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Secondary Tracheoesophageal Puncture After Laryngectomy Increases Complications With Shunt and Voice Prosthesis

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Objectives/Hypothesis: To evaluate the demographics, clinical features, management, and prognostic indicators of tracheoesophageal puncture complications in patients undergoing placement of voice prosthesis following cancer treatment.

Study Design: Retrospective analysis.

Methods: A retrospective analysis was conducted of cases from a tertiary referral center diagnosed between 1996 and 2015. Multivariate logistic regression was used to determine factors associated with tracheoesophageal puncture (TEP) and voice prosthesis–complication-free survival (TEP/VP-CFS).

Results: One hundred fourteen cases were identified. Most patients were males (92.9%) with pT3 (26.8%) or pT4 (58.1%) N+ (53.6%) tumors. All patients received laryngectomy as the primary treatment, with 75% of patients receiving adjuvant radiation therapy or chemoradiotherapy. Complications with TEP were common (65.2%). The most frequent problem was salivary leakage (50.0%), which at the same time was the most common reason for changing the prosthesis. On univariate regression analysis, prostatectomy placement time after adjuvant radiotherapy (hazard ratio [HR]: 4.17, 95% confidence interval [CI]: 2-8.69), secondary prosthesis placement after primary surgery (HR: 3.97, 95% CI: 1.99-7.9), and laryngectomy with flap reconstruction (HR: 1.96, 95% CI: 0.99-3.89) were significant prognosticators for complications. Multivariate regression analysis revealed secondary prosthesis placement after adjuvant radiotherapy (HR: 3.66, 95% CI: 1.39-9.68) or after primary surgery (HR: 2.57, 95% CI: 0.92-7.2) to be the strongest predictors of reduced TEP/VP-CFS.

Conclusions: Secondary prosthesis placement after primary surgery, placement after previous irradiation, and laryngectomy with flap reconstruction are predictors of poor TEP/VP-CFS. Planned adjuvant radiotherapy is not a contraindication for TEP with prosthesis placement, but it is very important to place the prosthesis during the primary surgery or at least before scheduled radiotherapy.

Key Words: Larynx, voice preservation, head and neck cancer, voice prosthesis, tracheoesophageal shunt.

Level of Evidence: 4

INTRODUCTION

Today, success of complete laryngectomy is not only measured by oncological criteria but also by functional considerations such as the ability to speak and to swallow. Voice function is one of the most important ways of human communication, and voice rehabilitation by means of voice prosthesis is now considered state of the art.1–3 The placement of tracheoesophageal puncture (TEP) can be primarily at the time of extirpative surgery or as a secondary procedure after laryngectomy, before irradiation or afterward. TEP was initially described as a secondary procedure performed at least 4 weeks after laryngectomy.4 In subsequent years, voice prosthesis placement was performed directly at the time of laryngectomy, thereby avoiding multiple procedures and simplifying the placement. There are only very few contraindications for a primary puncture such as disruption of the tracheoesophageal party wall, increasing the risk of mediastinitis, or surgeon experience.5 Therefore, TEP is now mostly done during the primary procedure.6,7 The timeframe of secondary placement after radiotherapy should be broad to give the tissue time to recover from microvascular tissue damage caused by irradiation.6,8,9 Neumann and Schultz-Coulon recommend at least 12 month after radiotherapy.5 However, both primary and secondary placement can lead to complications.5,7 In the literature, the incidence of complications ranges from 20% to 72%.6,8,10,11 Severe complications, such as deep neck abscesses, osteomyelitis, or aspiration pneumonia, and

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minor complications, such as granulation tissue around the valve or salivary leakage, have been described.6,8,12 Excellent voice production via voice prosthesis13,14 can only be beneficial for patients if complication frequency and management are acceptable to them. Therefore, this study was designed to examine the occurrence of complications, with special focus on prognostic factors and on management strategies.

MATERIALS AND METHODS
A retrospective review of the clinical records of the ear, nose, and throat (ENT) department and the department of phoniatrics at a tertiary referral center from 1996 to 2015 was conducted.

