

## ORIGINAL RESEARCH

# The effect of unilateral endoscopic arytenoid abduction lateropexy on swallowing in cases of bilateral vocal fold palsy

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**Abstract**

**Objective:** Endoscopic arytenoid abduction lateropexy (EAAL) is a minimally invasive surgical technique for the immediate management of bilateral vocal fold palsy (BVFP). Specifically, it achieves a stable and adequate airway by lateralizing the arytenoid cartilage without resecting laryngeal structures. Thus, this study evaluated the effect of EAAL on swallowing in cases of BVFP.

**Methods:** The participants consisted of 17 adult patients (15 female, 2 male) who underwent unilateral EAAL for BVFP. Swallowing function was evaluated by using the fiberoptic endoscopic evaluation of swallowing (FEES) on the 6th postoperative day and in the 6th postoperative month. The results were assessed by using the pharyngeal residue severity scale (PRSS) and the modified penetration-aspiration scale (mPAS). Additionally, the M.D. Anderson Dysphagia Inventory (MDADI) questionnaire was self-administered during the 6th postoperative month.

**Results:** Overall, 16 of the 17 patients demonstrated normal swallowing function during the early and late postoperative periods. Moreover, one patient experienced mild fluid aspiration early on, but initially managed it with dietary adjustments and eventually resolved it with a head flexion compensatory maneuver. There was no significant deterioration in swallowing-related quality of life according to the MDADI assessments.

**Conclusion:** Based on this evaluation of unilateral EAAL, our results confirmed that this procedure is not only a reliable solution for BVFP from the perspective of respiratory function and phonation but also in terms of swallowing quality.

**Level of Evidence:** 4.

**KEYWORDS**

bilateral vocal fold palsy, dysphagia, endoscopic arytenoid abduction lateropexy, fiberoptic endoscopic evaluation of swallowing

## 1 | INTRODUCTION

The larynx is responsible for a multitude of meticulously regulated vital functions such as swallowing, voicing, breathing, coughing, and chest stabilization. All of these functions require the coordinated

operation and intact innervation of numerous muscles.<sup>1</sup> However, in the event of laryngeal recurrent nerve paralysis, this complex system is disrupted. Specifically, vocal fold medialization may develop and in bilateral cases, severe dyspnea occurs,<sup>2,3</sup> which is an urgent medical condition that must be treated as soon as possible. Depending on the

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severity of the condition, the management of dyspnea should prioritize the creation of a definitive and patent airway.<sup>4</sup> Yet, glottis-widening procedures typically damage the delicate structures of the larynx to varying degrees and consequently impair the swallowing function by strictly focusing on airway rehabilitation. In this regard, endoscopic arytenoid abduction lateropexy (EAAL) is a quick, minimally invasive, reversible surgical technique that provides a sufficiently wide airway through the fixation of the arytenoid cartilage in its physiological, maximally abducted position with the utmost preservation of the anatomical boundaries.

As demonstrated in our previous publications, even in permanent bilateral vocal fold palsy (BVFP), unilateral EAAL simultaneously provides a socially acceptable voice quality and a good breathing function.<sup>2-5</sup> However, the unavoidable decrease in laryngeal sphincter function requires the assessment of swallowing for the holistic evaluation of the outcomes. Therefore, we introduce a commonly used method for evaluating swallowing: the fiberoptic endoscopic evaluation of swallowing (FEES), which is a minimally invasive, repeatable, and well-tolerable technique for visualizing the oropharyngeal phase of deglutition to assess the otorhinolaryngological and neurological causes of dysphagia.<sup>6</sup>

## 2 | MATERIALS AND METHODS

### 2.1 | Patients

The participants consisted of 17 adult patients (12 female, 5 male; mean age: 46.5 years; range 29–68 years) who had undergone unilateral EAAL for BVFP. The study spanned a duration of 2 years. Patients with significant vocal fold motion recovery were not enrolled. In all cases, BVFP developed after bilateral total thyroidectomy for a benign condition. The mean time between the thyroidectomy and EAAL was 42.2 days (range 1–95 days). The swallowing function was evaluated with the FEES on the 6th postoperative day and in the 6th postoperative month. The results were assessed through two subjective scales: the pharyngeal residue severity scale (PRSS) and the modified penetration-aspiration scale (mPAS). The self-administered M.D. Anderson Dysphagia Inventory (MDADI) questionnaire was also applied during the 6th postoperative month. Before the FEES, an indirect laryngeal endoscopy was performed by using a 70° rigid endoscope under local anesthesia to assess any spontaneous vocal fold motion recovery. Written informed consent was obtained from the participants. Ethical approval for this study was obtained from the Institutional Ethics Committee of the University of Szeged (Registration No. 24/2022-SZTE RKEB).

