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Indications and Outcomes of Endoscopic CO_2 Laser Cricopharyngeal Myotomy

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Abstract

Objectives/Hypothesis—To describe indications, management, and outcomes of endoscopic CO_2 laser cricopharyngeal myotomy (CPM).

Study Design—Case series with chart review.

Methods—All patients treated with endoscopic CO_2 laser CPM over a 6-year period were identified. A retrospective chart review was performed for surgical indication, history and physical examinations, and swallow evaluations. Swallowing outcomes were assessed using the Functional Outcome Swallowing Scale (FOSS); findings were compared across groups.

Results—Eighty-seven patients underwent endoscopic CO_2 laser CPM during the study period for cricopharyngeal dysfunction. Indications included Zenker's diverticulum (ZD) (39), DiGeorge syndrome (two), stroke (five), nerve injury (two), radiation for head and neck cancer (15), idiopathic (16), hyperfunctional tracheoesophageal speech (five) and dysphagia from cricopharyngeus stricture after laryngectomy (three). Mean, median, and mode time to feeding postoperatively were 1.4, 1, and 0 days respectively. Mean, median, and mode hospital stays were 1.8, 1, and 1 day respectively. Overall, FOSS scores improved from 2.6 to 1.6 ($P < .001$). Improvement was greatest for patients with ZD (2.4 to 1.0) and cricopharyngeal dysfunction from nerve injury (3.3 to 1.8) and least for those with prior radiation (3.9 to 3.2). All patients undergoing CPM for poor tracheoesophageal speech regained speech postoperatively. No patients developed mediastinitis, abscess, or fistula.

Conclusions—Endoscopic CO_2 laser CPM is a safe treatment for cricopharyngeal dysfunction of various causes, though swallowing outcomes may vary depending on the surgical indication. Early feeding postoperatively after CPM is safe and facilitates early hospital discharge.

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Keywords

Cricopharyngeal dysfunction; endoscopic cricopharyngeal myotomy; swallowing

INTRODUCTION

The cricopharyngeus (CP) muscle is comprised of the transverse fibers at the caudal portion of the inferior pharyngeal constrictor and is the primary location of the upper esophageal sphincter (UES). At rest it is tonically contracted and relaxes with deglutition. CP dysfunction occurs when the muscle does not appropriately relax during swallowing due to neurogenic dysfunction or fibrosis.[1] Symptoms of CP dysfunction include dysphagia, odynophagia, choking sensation, cough, and nasal regurgitation.[2,3] Aspiration and weight loss ensue in severe cases.

CP dysfunction occurs in a variety of disorders. Its diagnosis is made with a radiographic swallow study demonstrating impedance of bolus flow by the pathognomonic indentation of the contracted CP muscle and lack of UES relaxation during deglutition. Additionally, a hypertonic UES is measured on esophageal manometry.[4] CP dysfunction is also associated with Zenker's diverticulum (ZD) development, and can prevent optimal tracheoesophageal speech after total laryngectomy (TL).

Treatment for CP dysfunction includes swallow therapy, dilation, botulinum toxin injection, transcervical cricopharyngeal myotomy (CPM), and endoscopic laser CPM.[4–7] Dilation and botulinum injection, though less invasive, are temporary treatments.[8,9] Transcervical CPM has been the traditional treatment of CP dysfunction for more than 50 years, but requires an external neck incision, on average a 3-day hospital admission, longer operative time, and carries risks of postoperative hematoma, seroma, esophageal perforation, fistula, wound infection, and recurrent laryngeal nerve injury.[1,10,11]

Endoscopic laser CPM was first described using the potassium-titanyl-phosphate laser, and has since gained favor with the CO_2 laser.[2,3] Even with the potential benefits of no external scar, decreased operative time, and shorter postoperative recovery, many surgeons have reservations about performing endoscopic laser CPM due to the fear of esophageal perforation and mediastinitis.[8,12] Additionally, publications on endoscopic CPM report variations in operative technique and postoperative management, including mucosal closure, time to feeding, and length of admission. With such ambiguity, optimal management remains unclear.[3,13,14]

Thus, we undertook this investigation to evaluate endoscopic CPM at our institution. We reviewed our experience over a 6-year period and aim to describe findings regarding operative technique, postoperative management, and clinical outcomes. To our knowledge, this is one of the largest case series to date on endoscopic laser CPM for all-comers. We include all consecutive patients undergoing endoscopic CPM for all indications because the operative technique and postoperative management considerations are similar. We have developed and recommend a standard operative technique and postoperative care algorithm confirming the procedure's safety and clarifying appropriate patient care.