### Inclusion and Exclusion Criteria

The database initially was searched for patients being treated with laryngectomy with curative intent and as a primary treatment with or without postoperative radiotherapy or chemoradiotherapy. Only patients who met these criteria and TEP with a voice prosthesis inserted were included. Patients with preoperative chemoradiotherapy followed by salvage laryngectomy, individuals treated for palliation, and those with distant metastatic lesions (M1) were excluded even if they received a TEP. As part of information about language rehabilitation, TEP was discussed with all patients, but not recommended to all. Exclusions for TEP besides patient’s preference were prior radiotherapy >72 Gy, markedly reduced cognitive skills that preclude proper handling, and total laryngectomy with total pharyngectomy, and reconstruction with a tubed flap because

### TABLE I.

| Tracheoesophageal Puncture and Voice Prosthesis Complication-Free Survival by Relevant Demographic and Therapeutic Variables. |
|---------------------------------------------------------------|
| N = 112* | % † | 6 Months, P Value‡ | 12 Months, P Value‡ | 18 Months, P Value‡ | 24 Months, P Value‡ | 60 Months, P Value‡ |
| Gender | | | | | | |
| Male | 104 | 92.9 | | | | |
| Female | 8 | 7.1 | .085§ | .141 | .342 | .546 | .345 |
| Laryngectomy | | | | | | |
| With flap | 19 | 17 | | | | |
| Without flap | 92 | 82.1 | .016‖ | .062§ | .011‖ | .048‖ | .048‖ |
| Prosthesis placement | | | | | | |
| During primary surgery | 99 | 88.4 | | | | |
| After primary surgery | 13 | 11.6 | <.0001§ | <.0001§ | <.0001§ | <.0001§ | <.0001§ |
| Before radiotherapy | 101 | 90.2 | | | | |
| After radiotherapy | 11 | 9.8 | <.0001§ | <.0001§ | <.0001§ | <.0001§ | <.0001§ |
| Radiotherapy | | | | | | |
| Yes | 84 | 75 | | | | |
| No | 26 | 23.2 | .744 | .425 | .332 | .367 | .479 |
| Radiation dose | | | | | | |
| ≤60 Gy | 24 | 21.4 | | | | |
| 61–65 Gy | 27 | 24.1 | | | | |
| 66–68 Gy | 19 | 17 | | | | |
| >68 Gy | 11 | 9.8 | .212 | .916 | .991 | .991 | .987 |
| Chemotherapy | | | | | | |
| Yes | 65 | 58 | | | | |
| No | 45 | 40.2 | .446 | .650 | .982 | .878 | .945 |
| Nutrition | | | | | | |
| Oral | 68 | 60.7 | | | | |
| Oral and PEG tube | 28 | 25 | | | | |
| PEG tube | 15 | 15 | .454 | .201 | .179 | .092§ | .046‖ |
| PPI | | | | | | |
| Yes | 62 | 55.4 | | | | |
| No | 49 | 43.8 | .918 | .795 | .713 | .665 | .579 |
| Alcohol | | | | | | |
| Yes | 31 | 79.5 | | | | |
| No | 28 | 72.4 | .833 | .812 | .970 | .990 | .927 |

*Total number of patients for some variables may be less than N because of missing values.
†Percentages have been rounded and do not necessarily add up to 100.
‡Significance determined with log-rank test.
§P = .05–.09 = trend.
‖P ≤ .05 = significant.
§P ≤ .01 = highly significant.
PEG = percutaneous endoscopic gastrostomy; PPI = proton pump inhibitor.
here not enough oscillatory tissue would be left, and inflationary pressure could not be reached. This resulted in 114 patients meeting the inclusion criteria. The aim of the study was the evaluation of follow-up data for long-term problems due to TEP for the placement of a Provox voice prosthesis (Atos Medical, Malmö, Sweden). Two cases with missing follow-up information.

