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ORIGINAL RESEARCH

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Effectiveness of vocal fold medialization surgery on the swallowing function of patients with unilateral vocal fold paralysis

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Abstract

Objectives: Vocal fold medialization surgery is generally considered a phonosurgical procedure for improvement of vocal function in patients with glottic insufficiency. However, the literature describing this procedure for the management of dysphagia is limited. This study aims to assess the effects of medialization surgery on swallowing function in patients with unilateral vocal fold paralysis (UVFP).

Methods: We enrolled 32 patients with UVFP undergoing vocal fold medialization surgery (medialization laryngoplasty combined with arytenoid adduction [ML + AA], 12 cases; injection laryngoplasty [IL], 20 cases). We assessed the aerodynamic vocal function including maximum phonation time and mean flow rate to evaluate glottal closure status. The Hyodo score determined by flexible endoscopic evaluation and Functional Oral Intake Scale (FOIS) were evaluated pre- and postoperatively.

Results: Almost 60% of patients with UVFP had dysphagia, and one-third were at high risk for aspiration. Aerodynamic parameters effectively improved after IL and ML + AA. With regard to swallowing, both the FOIS and total Hyodo score were significantly improved postoperatively. We found a particularly significant improvement in pharyngeal clearance. However, patients with high vagal nerve paralysis and postoperative insufficient glottal closure showed poor swallowing benefits after the interventions. In patients with recurrent laryngeal nerve palsy, there were no significant differences in postoperative swallowing function between the ML + AA and IL groups.

Conclusion: Vocal fold medialization surgery was effective in improving swallowing function in most cases with UVFP, except for those with high vagal paralysis and insufficient postoperative glottal closure. Both IL and ML + AA showed an equivalent effect on swallowing improvement.

Level of evidence: 3b.

KEYWORDS
arytenoid adduction, injection laryngoplasty, medialization laryngoplasty, swallowing function, unilateral vocal fold paralysis

1 | INTRODUCTION

Patients with unilateral vocal fold paralysis (UVFP) often complain about not only breathy hoarseness but also dysphagia. Although the detailed pathophysiology of dysphagia in patients with UVFP is uncertain, insufficient glottal closure, poor pharyngeal movement, and decreased sensation are considered to be contributing factors to swallowing dysfunction.[1,2] According to previous studies, swallowing dysfunction has been reported in up to 60% of patients with UVFP, and 23%–53% of patients demonstrated aspiration.[3,4] These dysfunctions can greatly affect a patient's quality of life.

Several techniques have been developed to address glottal insufficiency, including medialization laryngoplasty (ML), arytenoid adduction (AA), and injection laryngoplasty (IL). These phonosurgical procedures for UVFP shift the paralyzed vocal cords to the midline to obtain sufficient glottal closure, aiming for improvement in vocal function; however, they do not improve the prospects of neural recovery. AA not only medializes but can also correct a large posterior glottic gap and fix mismatches in vocal fold height. This procedure is often combined with ML (ML + AA) to compensate for atrophy or bowing of the membranous portion.[5–7] ML + AA is performed under local anesthesia, and allows for the assessment of the patient's voice during the operation. IL is frequently used to inject a substance into the thyroarytenoid muscle of a paralyzed vocal cord to increase bulk. Several types of filler materials are used, including hyaluronic acid, atelocollagen, fat, and calcium hydroxyapatite (CaHA). Of these, hyaluronic acid and atelocollagen are eventually absorbed, and the effects of injection are often temporary. On the other hand, injection of CaHA can result in permanent augmentation. Although IL is a much simpler and faster technique than ML + AA is, CaHA injection is often performed without direct feedback on voice quality due to general anesthesia.

The benefits of the various interventions to improve vocal function have been well established. However, although better glottic closure could theoretically contribute to better swallowing function, limited literature has assessed swallowing pathology after medialization surgery on patients with UVFP. Particularly, few studies reported the swallowing impact of ML + AA on patients with UVFP while recent several studies assessed the effectiveness of IL on swallowing function.[8–11]

In this study, we evaluated swallowing function before and after vocal fold medialization surgery in patients with UVFP. Furthermore, we comparatively analyzed the differences in swallowing impact between IL and ML + AA.