MATERIALS AND METHODS

Approval for this review was obtained from the University of California, Los Angeles, Medical Institutional Review Board. Patients who underwent endoscopic CO_2 laser CPM from January 2006 through April 2012 by a single surgeon (D.K.C.) were identified. Clinic and hospital records were examined including dysphagia clinic notes, operative notes, progress notes, discharge summaries, radiographs, and swallow evaluations.

The endoscopic CO_2 laser CPM begins with CP exposure transorally with a Weerda diverticuloscope (Karl Storz, Tuttlingen, Germany) or a standard Dedo-Pilling laryngoscope placed in the postcricoid hypopharynx and advanced to the CP muscle. The CP muscle is then exposed for surgery by suspending the larynx. In some cases the CP is so tightly contracted that the esophageal inlet lumen cannot be cannulated or visualized to provide exposure for the laser. In these cases, prior to CPM a Savary-Gilliard dilator guidewire (*Wilson-Cook* Medical, Winston-Salem, NC) or an unexpanded controlled radial expansion (CRE) balloon catheter (Boston Scientific, Natick, MA) is passed into the esophagus under direct visualization with a 0° telescope or flexible esophagoscope. Dilation is then performed to open and better visualize the esophageal introitus. The diverticuloscope or laryngoscope is then repositioned for optimal CP exposure. We use a line-of-sight CO_2 laser to divide the CP muscle, layer by layer, in the posterior midline until the pharynx is flush with the cervical esophagus. Occasionally, while lasering at the junction of the cricopharyngeus and the thyropharyngeus muscles, brisk bleeding is encountered, which can be controlled using suction cautery. To avoid potential complications of subcutaneous emphysema and esophageal leak, we do not laser down to the buccopharyngeal fascia but perform CRE balloon dilation of the cricopharyngeal area to 18 to 20 mm after near-flush myotomy is performed (Fig. 1).

In this study we included all ZD patients with small pouches (<1 cm), because the operation performed was essentially an extended CP myotomy with similar postoperative considerations. Hospital and clinic records were evaluated for surgical indication, associated disease processes, supplemental nutrition, operative technique, length of admission, time to feeding, and complications. Pre- and postoperative Functional Outcome Swallowing Scale (FOSS) scores were calculated from dysphagia clinic records as described by Salassa.[15] FOSS is a six-point scale dependent on dysphagia symptoms, physiologic function, diet, and compensation. Lower values indicate better swallowing function.

Statistical analyses were performed using XLSTAT 2007 (Addinsoft, Paris, France) with $P < .05$ considered significant. A paired t test was performed to compare pre- and postoperative FOSS scores. One-way analysis of variance (ANOVA) tests were used to compare preoperative FOSS, postoperative FOSS, and change in FOSS with surgical indication and disease processes.

RESULTS

Eighty-seven patients were identified who underwent endoscopic CO_2 laser CPM during the study period. The distribution of patients among surgical indications and associated disease processes is presented in Table I.

For all patients, FOSS scores improved from an average of 2.6 to 1.6 ($P < .001$), and 91% reported subjective swallowing improvement. Figure 2 displays the preand postoperative FOSS scores across patient subgroups. One-way ANOVA revealed statistically significant differences in preoperative FOSS scores ($P < .0001$), postoperative FOSS scores ($P < .0001$), and FOSS score change ($P = .026$) with relation to preoperative conditions (gastrostomy tube, stroke or nerve injury, idiopathic CP dysfunction, radiation, ZD, and TL).

Of the 19 patients who were gastrostomy tube (GT) dependent preoperatively (one ZD, two stroke, two DiGeorge, three idiopathic, and 11 radiation), 10 had preoperative FOSS scores of 5 (no oral feeding). Only two remained with that score postoperatively, and the average change in FOSS score was 1.0. Four patients eventually had the GT removed (one stroke, three radiation). The remaining 13 required GT feeds for nutrition, but were able to take some food orally for pleasure. Of the 15 patients with CP dysfunction associated with radiation, 11 were GT dependent preoperatively, and seven required GT for nutrition postoperatively. The change in FOSS scores for all patients with prior radiation was 0.64, but was 0.90 for the subgroup of radiation patients who were GT dependent.