Fig. 1 (A) Kaplan-Meier analysis of 6-month tracheoesophageal puncture and voice prosthesis complication-free survival according to prosthesis placement time in terms of adjuvant radiotherapy. Patients with prosthesis placement after adjuvant radiotherapy had a significantly decreased complication-free survival compared with patients receiving the prosthesis placement before adjuvant radiotherapy. (B) Kaplan-Meier analysis of 6-month tracheoesophageal puncture and voice prosthesis complication-free survival in patients with primary or secondary prosthesis placement. The risk of developing complications was significantly higher in patients who had the prosthesis placed in a second procedure after laryngectomy. Cum = cumulative.
were excluded from the present study, as the condition of TEP or the occurrence of complications was unknown, leaving 112 eligible cases for analysis.

**Study Variables**

Patients were grouped and stratified according to gender, age, TNM classification (in accordance with the American Joint Committee on Cancer classification, 6th or 7th edition\(^{15,16}\)), extent of surgery, treatment modality, and time of prosthesis placement.

**Complications**

The primary outcome was complication rate and complication-free survival associated with tracheoesophageal shunt and voice prostheses. Complications with TEP were recorded during follow-up by a team consisting of otolaryngologists, phoniatrics, and speech therapists.

**Statistical Analysis**

Categorical variables are presented as frequency and percentage, whereas continuous variables are presented as

![Complications according to the interval of change of prosthesis](image-url)
RESULTS

Clinico-Demographic Characteristics

A total of 112 laryngectomies with placement of a voice prosthesis between the years 1996 and 2015 were identified. Most cases had pathologic T classifications of 3 or 4 (84.9%); 51.8% were registered as high grade. N staging indicated that regional metastasis was common (pN1, 11.6%; pN2, 39.3%; and N3, 2.7%).

Laryngectomy without flap reconstruction was the most common type of surgery (82.2%), followed by laryngectomy with free or pedicled flap transfer (16.9%). Postoperative radiotherapy was at a dose of 64 to 68 Gy; 2 Gy/d was administered to 75% of surgically treated patients. Chemoradiotherapy was done in 58% of cases. Chemotherapy included cisplatin (47.3%), 5-FU (33.9%), carboplatin (8%), cetuximab (3.6%), docetaxel (2.7), and mitomycin C (1.8%). In all cases a Provox prosthesis was placed at the time of initial TEP. Detailed patient demographics and therapeutic data are displayed in Table I. Overall, 88.4% of TEPs with prosthesis placements were done as primary procedures during laryngectomy. Secondary TEPs with prosthesis placement was done in 11.6% of cases either before or after radiotherapy. The reasons were tumor growth into the upper esophagus (4.5%), resulting in a very deep resection not allowing prosthesis implantation during the extirpative procedures. In 7.1%, the reasons were not documented. The time of the secondary puncture was between 3 and 5 weeks after primary laryngectomy for patients whose prosthetic implantation was performed after the primary operation but before radiotherapy. In patients whose implantation took place after radiotherapy, the puncture time was between 18 and 122 weeks after radiotherapy.

Because of biofilm formation that damages the material, the normal time frame for valve change is 4 to 6 months for patients without complications. Changes are either done by a speech pathologist or by an otolaryngologist. Maintenance instructions for the patient are daily cleaning with the brush and skin care around the tracheostomy.

Complications With Tracheoesophageal Shunts and Voice Prosthesis

The mean follow-up was 47.9 months (range, 1–219.6 months), with a 5-year overall complication rate of 65.2%. As shown in multivariate analysis, placement time relative to radiotherapy shows the highest and significant complication rates. The majority of complications occurred during the first 18 months. The complication rate was highest 3 to 9 months after surgery (29.5%). A dramatic decrease of complications, down to 6.3%, was observed after 18 months. The problems and complications that we encountered were rarely serious. The two most common complications were peristomal salivary leakage (50.0%) and enlargement of the TEP (47.3%), followed by granulation tissue around the prosthesis (36.6%) (see Supporting Information Video S1), dislocation of the prosthesis (16.1%), severe crusting (8.9%) (see Supporting Information Video S2), and loss of prosthesis (8%). Overall, 21.4% were dissatisfied with their voice, but the valve had to be removed in only 16% of those cases. The majority of dysphonia patients also had other complications (e.g., shunt enlargement, granulation tissue, and salivary leakage). Systemic complications such as aspiration pneumonia rarely occurred (2.7%). No prostheses were dislocated into the airway requiring procedure for removal.

