients (19%) had died from their cancer, 1 patient was alive with disease, and 16 patients (76%) were alive without evidence of disease.

Patient characteristics, indications for tracheostomoplasty, details of the tracheostomoplasty technique, and functional outcomes are presented in Tables 1 and 2. The absence of a circumferential stomal lip, alone or in addition to other deformities, was an indication for the procedure in all cases. The graft used for reconstruction of the stomal rim was a TFL tendon in 19 patients (90%) and a palmaris longus tendon in 2 patients (10%).

To achieve a stoma suitable for hands-free TE speech, other procedures, in addition to tracheostomoplasty, were performed as indicated. These included the release of the sternocleidomastoid muscle head in 4 patients, Z-plasty for release of cutaneous bands in 2 patients, and ablation of the previous TE puncture site in 1 patient. In 4 patients, skin advancement flaps were performed to provide the required peristomal skin laxity necessary

to successfully complete the tracheostomoplasty. These flaps included a V-Y flap (a flap in which the incision is made in a V shape and sutured in a Y shape to gain additional tissue) in 2 cases and other local advancement flaps in 2 cases. In another patient, a pectoralis major muscle flap performed at the time of salvage laryngectomy was debulked during the tracheostomoplasty.

A procedure to revise the neostoma was required in 5 patients (23.8%). In 3 of these patients, the neostoma dilated to the point that a snug fit of the customized stoma button could not be achieved. In 2 patients, the indication for revision surgery was the recurrence of the stomal deformity and thus air leakage during hands-free TE speech. Exposure to radiation therapy did not have a significant association with the necessity for revision procedures ($p = 1.0$).

Despite all attempts to prevent infection, cellulitis was the most frequent surgical complication (28.6%); although all cases of cellulitis presented in patients who had undergone previous radiation therapy, this association did not reach statistical significance ($p = .123$). The only life-threatening complication was a case of postoperative pneumonia that required hospitalization for intravenous antibiotic therapy. Delayed complications included 2 cases of stoma dilation, 2 cases of recurrent deformity of the stoma with air leakage, and 2 cases of stomal stenosis.

At the time of last follow-up, 18 patients (86%) were able to successfully wear a stoma button, either the BMB (InHealth Technologies, Carpinteria, CA) or Provox LaryButton (Atos Medical AB, Hörby, Sweden) for TE speech. Only 3 of the 18 patients were unable to achieve hands-free TE speech but did achieve good TE speech with digital occlusion of the button and tolerated the button for 6 hours. The other 15 patients achieved hands-free speech for an overall success rate of 71%: 8 were able to use a standard button, and 7 required a customized button. In 3 patients (14.2%), the surgical procedure was considered unsuccessful, regardless of their TE speech fluency, because these patients were unable to wear the button for 6 hours. These patients included 2 patients with stomal stenosis and 1 patient with recurrent granulation tissue forming in the TE puncture site. Exposure to radiation therapy was not associated with the final outcome of successfully achieving TE speech ($p = .184$).

DISCUSSION

In this study we describe a novel surgical procedure, tracheostomoplasty, used to restore a functional tracheostomy for hands-free TE voice restoration in a group of 21 patients who desired hands-free speech but were unable to wear a BMB. Although the procedure was unsuccessful in 3 patients, 81% could wear a BMB for at least 6 hours, and 71% of the patients could successfully speak without using digital occlusion of the button for hands-free voice restoration.

The primary indication for tracheostomoplasty is the presence of a tracheostomal deformity that precludes the use of a conventional or modified intraluminal stoma button. Such deformities include a noncircular or irregular stoma, inadequate or incomplete rim of

cicatrix around the stoma, and retraction of the stoma to a retrosternal position with a funnel-shaped deformity. In this study, the absence of a posterior stomal rim, either alone or in combination with other problems, was the indication for tracheostomoplasty in all patients. The absence of an adequate stomal rim can be caused by the absence of cartilaginous support in the membranous trachea, an obtuse angle between the skin and mucosal surfaces in the posterior wall, the flattening effect of soft-tissue retraction during the cicatrization period, and/or deleterious effects of radiation on cicatrix formation.¹⁰ Additionally, we have found that, although the tracheostomy is often created under tension at the time of laryngectomy, the tension is slowly relieved postoperatively by the constant downward pull of the trachea; the result can be stoma deformity. Beveling of the tracheal incision has also been singled out as a possible cause of stoma deformity, and it is perhaps the only such factor modifiable by the surgeon.⁶ We continue to see patients with this type of deformity despite the fact that we abandoned beveling the tracheal incision several years ago; this suggests that nonsurgical factors may be playing a major role.

Other indications for tracheostomoplasty are related not to the stoma morphology itself but rather to the quality and morphology of the peristomal tissues. Some patients are unable to tolerate the peristomal housing of the BMB because of chronic irritation of the peristomal skin.¹¹ Also, if the clavicular heads of the sternocleidomastoid muscles are not transected at the time of laryngectomy, they often form an uneven peristomal surface that may interfere with the use of an intraluminal stoma button. In this series, these peristomal abnormalities were always associated with an intrinsic stomal deformity, and were not the sole indication for tracheostomoplasty in any of the patients.