2 | MATERIALS AND METHODS

2.1 | Study sample

We included in this retrospective study patients with UVFP who underwent ML + AA or IL between 2013 and 2018. Patients with a history of laryngeal surgery, radiation to the larynx, and other cranial nerve disorders were excluded. Patients without data on vocal and swallowing evaluations were also excluded. Pre- and postoperative functional data were comparatively assessed.

This study was conducted in compliance with the postulates of the Declaration of Helsinki on medical protocol and was approved by the institutional review board. The consent to participate was given via opt-out.

2.2 | Procedures

To allow for spontaneous recovery, surgical procedures were delayed at least 6 months after nerve injury. We performed ML + AA for patients with UVFP who had a mismatch of glottal level between the right and left as confirmed by cone-beam computed tomography, whereas we preferred IL for patients without glottal gap.

We performed ML + AA with the patient under intravenous anesthesia without intubation. The paralyzed side of the sternohyoid muscle was dissected, and a window was created at the vocal fold level on the thyroid cartilage. After the dissection of the thyropharyngeal muscle, the muscular process of the arytenoid cartilage was exposed and rotated anteriorly to adduct the arytenoid. Then, we placed GoreTex® into the subperichondrial space beneath the window while observing the video monitor and conducted an acoustic evaluation using vocal feedback from the patient.

We performed IL while the patient was under general anesthesia with intubation. After inserting a rigid laryngoscope transoral, we placed a 21-gauge needle at the midlateral or posterior vocal fold. CaHA (Biopex®) was used as the injection material, with the volume was dependent on the size of the deficit, ranging from 0.3 to 1.0 mL.

2.3 | Functional evaluations

We assessed both vocal and swallowing function. Data were collected at pre- and postsurgery (at least 3 months after the procedures).

2.3.1 | Aerodynamic examination

We measured aerodynamic parameters including maximum phonation time (MPT) and mean airflow rate (MFR) to evaluate glottal closure status using the Multi-Dimensional Voice Program, model 5150 (KayPENTAX, Lincoln Park, NJ). Each subject was asked to sustain a vowel /a/ phonation. An average value of MPT <10 s and that of MFR >250 mL/s were considered abnormal.[12]

2.3.2 | Fiber-optic endoscopic evaluation of swallowing

Patients were observed with a flexible endoscope during resting breathing. We then examined swallowing status by oral intake with 3 mL of water mixed with a blue dye.

The findings were rated using the Hyodo score,[13–15] a clinical-based scoring system composed of four parameters including (1) the degree of salivary pooling at the vallecula and pyriform sinuses, (2) glottal closure reflex induced by touching the epiglottis or arytenoid with the endoscope, (3) location of the bolus at the swallowing reflex, and (4) extent of pharyngeal clearance after the patient swallowed the blue-dyed water. Each parameter was scored on a 4-point scale (0 = normal, 1 = mildly impaired, 2 = moderately impaired, 3 = severely impaired) (Table S1). A total score > 3.4 was indicative of dysphagia, and a score of >6 predicted aspiration.[14]

TABLE 1 Clinical characteristics of patients.

Demographic	*n* (%)
Age (mean ± SD)	63.3 ± 15.1 (range 28–85 y/o)
Sex	Male 25 (78.1%), female 7 (21.9%)
Side of UVFP	Left 26 (81.2%), right 6 (18.8%)
Etiology	
Aortic aneurysm	8 (25.0%)
Esophageal cancer	7 (21.9%)
Lung cancer	5 (15.6%)
Thyroid cancer	4 (12.5%)
Vagal schwannoma	4 (12.5%)
Idiopathic	3 (9.4%)
Cervical trauma	1 (3.1%)
Surgery	
IL	20 (62.5%)
ML + AA	12 (37.5%)

Abbreviations: IL, injection laryngoplasty; ML + AA, medialization laryngoplasty combined with arytenoid adduction; UVFP, unilateral vocal fold paralysis.