Table I displays variables significantly associated with worse TEP/VP-CFS on regression analysis. Kaplan-Meier plots of selected variables that were associated with decreased TEP/VP-CFS are displayed in Figure 1 and Supporting Information Figure S1. In our data, the mode of tumor therapy played a very important role in developing complications. Of the preirradiated patients with secondary valve placement postradiotherapy, 90.1%

### TABLE III.

| Prognostic Categorization by Univariate Analysis |
|-----------------------------------------------|
| Favorable | 6-Month TEP/VP-CFS | Unfavorable | 6-Month TEP/VP-CFS | P Value* | Difference |
|-----------|--------------------|------------|--------------------|---------|------------|
| Male      | 60.6%              | Female     | 28.6%              | .085†   | 32%        |
| Laryngectomy without flap | 62.9% | Laryngectomy with flap | 20% | .016‡ | 42.9% |
| Prosthesis placement after primary surgery | 63.9% | Secondary prosthesis placement after primary surgery | 18.2% | <.0001§ | 45.7% |
| Prosthesis placement before radiotherapy | 66% | Prosthesis placement after radiotherapy | 20% | <.0001§ | 46% |

*Significance determined with log-rank test.

†P = .05–.09 = trend.

‡P ≤ .05 = significant.

§P ≤ .01 = highly significant.

TEP = tracheoesophageal puncture; VP-CFS = voice prostheses–complication-free survival.
suffered from TEP complications. The most common complications in this group were salivary leakage (54.5%), formation of granulation tissue (54.5%), and shunt enlargement (45.5%). These problems often occurred in combination. Most complications were easily managed. However, permanent shunt closure was much more frequent in preirradiated patients (36.4%) than in the group receiving TEP before radiotherapy (10.5%).

**Management of Complications**

In the majority of cases, complications encountered in patients with TEP and prosthesis placement could be tackled easily and resolved successfully. Management strategies applied for different complications were identified and are displayed in Table II. According to the most common complications (e.g., salivary leakage, shunt enlargement, granulation tissue), problems could mostly be solved by replacement of the prosthesis, shrinking of the TEP, or sclerotization by bipolar coagulation or silver nitrate. As shown in Figure 2, alteration of the time frame of prosthesis change is not accompanied by a change in the frequency of complications. If the planned change of time frames was extended markedly, no increase in rate of acute complications was seen. In 22 cases, a customized voice prosthesis with silicon flange measured according to the patients particular shunt size and shape was successful. For patients with persistent leakage around the prosthesis, injection of hyaluronic acid was found to be useful. Despite the complications, 83.3% kept their valve. In 16.7% of patients with persistent complications, in whom previous conservative measures have not been successful, the shunt had to be closed surgically.

**Prognostic Factors for Complications**

Favorable and unfavorable therapy mode characteristics were determined based on the statistical survival analysis. By dichotomizing closure of the defect, time of prosthesis placement in relation to laryngectomy and time of radiotherapy in relation to prosthesis placement, statistically significant differences in 6-month complication-free survival were observed (Table III). Of these characteristics, the largest absolute differences in percent survival were