Five patients initially presented following total laryngectomy with difficulty phonating with the tracheoesophageal prosthesis (TEP), in spite of prosthesis replacement and troubleshooting by a senior speech language pathologist. These patients were found to have a hypertonic pharyngoesophageal segment on fluoroscopic evaluation that corresponded with a hypertonic CP muscle above the prosthesis site with difficulty passing air rostrally during attempted phonation when visualized by transnasal esophagoscopy. All of the laryngectomees who underwent endoscopic CO_2 laser CPM for poor phonation through TEP puncture regained tracheoesophageal speech.

Twenty-seven CPM procedures (31%) were performed on patients with one or more prior treatment or attempted treatment of CP dysfunction. Six cases were for recurrent ZD: three following open diverticulectomy with CPM and three following endoscopic staple diverticulotomy, all presenting with a thickened CP bar, esophageal narrowing at the site of prior surgery, and shallow (<1 cm) diverticulum. An additional three ZD cases were for patients with prior failed attempted endoscopic exposure. Thirteen patients presented with recurrent CP dysfunction following prior dilation. Of these, 10 patients reported initial improvement with prior dilation, and three did not. Ten patients presented with recurrent CP dysfunction following previous botulinum toxin injection, and following the injection, symptoms were reportedly improved in three, worse in two, and unchanged in five cases.

Twelve patients (14%) required subsequent surgical procedure(s) due to recurrent dysphagia. Surgical indications were recurrent ZD (two), radiation (seven), stroke (two), and idiopathic CP dysfunction (one). Five patients were managed with esophageal dilation; six patients underwent repeat endoscopic CO_2 laser CPM. One patient with CP achalasia and scarring following radiation for hypopharyngeal cancer underwent several laser procedures with dilations for recurrent scarring.

Four complications (rate 4.6%) were identified. One patient aspirated from emesis with GT feeding during peritoneal dialysis, necessitating intubation and bronchoscopy with complete recovery and no further events. An 87-year-old nasogastric tube-dependent female with preoperative ZD, aspiration, and pharyngeal weakness developed a left vocal fold paralysis, continued pharyngeal weakness, and aspiration postoperatively of unclear etiology. One patient died of urosepsis within 1 month of surgery (related to medical comorbidities), and one patient died on postoperative day 14 due to complications from preexisting pancreatic cancer. There were no cases of fever, abscess, or mediastinitis.

During the study period, the surgical technique evolved. A nasogastric tube was placed in the operating room for postoperative feeding twice during the first year of the study, and in no subsequent cases. Suture closure of the overlying mucosa was used in two cases in the first year and none since. Additional means of closure, such as fibrin glue or hemostatic matrix, were used in three cases, twice during the first year, once during the second year, but not since then. None of these cases had postoperative complications.

The use of dilation with CPM varied from case to case. Ten cases (11.5%) required dilation before CPM to achieve adequate exposure. Of these, five used the Savary dilator and five used the CRE dilator. There was no association between need for pre-CPM dilation and FOSS score. Dilation was performed immediately after CPM in 49 cases (56.3%), most after 2009, all without complication. When comparing average pre- and postoperative FOSS scores between those patients with and without dilation, there was no difference.

Postoperative management of patients similarly evolved. Overall, 22% of patients underwent neck radiographs postoperatively. In the initial 3 years, postoperative lateral neck radiographs were obtained routinely (17 of 22 cases). Only three patients had extraesophageal air and were followed with daily films until resolution. Two of these patients had radiographic swallow studies, with one showing a small contained leak. No further intervention was performed. In the final 3 years of the study, neck films were only obtained if there was clinical concern. During this period with 65 patients, two patients had subcutaneous crepitus prompting neck films, both showing air in the neck that resolved spontaneously. None of the patients with or without air on plain films developed fevers, neck pain, chest pain, or evidence of mediastinitis.