2.3.3 | Functional oral intake scale

The functional oral intake scale (FOIS) score was reported to reflect the swallowing impairment by describing the degree of dietary restriction (Table S2). An FOIS score of <6 was considered abnormal.[16]

2.3.4 | Eating assessment tool 10

The eating assessment tool 10 (EAT-10) is a self-administered, symptom-specific outcome instrument for dysphagia. It consists of 10 questionnaires that a patient rates on a scale of 0–4, with 0 = no problem to 4 = severe problem. EAT-10 ≥ 3 is considered abnormal.

2.4 | Statistical analyses

We performed all statistical analyses using SPSS software for Windows (IBM, Armonk, NY, USA). We assessed the statistical significance of the intergroup differences using the Fisher exact test or chi-square test. Continuous variables were expressed as means ± standard deviation (ranges) and were analyzed using a paired *t* test. Two-sided *p* values of <.05 were considered statistically significant.

3 | RESULTS

3.1 | Clinical characteristics of patients

We enrolled 32 patients with UVFP in this study. Table 1 summarizes the patients' demographic and clinical characteristics. The study group included 21 men and 11 women, and the mean patient age at the time of the intervention was 66 years (±15 years, range 28–85 years). The etiologies of UVFP were as follows: aortic aneurysm (*n* = 8),

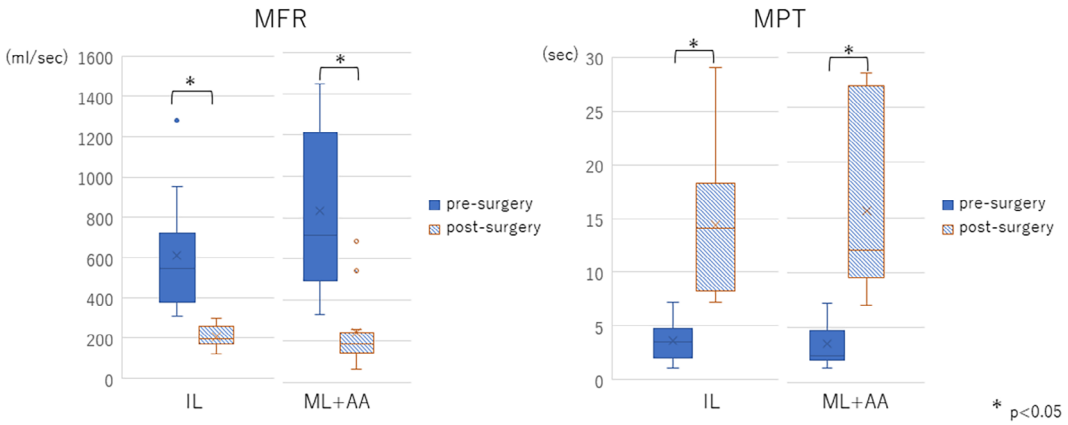

FIGURE 1 Improvement of aerodynamic parameters after IL and ML + AA. (Left) MFR was significantly improved after IL and ML + AA with mean postoperative values below 250 mL/s. (Right) MPT was significantly improved after IL and ML + AA with mean postoperative values above 10 s. IL, injection laryngoplasty; MFR, mean flow rate; ML + AA, medialization laryngoplasty combined with arytenoid adduction; MPT, maximum phonation time.

esophageal cancer ($n = 7$), lung cancer ($n = 5$), thyroid cancer ($n = 4$), vagal schwannoma ($n = 4$), idiopathic ($n = 3$), and cervical trauma ($n = 1$). Twenty patients underwent IL, and 12 patients underwent ML + AA.