| TABLE IV. Univariate and Multivariable Cox Regression Analysis for 5-Year Tracheoesophageal Puncture and Voice Prosthesis Complication-Free Survival. |
|---------------------------------------------------------------|
| **Univariate** HR (95% CI) | P Value* | **Multivariate** HR (95% CI) | P Value* |
|-----------------------------|----------|-----------------------------|----------|
| Laryngectomy Without flap | Ref      |                           |          |
| With flap                   | 1.96 (.99–3.89) | .053†                      |          |
| Prosthesis placement        | Ref      |                           |          |
| During primary surgery      | 3.97 (1.99–7.9) | .001‡                      |          |
| After primary surgery       | Ref      |                           |          |
| After radiotherapy          | 4.17 (2–8.69) | .001‡                      |          |
| Nutrition                   | Ref      |                           |          |
| Oral                        | .473 (.22–1) | .051†                      | .55 (.23–1.32) | .183 |
| PEG tube                    | .98 (612–1.58) | .945                       |          |
| PPI                         | Ref      |                           |          |
| Yes                         | .88 (55–1.4) | .598                       |          |
| Alcohol                     | Ref      |                           |          |
| Yes                         | 1.02 (64–1.63) | .928                       |          |

*Significance determined with log-rank test.
† P = .05–.09 = trend.
‡ P < .01 = highly significant.
CI = confidence interval; HR = hazard ratio; PEG = percutaneous endoscopic gastrostomy; PPI = proton pump inhibitor; Ref = reference.
seen between prosthesis placement before and after radiotherapy (46%, $P < .0001$) and prosthesis placement during or after primary laryngectomy (45.7%, $P < .0001$) followed by mode of defect closure with or without flap (42.9%, $P = .016$). Although significant as a trend, gender appeared to have the least impact on 6-month TEP/VP-CFS of the variables analyzed (32%, $P = .085$).

These factors, among others, including radiotherapy, radiation dose, chemotherapy, nutritional mode, intake of proton pump inhibitor, and alcohol abuse, were initially implemented in a univariate Cox regression analysis. For example, most of the patients (85.7%) received an oral diet with or without percutaneous endoscopic gastrostomy (PEG) tube support. A small part (13.4%) were totally dependent on a PEG-tube diet. However, only in univariate analysis was complete PEG tube nutrition for 5 years protective against complications (hazard ratio [HR]: 0.473, 95% confidence interval [CI]: 0.22-1). Moreover, many other variables were significant in univariate analysis, and multivariable analysis only revealed prosthesis placement, in relation to laryngectomy and time of radiotherapy in relation to prosthesis placement, to be independent prognosticators (Table IV). The largest increase in risk of complications was seen in patients with TEP and prosthesis placement after radiotherapy (HR: 3.66, 95% CI: 1.39-9.68) when compared to patients being punctured and placed with a prosthesis before the start of radiotherapy. Likewise, prosthesis placement as a second procedure after the laryngectomy imposed greater than two times (HR: 2.57, 95% CI: 0.92-7.2) the risk when referenced to prosthesis placement directly during the laryngectomy.

DISCUSSION
To achieve the best oncological results, advanced laryngeal carcinomas (T3 and T4) are recommended for upfront laryngectomy.17,18 For organ and voice preservation, chemoradiotherapy might be an option. Unlike early-stage laryngeal carcinomas that show excellent results on survival and on voice quality, it should be noted that voice preservation is often not possible when treating advanced tumors by irradiation, even if the larynx is preserved.19-21 Today, the decision on laryngectomy is less dramatic for patients, as voice rehabilitation can be done in most cases. The intraoperative voice prosthesis placement during primary TEP directly after a laryngectomy procedure has been the standard of care for voice restoration since the TEP directly after a laryngectomy procedure has been the intraoperative voice prosthesis placement during primary voice rehabilitation can be done in most cases. The decision on laryngectomy is less dramatic for patients, as voice preservation and on voice quality, it should be noted that voice preservation is often not possible when treating advanced tumors by irradiation, even if the larynx is preserved.22 However, numerous publications have shown an improvement in voice and patient comfort, whereas complications of the voice prosthesis have been discussed only a little so far in the literature. The rate of complications in patients with TEP ranged from 15% to 72% in the literature. Serious complications include mediastinitis, cervical cellulitis, deep neck abscess, esophageal perforation, and prosthesis aspiration.12,23 None of these were encountered in the present study. Complications were found in 65.2% of all 112 patients. Most problems were uncritical and could be solved easily.