### 2.2 | Surgical procedure of EAAL

Because the EAAL procedure was described in our earlier publications, only a brief summary is reported here.<sup>2,3,5,7</sup> This procedure is performed under general anesthesia by using supraglottic jet ventilation. First, the larynx is explored with a modified Weerda

laryngoscope and the passive mobility of the cricoarytenoid joints is assessed. Then, the mobile arytenoid cartilage is tilted up and backward by using the endolaryngeal thread-guided instrument (ETGI, Mega Kft., Szeged, Hungary). Next, the curved and built-in blade is pushed through under the vocal process out of the surface of the neck, after which a nonabsorbable suture thread is led through the hole at the tip of the blade and then retracted into the ETGI. After the arytenoid cartilage is repositioned, the blade with the doubled-over thread is extruded above the vocal process to the outer surface of the neck. Finally, the corresponding ends of the thread are knotted under the skin (see Figure 1).

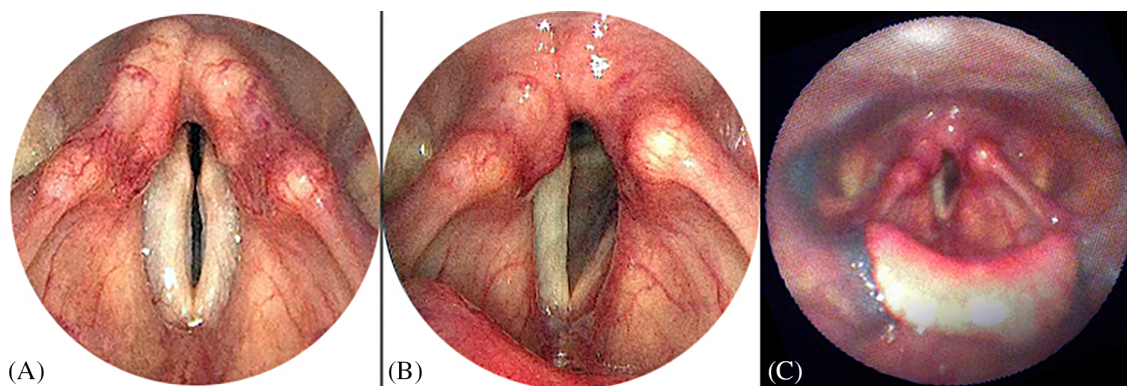
In general, patients are treated (peri- and postoperatively) with 7 days of antibiotics and 5 days of continuously reduced dosage of parenteral methylprednisolone therapy. Prohibition of speech is recommended for 2 weeks postoperatively. As for oral fluid intake, it can begin on the day of the intervention, but a thicker consistency of food consumption can be progressively introduced on the first postoperative day.

### 2.3 | Evaluation of swallowing

In the FEES, the oropharyngeal phase of deglutition is examined via the swallowing of three test materials of different consistencies. In this regard, the International Dysphagia Diet Standardization Initiative (IDDSI) uses a 7-grade scale for foods and liquids based on their consistency.<sup>8</sup> The first test material is a thin liquid colored with blue food dye (Sulfan blue), with a consistency of 0 on the IDDSI scale. The second test material is prepared by adding 15 g of fluid thickener (Nutilis Powder, Nutricia) and dissolving it in one deciliter of room temperature water to form a puree, with a consistency of four on the IDDSI scale. In this case, it is colored with yellow food dye (Tartazine). The coloration of the test materials helps us evaluate the severity of the pharyngeal residue, with a more vivid coating effect. Finally, the third test material includes a thicker consistency. It is generally a bite-sized biscuit, with a consistency of 7 on the IDDSI scale.