The majority of the patients in our series were exposed to radiation therapy, and we observed an apparent association between radiation and infection after tracheostomoplasty, although the difference was not statistically significant. All patients who developed a peristomal infection had a successful functional result, leading to the conclusion that prompt identification and treatment of cellulitis may prevent necrosis or rupture of tendon grafts. In the more recently treated patients in this series and in our current practice, we placed a size 10 round Blake drain in the subcutaneous tunnel along the side of the tendon graft. The drain was left in place to provide a continuous vacuum until the fifth postoperative day, irrespective of the volume of fluid that drains from the graft site. We have observed that the presence of a continuous vacuum along with prophylactic oral antibiotics for 5 days may decrease the rate of infectious complications.

A relatively high proportion of patients (23.8%) in the series required a revision procedure, with excessive dilation of the neostoma being the most common indication for revision. Stomal dilation may have multiple causes, such as imperfect calibration of the neostoma, premature digital occlusion of the stoma during wound healing, and pressure atrophy of a small layer of fat located between the graft and the underside of the skin after the patient starts using the stoma button. Identifying the specific reasons for functional failure in each case in our study was not possible retrospectively. However, these findings emphasize the level of attention to detail required to achieve success when performing this reconstructive technique. Perhaps most important, 4 of the 5 patients who underwent a revision procedure were able to wear a stoma button and successfully achieved TE speech in the long-term.

Overall, tracheostomoplasty provides a viable surgical alternative for improving the retention of an intraluminal stoma button, facilitating the attachment of speaking valves for hands-free TE speech. This standardized, minimally invasive technique is associated with few major complications and achieves a high success rate, even in patients with previous radiation exposure and complex stomal deformities. Cooperation between speech pathologists, head and neck surgeons, and plastic surgeons is of paramount importance to achieve successful speech rehabilitation in these patients.

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FIGURE 1.

Intraoperative photograph of the original tracheal stoma with 1-cm markings at the 12, 3, 6, and 9 o'clock positions. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

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FIGURE 3.

Intraoperative photograph demonstrating a Barton–Mayo button over a size 6 reinforced endotracheal tube. A size 10 drain exits the skin on the patient’s left. All incisions have been closed. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Table 1

Patient characteristics and indications for tracheostomy.

Patient characteristics				Indications for tracheostomoplasty					
Patient	Age, y	Sex	XRT	No superior stoma lip	Retrosternal stoma	Poor peristomal skin	Abnormal stoma shape	TEP close to MC junction	Prominent SCM head
1	62	F	Yes	Yes	–	Yes	–	Yes	–
2	49	M	Yes	Yes	Yes	Yes	Yes	–	–
3	59	F	Yes	Yes	–	–	Yes	–	–
4	59	F	Yes	Yes	–	–	–	–	–
5	77	M	Yes	Yes	Yes	–	–	–	–
6	62	M	Yes	Yes	Yes	–	Yes	Yes	–
7	56	M	Yes	Yes	Yes	Yes	Yes	Yes	–
8	75	M	Yes	Yes	–	Yes	–	–	Yes
9	67	F	–	Yes	Yes	–	–	Yes	Yes
10	69	M	–	Yes	–	–	–	–	Yes
11	84	M	Yes	Yes	Yes	–	–	Yes	–
12	68	M	Yes	Yes	–	Yes	–	–	–
13	60	M	–	Yes	–	–	Yes	–	–
14	63	M	Yes	Yes	Yes	–	–	–	–
15	69	M	Yes	Yes	Yes	–	–	Yes	–
16	72	M	Yes	Yes	–	Yes	–	–	Yes
17	72	M	–	Yes	–	–	Yes	–	–
18	66	F	–	Yes	–	Yes	Yes	Yes	–
19	61	M	Yes	Yes	Yes	–	–	Yes	–
20	77	M	Yes	Yes	Yes	–	–	–	–
21	53	M	–	Yes	–	Yes	–	Yes	–

Abbreviations: –, No; XRT, previous treatment with radiation therapy; TEP, tracheoesophageal puncture; MC, mucocutaneous; SCM, sternocleidomastoid muscle; F, female; M, male.

Table 2

Tracheostomoplasty technique and outcomes.

Patient	Technique		Outcomes	
	Graft	Local skin flap [*]	Complications	Successful use of stoma button
1	PLT	–	Cellulitis and sternocleidomastoid abscess	Yes
2	PLT	–	Cellulitis	Yes
3	TFL	Yes	None	Partial
4	TFL	–	Stoma dilatation	Yes [†]
5	TFL	–	None	Partial
6	TFL	Yes	Stoma dilatation	Yes [†]
7	TFL	–	Cellulitis	Yes
8	TFL	–	Cellulitis	Yes
9	TFL	Yes	Stomal stenosis	No
10	TFL	–	Recurrent granulation in TEP	No
11	TFL	–	None	Yes
12	TFL	–	Cellulitis	Yes
13	TFL	Yes	Recurrent defect with air leak	Yes [†]
14	TFL	–	None	Yes
15	TFL	–	Recurrent defect with air leak	Yes [†]
16	TFL	–	Pneumonia and cellulitis	Partial
17	TFL	–	None	Yes
18	TFL	–	None	Yes
19	TFL	–	Stomal stenosis	No [†]
20	TFL	–	None	Yes
21	TFL	–	None	Yes

Abbreviations: –, No; PLT, palmaris longus tendon; TFL, tensor fascia lata; TEP, tracheoesophageal puncture; Partial, patient was able to wear stoma button for 6 hours daily, but required digital pressure on the button for tracheoesophageal speech.

^{*} Local skin flap, such as V-Y advancement flap, was used.

[†] Revision of tracheostomoplasty was required.