Though postoperative management evolved, a standard schedule was developed. The patient was fed a clear liquid diet on postoperative day (POD) 0, then observed overnight, advanced to a soft diet on the morning of POD 1, and once the diet was tolerated, discharged on the afternoon of POD 1 with soft diet for 1 to 2 weeks. If there was concern due to crepitus or extraesophageal air on x-ray, the oral diet was held until these resolved. The mean, median, and mode length of admission were 1.8, 1, and 1 day, respectively. In examining time to oral feeding postoperatively, five outliers were removed. Three patients with preexisting gastrostomy tubes were never fed orally due to continued aspiration, and two patients with a

GT and poorly recorded follow-up had unclear time to feeding. Excluding these outliers, the mean, median, and mode time to feeding were 1.3, 1, and 0 days, respectively.

DISCUSSION

Historically, CP dysfunction was treated with transcervical CPM[10]; however over the past 20 years endoscopic laser CPM was developed and shown to be safe and effective.[2,3,7,9,14,16,17] Nevertheless, due to the fear of mediastinitis, many continue to prefer transcervical CPM.[11] Interestingly, reports of esophageal perforations or mediastinitis after endoscopic laser CPM are rare. Lim reported two cases of esophageal perforation requiring external drainage in a series of 44 patients.[7] Herberhold and Walther reported one patient with postoperative “impending mediastinitis” who underwent a negative neck exploration.[16]

In our experience with 87 patients, there were no cases of mediastinitis, neck abscess, or fistula. We had one patient with vocal fold paralysis postoperatively of unclear cause. The three remaining complications should not be ignored, but were all related to medical comorbidities. The patient population with CP dysfunction typically has comorbidities, and preoperative surgical risk should be carefully assessed prior to surgery.

In describing the CPM technique, most authors simply report that the CP muscle is exposed with a diverticuloscope.[2,3,7,14] We found that in 10 cases (11.5%), the CP was so tightly contracted that the esophageal inlet lumen could not be exposed, necessitating dilation prior to myotomy, thus allowing appropriate exposure to perform the procedure. Though the swallowing outcomes were not different for those who underwent pre-CPM dilation, in our experience the dilation increased the likelihood of successfully completing the procedure. Understanding and utilizing this technique may allow surgeons to perform endoscopic CPM on patients who otherwise may have required an open operation.

Large variation in postoperative management following endoscopic CPM exists in the literature regarding imaging, swallow studies, time to feeding, and length of hospitalization.[7,17,18] A comparison of these recommendations was reviewed by Ho *et al.* in 2011.[3] We offer our recommendations for postoperative management based on our experience with 87 cases. Unless there is clinical suspicion for a complication, such as fever, neck pain, chest pain, or subcutaneous emphysema, the patient who was eating preoperatively may be fed a clear liquid diet immediately postoperatively. On the morning of POD 1, the patient can advance to a soft diet and then be discharged once this is tolerated. Exceptions to feeding are those who are GT dependent and/or have severe aspiration risk, as they should be maintained on supplemental nutrition until the aspiration risk is formally reassessed. Additionally, patients with clinical suspicion for complication should remain without oral feeding and be evaluated radiographically. A lateral neck x-ray may reveal free air in the neck, which can be followed with daily x-rays until resolution. If concern persists, a radiographic swallow study should be performed to assess for leak.

Of our patients, the average FOSS score improved from 2.6 to 1.6, which was statistically and clinically significant improvement. The greatest improvement in FOSS score was seen in patients with ZD or CP dysfunction from stroke or vagal nerve injury. The least improvement was seen in patients with prior radiation. These findings are not surprising, as dysphagia associated with radiation is likely multifactorial including pharyngeal weakness and reduced hyolaryngeal elevation. Radiation patients who were GT dependent preoperatively had improvement in swallowing with surgery, but most continued to require supplemental nutrition. This finding is important in preoperative counseling. The surgeon should communicate clearly that surgery may not allow the patient to remove the GT, but may allow the patient to take some food by mouth, improving quality of life. Our current approach to postradiation dysphagia with CP dysfunction is multidisciplinary, including esophageal dilation, CP myotomy as indicated, and aggressive swallowing therapy.