During a prior anterior rhinoscopy, any obstructive anatomical features, such as nasal septal deviation, enlarged turbinates, or nasal polyposis, are assessed. Then, the lower meatus is locally anesthetized with cotton wool, lightly dipped in tetracaine-ephedrine solution (ephedrini racemici hydrochloridum 0.2 g, tetracaine hydrochloridum 2 g, and aqua distillata 97.95 g). After removing the cotton wool, the flexible fiberscope is inserted into the lower nasal meatus. This way, the mesopharynx and hypopharynx can be optimally visualized from above, in addition to the supraglottis and glottis.<sup>6</sup>

In this study, the mPAS and the PRSS are both used to assess the patients' oropharyngeal swallowing function. Specifically, the mPAS defines the airway penetration of the materials as follows: (1) no airway entry; (2) material enters the airway, but remains above the level of the vocal folds; (3) material enters the airway and contacts the vocal folds; (4) material enters the airway below the level of the vocal folds and triggers coughing; and (5) material enters the airway below the level of the vocal folds without coughing. As for the PRSS, the



**FIGURE 1** Bilateral vocal fold palsy treated with unilateral endoscopic arytenoid abduction lateropexy (EAAL) (Patient #15, endoscopic pictures). (A) Vocal folds in paramedian position. (B) Adequate airway after left-sided EAAL (6th postoperative month). (C) Minimally coated mucosa in the right pyriform sinus and epiglottic vallecula (6th postoperative month).

severity of the retention of the test material in the pharynx is rated as follows: 0—no food residue in the pharynx; 1—the colored test material forms a thin coating on the pharyngeal mucosa, without pooling; 2—slight pooling/small amount of food residue visible; 3—moderate pooling/medium amount of food residue; 4—a large amount of test material is retained in the pharynx.<sup>6,9-11</sup>

The patients are also required to complete the MDADI (translated into Hungarian) during the 6th postoperative month. This is used to determine the potential abnormalities in swallowing, which may affect the quality of life. The questionnaire includes four domains, consisting of 20 items and a total score. The global domain describes the limitation of the patient's daily activities, due to his/her possible swallowing disorder. The emotional domain (six items) shows the patient's emotional response to the swallowing disorder, but the functional domain (five items) describes the impact of the patient's swallowing problem on daily activities. Finally, the physical domain (eight items) assesses the patient's experience of the dysphagia. Each item is rated on a 5-point scale, ranging from 1 (strongly agree) to 5 (strongly disagree). The global domain is individually represented, and the sum and average scores of the other domains are calculated and converted into scores ranging from 20 (very low performing) to 100 (high performing). In this case, a higher score indicates a better health-related quality of life.<sup>12</sup>

### 3 | RESULTS

Airway stability and patency were consistently maintained in all the patients throughout the entire follow-up period. None of the patients required revision surgery. Overall, 16 of the 17 patients showed physiological swallowing function in the early and late postoperative periods. Meanwhile, the value of the mPAS was 1 in 16 cases, indicating that the test material did not enter the airway, whereas the value of the PRSS was 0 in all cases, showing no pharyngeal food residue. One patient experienced mild fluid aspiration-related symptoms in the early postoperative period; however, during FEES, this patient scored

a 2 on the mPAS scale for fluid, indicating that the material entered the airway, but remained above the level of the vocal folds. In the same patient, a slight pharyngeal coating effect was also detected, meaning 1 on the PRSS scale. The dysphagia was initially managed through dietary modification (fluid thickener) and eventually resolved with the use of a head flexion compensatory maneuver. At the 6-month follow-up, the patient scored a 1 on the mPAS scale (with no changes in the PRSS scale) and a 97.78 on the MDADI. Overall, there was no significant difference between the preoperative and postoperative results in terms of either PRSS or mPAS values ( $p$ -values  $>0.05$ ). The average MDADI score was 99.86 in the 6th postoperative month. None of the other patients showed any deterioration in swallowing-related quality of life at the 6-month visit, whereas four of the 17 patients showed endoscopic signs of adduction recovery during this follow-up period.