Half of all patients developed periprosthetic leaks, most of them due to an enlarged fistula. In the literature, leakage is also described as a very common complication at up to more than 70%.24 Prosthetic leaks were the most common cause of prosthesis replacements in our study. In many cases, leakage is not only a complication but also a consequence of other complications such as granulation tissue, encrustation, or shunt enlargement. During the normal aging process of the prosthesis, a transprosthetic leakage can occur. Therefore, transprosthetic leakage was not counted as a complication but a regular finding during the aging process of the valve. For enlarged shunts, if replacement was successful, other conservative approaches were adopted. As already recommended by Andrews et al. in 1987,8 in our management of cases in which the insertion of a bigger prosthesis alone was not sufficient, the prosthesis was removed and a nasogastric tube and a blockable tracheal cannula was inserted for a few days. We waited for the shrinkage of the shunt, at which time a similar prosthesis was inserted. Placement of an enlarged custom-made tracheal flange on the voice prosthesis has been done in 22 cases. This method has been in practice for years.25-27 Lewin et al.28 cited an 80% long-term success rate using this method to avoid permanent gastrostomy, aspiration pneumonia, and surgical shunt closure. Since 2015, a prosthesis with an extended esophageal flange has become commercially available (Provox Vega XtraSeal, Atos). This flange is not custom made, but it adapts itself to the mucosa of enlarged shunts by its very soft material. As described in the literature, another more invasive method used in our department to solve the problem is the injection of hyaluronic acid into the tracheoesophageal wall to increase bulk and to prevent any leakage.28,29 Secondly, the TEP had to be closed in 16.7% of patients because of complications. It can be a challenging operation with significant risk of tissue breakdown, especially in previously irradiated patients.30 The frequency of shunt closure is described as between 5% and 20.5%.31,32 Thus, in the discussion with the patient prior to laryngectomy, the description of voice rehabilitation should not only refer to the high degree of success of the prosthetic voice, but also potential failure and the need for surgical shunt closure should also be mentioned.

A common but harmless complication is granulation tissue. As also explained by Neumann and Schultz-Coulon, we used etching with silver nitrate or electrocoagulation as simple treatment methods.6 Unlike previous investigations,33-35 our results show no increase in complication rate or reduced TEP/VP-CFS with proton pump inhibitor intake.

A total of 24 patients were dissatisfied with their voice. Kummer et al. found in an older patient population at our institution that the success of voice rehabilitation was significantly reduced if radiation took place before prosthesis insertion.36 Other authors found that the voice is probably not restricted by postoperative radiotherapy permanently.3,34,35 Furthermore, our data generally show no increase in complications after radiotherapy ($P > .3$, Table I). In the study conducted by Trudeau et al. on the effect of...
radiation on TEP, the majority of patients received primary puncture. However, we found a significant influence on TEP/VP-CFS for placement time. If the placement of the prosthesis cannot take place during extirpative surgery, it needs to be before radiotherapy by several days to allow the healing process to take place before radiotherapy starts. Secondary puncture after radiotherapy took place between 18 and 122 weeks after radiotherapy. In our data, secondary TEP and prosthesis insertion after radiotherapy led to a significant increase in complication rate and to a significant reduction in TEP/VP-CFS, with an HR of 3.66 (95% CI: 1.39-9.68) in multivariate analysis. Moreover, secondary insertion independent of radiation significantly decreases TEP/VP-CFS, with an HR of 3.97 (95% CI:1.99-7.9) but is only significant in univariate analysis (Table IV). Prognostic factors by univariate analysis were determined and revealed secondary prosthesis placement after primary surgery and after radiotherapy, laryngectomy with flap reconstruction, and female gender to be the greatest risk factors for a decreased TEP/VP-CFS. Rachelle et al. and Kummer et al. reported on an increased complication rate after secondary prosthesis implantation, especially after radiation. We confirm that puncture in previously irradiated tissue is traumatic and therefore fraught with complications. This could be a relative contraindication for prosthetic treatment. However, to reduce the functional tissue damage caused by irradiation, studies are currently underway concerning the de-escalation of radiation in the head and neck area. One is the prospective multicentric DIREKHT trial (De-Intensification Radiotherapy Postoperative Head Neck, NCT 02528955) trial, which is still recruiting patients. It investigates de-escalation of adjuvant radiotherapy in a defined low-risk head and neck patient population. Another retrospective study has shown that the preservation of functionally important structures by special intensity-modulated radiation therapy techniques is possible and even reduces the rate of aspiration. Whether de-escalation is possible in the head and neck region could depend on tumor and lymph node volume.