3.2 | Aerodynamic analysis

Both IL and ML + AA significantly improved the mean values of both MPT and MFR in most patients (Figure 1). However, three patients (15%) who underwent ML + AA and two patients (17%) who underwent IL showed insufficient glottal closure, with MFR values >250 mL/s. This result was due to a large posterior glottic gap in three patients and mismatches of the vocal fold height in two patients.

There were no significant differences in postoperative MFR values between patients undergoing IL and ML + AA, suggesting the effect of glottal closure improvement was considered almost similar between the different surgical methods.

3.3 | Swallowing evaluation

Table 2 shows the mean values of the swallowing functional parameters before and after therapy, including the FOIS and Hyodo score. Our data showed that 59.4% of patients with UVFP had dysphagia, and 18.8% of patients were at high risk for aspiration, as defined by preoperative total Hyodo score. Improvement in FOIS scores from pre- to postsurgery was statistically significant.

Significant improvement in postoperative swallowing outcomes, defined by total Hyodo score, was also demonstrated by the fiberoptic endoscopic evaluation of swallowing (FEES) evaluation. With regard to each component parameter of the Hyodo score, the extent of pharyngeal clearance showed statistically significant improvement after the intervention, whereas there were no significant changes in the degree of salivary pooling, glottal closure reflex, or initiation of swallowing reflex.

To assess the factors that affect swallowing function, we divided patients with UVFP into an improvement group and a non-improvement group based on both the FOIS and total Hyodo score. As shown in Table 3, patients with postsurgical MFR values >250 mL/s and patients with high vagal paralysis and idiopathic

TABLE 2 Changes in swallowing function after surgery.

	Presurgery	Postsurgery	*p* value
FOIS	4.7 ± 2.0	5.6 ± 1.0	.001
Hyodo score (total)	4.8 ± 2.1	3.8 ± 2.3	.044
(1) Salivary pooling	1.3 ± 0.9	1.2 ± 0.9	.327
(2) Glottal closure reflex	1.1 ± 0.9	1.0 ± 0.8	.307
(3) Swallowing reflex initiation	0.5 ± 0.5	0.4 ± 0.5	.392
(4) Pharyngeal clearance	1.9 ± 0.7	1.2 ± 0.9	.001

TABLE 3 Comparison between improvement and non-improvement group.

	Improvement	Non-improvement	*p* value
Mean age	64.8 ± 15.9	61.1 ± 12.9	.264
Sex			
Male	16	9	
Female	5	2	.544
Side of UVFP			
Left	17	9	
Right	4	2	.671
Etiology (injury point)			
Recurrent laryngeal nerve	19	6	
Vegal nerve	0	4	
Idiopathic palsy	2	1	.012
Comorbidities			
GERD	4	2	.671
Surgery			
IL	14	6	
ML + AA	7	5	.383
Postoperative MFR			
<250 mL/s	20	7	
≥250 mL/s	1	4	.037

Abbreviations: IL, injection laryngoplasty; MFR, mean flow ratio; ML + AA, medialization laryngoplasty combined with arytenoid adduction; UVFP, unilateral vocal fold paralysis.

TABLE 4 Comparison between IL and ML + AA group.

	IL ($n = 15$)	ML + AA ($n = 8$)	p value
Mean age	70.7 ± 9.8	53.8 ± 13.7	.028
EAT-10	1.6 ± 1.2	1.9 ± 1.6	.339
FOIS	5.9 ± 0.9	6.0 ± 1.0	.383
Hyodo score (total)	3.4 ± 2.0	3.0 ± 1.5	.308
(4) Pharyngeal clearance	1.0 ± 0.8	0.9 ± 0.8	.501

Abbreviations: IL, injection laryngoplasty; ML + AA, medialization laryngoplasty combined with arytenoid adduction.

paralysis showed poor results, whereas age, sex, comorbid GERD and side of paralysis were not considered to be significant predictors.