### 4 | DISCUSSION

The larynx is one of the most densely innervated human organs, which behaves as a valve of the upper airway and is responsible for many complex, highly advanced vital functions such as voicing, swallowing, breathing, coughing, and chest stabilization.<sup>1,13</sup> When the laryngeal innervation is disturbed, a dysfunctional condition of varying intensity and severity occurs.<sup>14</sup> Vocal fold palsy most often develops as part of a complication of neck or thoracic surgery.

The background of this process is the injury of the recurrent laryngeal nerve (RLN) and/or the vagus nerve (VN). Damage to the RLN is more frequent than damage to the entire vagus nerve, and in the 25%–58% of the cases, it is commonly seen as a complication of thyroid surgery. This injury can be categorized into three main degrees: neurapraxia (the least severe), axonotmesis, and neurotmesis. In case of thyroid surgeries, the prevalence of temporary vocal fold palsy varies between 0% and 12%, whereas persistent palsy ranges between 0% and 3.5%.<sup>15-20</sup>

The classic symptoms of BVFP are dyspnea, with a varying degree, and inspiratory stridor.<sup>21</sup> These symptoms manifest with variable intensity and differing dominance, due to the complex innervation of the larynx. Such complexity stems from various factors such as bilateral and dual innervation of specific muscles (e.g., interarytenoid muscles), variability in the branching patterns of the RLN's anterior and posterior branches, and the diverse network of neural anastomoses (e.g., the anastomosis of Galen and the human communicating nerve).<sup>22</sup> The symptoms may rapidly develop in the early postoperative stage but may also gradually and insidiously appear in later periods. Not only the status of the vocal folds but also the patient's general health condition, cardiopulmonary status, and physical activity influence the severity of dyspnea in BVFP, which (due to the risk of sudden severe airway obstruction) usually requires immediate surgical intervention.

Tracheostomy has been the standard surgical procedure for centuries, ignoring the serious psychosomatic adverse effects of cannulation.<sup>2,23,24</sup> However, with the development of diagnostics, anesthesia, and surgical technology, the treatment for restoring airway patency while avoiding a tracheostomy became possible. Currently, there are numerous temporary and permanent techniques of laryngeal airway enlargement surgeries that can be individualized for each patient's circumstance. As for the resection of anatomical structures, it can be divided into the resection of soft tissue or cartilaginous parts. Among the soft tissue resection procedures, posterior CO<sub>2</sub> laser cordectomy and transverse cordotomy are the most widely used methods. In this case, the posterior "respiratory" glottis can also be enlarged via the (partial) removal of the arytenoid. Moreover, the multifarious modifications of these resection techniques can be applied in combination. Interventions that rebuild existing structures with minimal tissue removal, such as Réthi's laminotomy, are still used today.

The most feared complications of tissue resection-based procedures are the risk of posterior glottic stenosis caused by postsurgical scarring and aspiration arising from the lowered aryepiglottic folds and/or desensibilization of the interarytenoid mucosa. Meanwhile, glottic reconfiguration may be achieved by less-invasive suture lateralization of the paralyzed vocal fold. The success of laryngeal reinnervation, as a promising method of dynamic rehabilitation, is still limited, requiring further clinical validation.<sup>4,21,24-26</sup>

It has been shown that vocal fold movements can completely or partially return in 40%–86% of cases if the RLN is not entirely transected during the cervical or thoracic surgery. Thus, reversible, temporary surgical solutions should be prioritized. In this regard, EAAL, a nondestructive and minimally invasive procedure widens the glottis, while maintaining laryngeal integrity. This technique also preserves the framework of the larynx without causing damage to either the treated or the contralateral vocal fold. More importantly, EAAL does not impede the natural neural regenerative process. However, reinnervation frequently leads to synkinesis, rather than complete functional restoration, possibly due to the complex interplay of axons that serve opposing (abduction/adduction) functions. Furthermore, the numerical predominance of adductor muscle fibers and axons generally favors the reinnervation of adductory muscles. This rather

common phenomenon was also observed among our patients. It should be noted that adduction recovery may not enhance respiratory function, but it can confer benefits for phonation and swallowing.<sup>4,16,23-25</sup> These findings present yet another compelling argument for the application of EAAL.