Thirty-one percent of our patients presented after prior treatment for CP dysfunction. The majority previously underwent botulinum toxin injection or esophageal dilation. It is notable that of the 10 patients who previously underwent botulinum injection, only three reported improvement with injection. This may be explained by the histologic findings reported by Lacau St Guily *et al.* regarding connective tissue infiltration and fibrosis within the CP muscle.[19] These authors hypothesized that this fibrosis explains why botulinum is ineffective in some patients. An additional concern in our patients is that two complained of worsening dysphagia and aspiration with botulinum toxin injection. This brings concerns that botulinum injection into the CP may worsen dysphagia by causing global pharyngeal weakness through diffusion to surrounding muscles.[8] It has been hypothesized that the results of botulinum injection to CP may predict CPM outcomes, and our data support this hypothesis.[20] The average improvement in FOSS for the three patients who responded well to their prior botulinum injection was 1.5, but was only 0.5 for those who worsened or had no change with prior botulinum injection. As most of our patients had their prior botulinum injection elsewhere, we do not have preinjection FOSS data and cannot compare improvements between botulinum injection and CPM. In general, we have refrained from CP botulinum injection because of the unpredictable complication of worsening dysphagia and also because in our experience endoscopic CPM can be safely performed with minimal morbidity using the same exposure as CP botulinum injection in the operating room.

CONCLUSION

Endoscopic CO_2 laser CPM has become a versatile operation with low surgical morbidity. Early oral feeding postoperatively is a safe approach in the treatment for cricopharyngeal dysfunction. However, swallowing outcomes vary depending on surgical indication and associated conditions.

Acknowledgments

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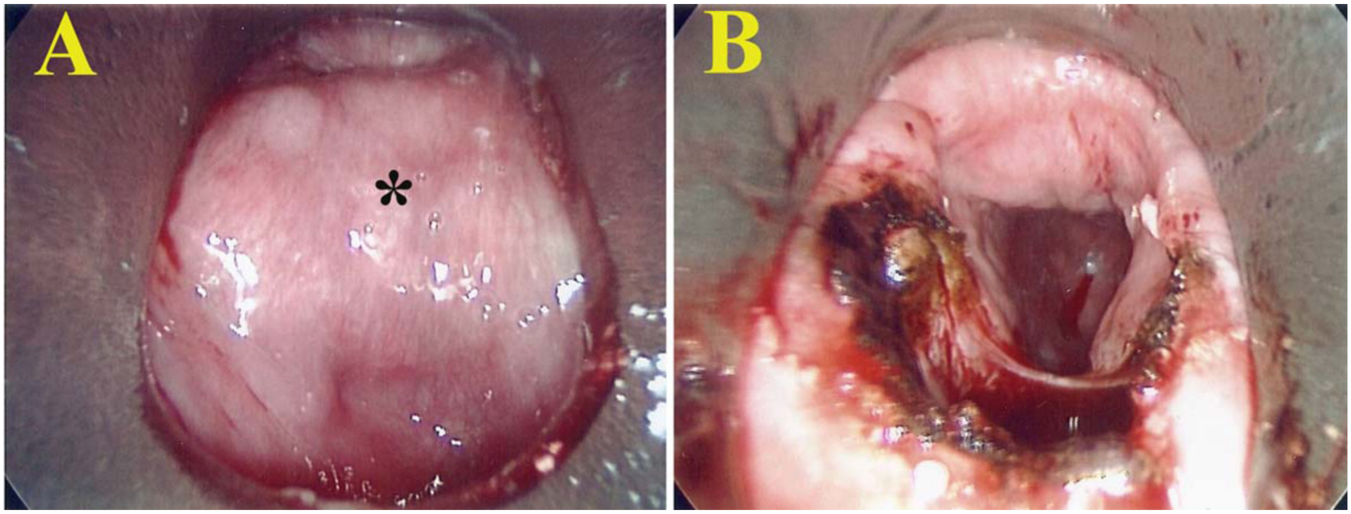

Fig. 1.

Intraoperative view of idiopathic cricopharyngeus (CP) hypertrophy causing dysphagia (A) before and (B) immediately following CO_2 laser myotomy and dilation. *Hypertrophic CP bar. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