Laryngectomy with flap reconstruction is another predictor of a reduced TEP/VP-CFS in univariate analysis, with an HR of 1.96 (95% CI: 0.99-3.89). In the multivariate analysis, however, it could not withstand. Interestingly, the diet via a PEG feeding tube for several years appears to be protective against complications (HR: 0.473, 95% CI: 0.22-1) but only in univariate analysis. In accordance with other reports, we have had good results with a temporary nasogastric tube diet during treatment of acute complications such as an enlarged TEP. However, we think it is not reasonable for patients to abstain from an oral diet permanently.

**Limitations**

There are limitations to this study. Data analysis was derived from a retrospective database. It is difficult for a single institution to accrue a series of laryngectomized cases with TEP and prosthesis placement large enough to conduct meaningful complication rates. We managed to evaluate more than 100 patients. A limitation is that the sizes of subgroups within these 112 patients were different. Secondary TEP and TEP after radiotherapy are not the standard timing for TEP in our institute. Usually TEP and prostheses placement take place primarily during laryngectomy. Therefore, the secondary groups are comparatively small. However, the homogeneous structure within these groups made it possible to achieve statistically significant values by comparison. We were only able to include patients in the study who had follow-up in our clinic. Complication-free follow-up is sometimes also carried out in private practices. Patients with an uncomplicated follow-up often leave the care provided by our institute quickly, such as in four cases after a month of follow-up. Therefore, a censoring method was used for TEP/VP-CFS evaluation so that all eligible TEP patients could be integrated into the study. It is also possible that some patients with complication-free follow-up were not recorded. Other limitations are due to the retrospective nature of the study. Because of the time span of the study, modifications have been made to data collection techniques and adequacy over the years, and selection bias as well as documentation gaps may have occurred as a result. Therefore, not all information can be determined. In this context, no special pathologies that have necessitated a delay in placement of the puncture could be found. Overall, despite such limitations, this study utilized a large monocentric patient cohort with the goal of providing deeper insight to the yet elusive long-term complications with artificial voice prostheses.

**CONCLUSION**

TEP with prosthetic placement is a common practice of voice rehabilitation. However, for the first time, this study evaluated complication-free survival associated with TEP and voice prosthesis (TEP/VP-CFS) after prosthetic placement apart from complication rate. Secondary prosthesis placement after primary surgery, placement after previous irradiation, and laryngectomy with flap reconstruction stood as independent predictors of poorer TEP/VP-CFS in univariate analysis. In general, the rate of minor complications is high, but in most cases it was easy to control. The current data provide objective evidence that not the adjuvant radiotherapy itself, but TEP after radiotherapy and secondary prosthesis placement, is significantly associated with the occurrence of complications and reduced TEP/VP-CFS. Therefore, planned adjuvant radiotherapy is not a contraindication for TEP with prosthetic placement. It is very important to place the prosthesis during the primary surgery or at least before scheduled radiotherapy.

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**BIBLIOGRAPHY**

1. Blom ED. Tracheoesophageal voice restoration: origin—evolution—state-of-the-art. Folia Phoniatr Logop 2009;52:14-23.

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Scherl et al.: Complications of Voice Prosthesis
2. Brown DH, Hilgers FJ, Irish JC, Balm AJ. Post-laryngectomy voice rehabilitation: state of the art at the millennium. World J Surg 2003;27:824-831.

3. Hilgers FJ, Balm AJ. Long-term results of vocal rehabilitation after total laryngectomy with the low-resistance, indwelling Provox voice prosthesis system. Clin Otolaryngol Allied Sci 1995;18:517-523.