As described in our earlier publications, EAAL is a quick and safe treatment for vocal fold palsy. The endoscopically guided suture holds the vocal process—and consequently, the body of the arytenoid cartilage—in a maximally abducted position to provide a stable airway, without the resection of laryngeal structures. As opposed to ablative techniques, EAAL provides a socially acceptable voice quality with a patent airway, even in cases of permanent BVFP.<sup>2,27</sup> In our experience, swallowing difficulties are remarkably rare in cases of unilateral EAAL.<sup>2,23</sup>

In general, the airway is protected at multiple levels during swallowing. Meanwhile, aspiration is prevented by the central blockage of inspiration and the synchronized closure of multiple anatomical structures.<sup>3,26</sup> Considering the complex mechanics of deglutition, aspiration-free swallowing does not only depend on glottic closure, but it also requires an unaffected central nervous system and intact sensory and motor innervation.<sup>14,28-30</sup> The foundation of the peripheral, swallowing-related neurofunction is the integrity of the afferent and efferent innervation of the superior (SLN) and inferior laryngeal nerves.<sup>31</sup> The sensory innervation of the hypopharyngeal mucosa and the mucosa over the vocal folds is supplied by the internal branch of the SLN, but the external branch is responsible for motor innervation of the lower pharyngeal constrictor and the upper esophageal sphincter. In case of injury to the external branch or the pharyngeal plexus, decreased pharyngeal contraction and the formation of more pharyngeal bolus residues may increase the risk of aspiration.<sup>32</sup> As for the pharyngoesophageal junction, it is supplied by sensory and motor innervation from the RLN and VN. The aspiration and swallowing dysfunction are more common in RLN and SLN co-injuries. In patients with RLN injury without involvement of the pharyngeal plexus, aspiration may occur in the presence of multiple abnormalities of the laryngopharyngeal junction, such as laryngeal elevation and insufficient glottic closure, which may impede hypopharyngeal suction.<sup>15</sup> Due to the complex innervation detailed above, following glottis-widening procedures, it is necessary to examine other components of the swallowing process beyond the potential loss of laryngeal sphincter function.

Regarding the FEES and video fluoroscopic swallowing screening (VFSS), they are the "gold standards" for the assessment of swallowing function. VFSS is a procedure in which the swallowing process is evaluated by the passage of the bolus through all the swallowing phases. By using radiation, it has lower reproducibility and repeatability, compared to the FEES.<sup>33</sup> The FEES, introduced by Dr. Susan Langmore in 1988, is a relatively well-tolerated, repeatable method that indirectly allows the assessment of the pharyngeal and laryngeal anatomical features, while simultaneously evaluating sensorimotor dysfunction of these organs can be evaluated simultaneously.<sup>34</sup> By nasofiberoptic swallowing examinations, we demonstrated that EAAL is a highly reliable surgical procedure without the resection of



the laryngeal framework, which can immediately provide a sufficiently wide airway without significant interference with swallowing.

If patients are experiencing dysphagia, then positional maneuvers and dietary modifications can be introduced to improve swallowing.<sup>35</sup> Depending on age and cooperation, positional maneuvers (chin tuck and head turn) have been shown to be effective. Meanwhile, thicker bolus consistency can increase the oropharyngeal muscle activity by the heightened stimulation of the swallowing trigger points.<sup>15</sup>

## 5 | CONCLUSION

In the treatment of BVFP, the absolute priority is securing the airway. However, achieving this should not lead to further deterioration of the already impaired function of the larynx. Based on this evaluation of unilateral EAAL, our results confirmed that this procedure is not only a reliable solution for BVFP from the point of respiratory function and phonation but also in terms of swallowing quality.

## 6 | LIMITATIONS

The FEES seems to be an efficient tool for the examination of the deglutition of patients with glottis-widening interventions; however, the results must be evaluated precisely alongside the entire clinical presentation of the symptoms. Other limitations of this study are the small patient population and the single-center experience. Specifically, the focus of this study was the evaluation of swallowing function following EAAL. In the future, we plan to conduct a more complex study in which we simultaneously present the results of swallowing, breathing, and phonation functions as well as their possible correlations. Another limitation is the lack of pre-EAAL evaluations.

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### CONFLICT OF INTEREST STATEMENT

The endolaryngeal thread guide instrument was patented in Hungary in 2008 (Patent No. U 0700163). László Rovó has intellectual property rights pertaining to this device.

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