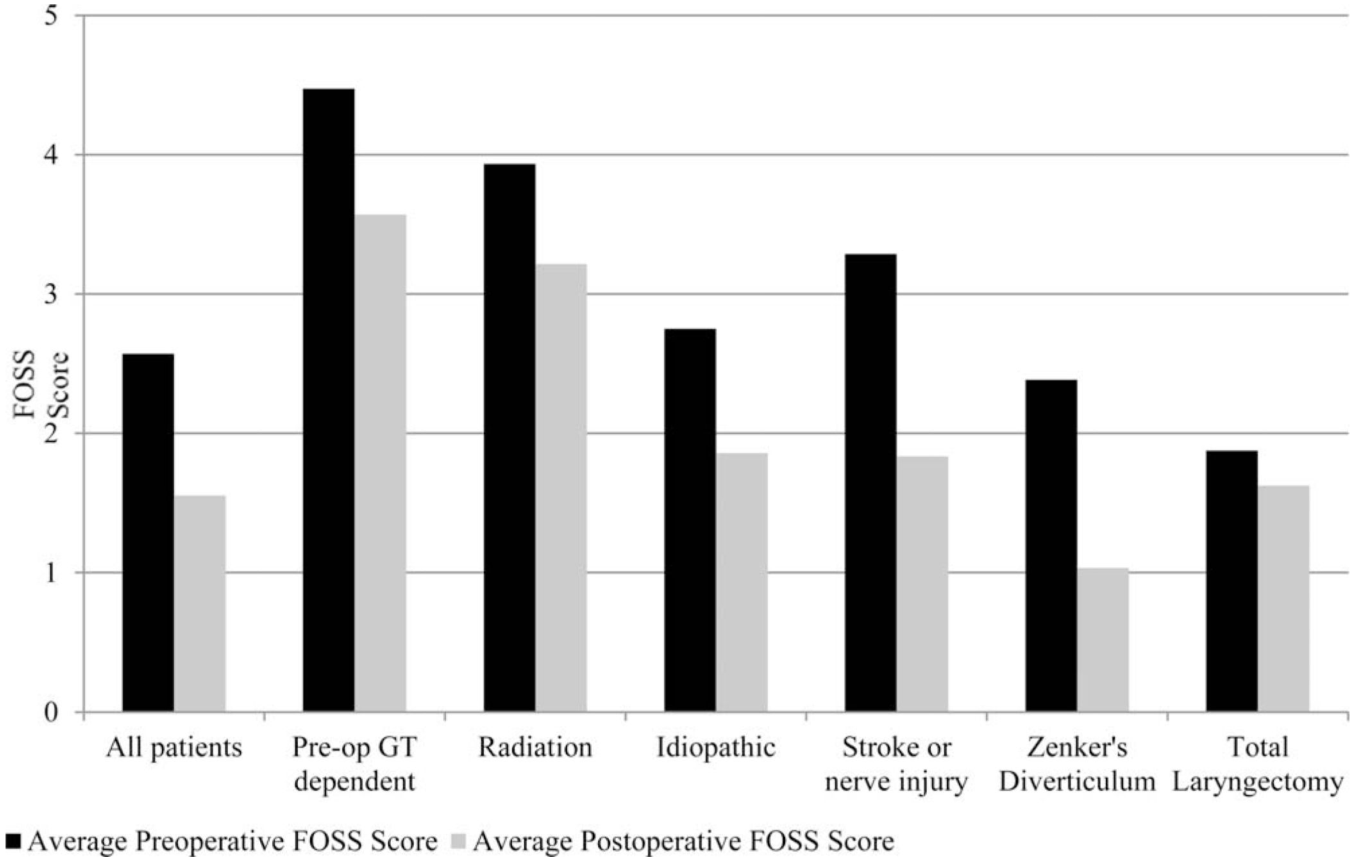

Fig. 2.

Pre- and postoperative Functional Outcome Swallowing Scale (FOSS) scores across patient groups. GT = gastrostomy tube.

TABLE I

Indications for Operation and Associated Disease Processes.

	No.	%	Age, yr		Gender	
			Range	Average	Male	Female
Zenker's diverticulum	39	44.83	41–97	71.8	23	16
Idiopathic CP dysfunction	16	18.39	45–91	74.4	7	9
Radiation for head and neck cancer	15	17.24	45–82	66.5	10	5
Stroke	5	5.75	54–78	67.4	5	0
Iatrogenic nerve injury	2	2.30	55–84	69.5	1	1
TL, failed TEP speech	5	5.75	69–87	76.4	5	0
TL, dysphagia from CP dysfunction	3	3.45	65–92	75.3	1	2
DiGeorge syndrome, CP dysfunction	2	2.30	2–3	2.5	0	2
Total	87	100.00	2–97	69.9	52	35

CP = cricopharyngeus; TL = total laryngectomy; TEP = tracheoesophageal puncture.