4. Singer MI, Blom ED. An endoscopic technique for restoration of voice after laryngectomy. Ann Otol Rhinol Laryngol 1989;89:529-533.

5. Zeng J, Goldsmith T, Bunting G, Deschler DG. State of the art: rehabilitation of speech and swallowing after total laryngectomy. Oral Oncol 2018;76:8-14.

6. Neumann A, Schultz-Coulon HJ. Management of complications after prosthetic voice rehabilitation. HNO 2000;48:508-516.

7. GITTMAN SA, HUTCHESSON KA, CHRISTANSON BL, et al. Influence of timing, radiation, and reconstruction on complications and speech outcomes with tracheoesophageal puncture. Head Neck 2016;38:1765-1771.

8. Roesel JC, Michel EA, Hanson DG, Monahan GP, Ward PH. Major complications following tracheoesophageal puncture for voice rehabilitation. Laryngoscope 1987;97:562-567.

9. Iezdek K, Reed CG, Ross JC, Hilsinger RL Jr. Problems with tracheoesophageal fistula voice restoration in totally laryngectomized patients. A review of 95 cases. Arch Otolaryngol Head Neck Surg 1994;120:840-845.

10. MANNI JJ, Van den Broek P. Surgical and prosthesis-related complications using the Greenin- gen button voice prosthesis. Clin Otolaryngol Allied Sci 1990;15:515-523.

11. Silver FM, Guckmann JI, Donegan JO. Operative complications of tracheoesophageal puncture. Laryngoscope 1985;95:1360-1362.

12. Wang RC, Bui T, Sauris E, Ditkoff M, Anand V, Kotsani A. Voice rehabilitation after laryngectomy with the Provox voice prosthesis. Eur Arch Otorhinolaryngol 2016;273:697-702.

13. Scherl C, Mantsopoulos K, Semrau S, et al. Management of complications of the voice prosthesis in patients treated with standard-of-care radiotherapy. Strahlenther Onkol 2019;195:792-804.

14. Thorne TD, Tietze J, Fassial N, et al. Management of complications of the voice prosthesis following laryngectomy. Laryngoscope 2017;127:2476-2481.

15. Chambers MS. Customization of the voice prosthesis to prevent leakage from the enlarged tracheoesophageal puncture: results of a prospective trial. Laryngoscope 2012;122:1767-1772.

16. Al Jassah B, Papageorgiou G, Schneider M, Schick B. Novel modification of voice prosthesis. Eur Arch Otorhinolaryngol 2016;273:697-702.

17. Remacle MJ, Declaye XJ. Gas-collagen injection to correct an enlarged tracheoesophageal fistula for a vocal prosthesis. Laryngoscope 1989;98:1350-1352.

18. Clapp MD, Balm AJ, Gregor RT. Prosthetic voice rehabilitation after laryngectomy with the Provox voice prosthesis. Surgical and technical aspects II. HNO 1995;43:261-267.

19. Hillers FJ, Balm AJ, Gregor RT. Prosthetic voice rehabilitation after laryngectomy. The management of fistula complications with anti-reflux medication. HNO 1995;43:261-267.

20. Kress P, Schafer P, Schwerdtfeger FP. The custom-fit voice prosthesis, for treatment of periprothetic leakage after prosthetic voice rehabilitation. HNO 2006;54:315-322.

21. Kummer P, Schuster CM, Rosanowski F. Prosthetic voice rehabilitation after laryngectomy. Failures and complications after previous radiation treatment of periprothetic leakage after tracheoesophageal voice restoration. Eur Arch Otorhinolaryngol 2012;269:118-122.

22. Trudel MD, Schaller DE, Hall DA. The effects of radiation on tracheoesophageal puncture. A retrospective study. Arch Otolaryngol Head Neck Surg 1989;115:1116-1117.

23. Carpen T, Saariluht H, Kägi J, et al. Tumor volume as a prognostic marker in p16-positive and p16-negative oropharyngeal cancer patients treated with definitive intensity-modulated radiotherapy. Strahlenther Onkol 2018;194:759-770.