For further analysis, we analyzed patients with recurrent laryngeal nerve palsy with postsurgical sufficient glottic closure and compared the impact of IL and ML + AA on swallowing function. In this subgroup analysis, we also evaluate EAT-10 scoring as a subjective assessment. The mean age of patients who underwent ML + AA was relatively higher than that of patients who underwent IL. There were no significant differences in mean EAT-10 and FOIS score, total Hyodo score, or extent of pharyngeal clearance between the IL and ML + AA groups, suggesting both treatment modalities have an equivalent effect on swallowing (Table 4).

4 | DISCUSSION

In this study, we used FOIS and FEES to evaluate objective swallowing function. Several studies have demonstrated numerous advantages afforded by FEES over videofluoroscopy (VF). Although FEES is more convenient and mobile and does not result in radiation exposure, the sensitivity and specificity in identifying aspiration, penetration, bolus residue, and spillage during FEES were acceptable compared with VF study.[17,18] The Hyodo score is a clinical-based scoring system, and such objective criteria may be useful in generating reproducible evidence. Although no study has compared the sensitivity of the Hyodo score and subjective assessments, the Hyodo score is more informative because it can evaluate the mild salivary pooling and a minor decrease in the laryngeal sensation, which may be difficult to recognize by patient perception. The FOIS is the most frequently used scale for assessing oral intake and has high sensitivity in predicting aspiration, and it allows for a quantitative description of diet. Previous studies reported dysphagia in 50%–60% of patients with UVFP, and 23%–53% of patients demonstrated aspiration. In this study, the percentage of patients with dysphagia as defined by the Hyodo score was almost similar to that in the previous study, whereas the aspiration rate was slightly lower than in other reports. These results were compatible with the FOIS evaluation. The EAT-10 is also utilized as a subjective swallowing evaluation to avoid observer bias in subgroup analysis. This evaluation is one of the most commonly used clinical research tools globally for patients with swallowing difficulty and is the primary outcome measure for many investigations and clinical trials.

There is a wide range of dysphagia severity in patients with UVFP, dependent on the level of neurologic damage. The recurrent laryngeal nerve promotes intrinsic laryngeal muscles and the upper esophageal sphincter (UES) muscle, and the superior laryngeal nerve supplies laryngeal sensitivity. Thus, damage to the vagal nerve proximal to the branch point of the superior laryngeal nerve results in more severe swallowing disorder due to impairment of sensation and motion in the larynx. A previous study reported that 78% of patients with idiopathic UVFP presented with clinically significant dysphagia.[19] In our study, almost 80% of cases with UVFP were due to recurrent laryngeal nerve injury, resulting in a lower aspiration rate than in the previous report.

Our data suggest that patients with idiopathic and high vagal paralysis received less benefit from medialization surgery. Although laryngeal sensation is essentially for the complex sequence of swallowing events, medialization surgery cannot improve the sensory abnormalities of the larynx, as these interventions do not improve the prospect of neural recovery. Structural changes alone may be insufficient to indicate a significant improvement in swallowing. On the other hand, we found that patients with recurrent laryngeal nerve paralysis do benefit from interventions for improvement of dysphagia. However, other researchers have reported diverse results of swallowing impact after medialization interventions in patients with UVFP. Tabaee et al. reported that improving glottal closure alone was not sufficient to improve swallowing function.[4] Nayak et al. also reported that 44% and 16% of patients continued to demonstrate penetration and aspiration after medialization for UVFP, respectively.[20] Prolonged pharyngeal transit time and decreased pharyngeal strength were also demonstrated in patients with UVFP, indicating that the mechanism of dysphagia after paralysis is a complex, multistep process that requires various motor and sensory inputs.[21]

How patients with UVFP alter their swallowing pressure, including mesopharynx and UES pressure, remains controversial. Kammer et al. proved that mesopharygeal pressure and UES in patients with UVFP were higher than that reported in healthy individuals by high-resolution manometry (HRM), indicating that patients with UVFP need to swallow with greater effort to deliver the bolus against high residual UES pressure. Furthermore, although the mesopharynx maximum pressure and rise rate are significantly increased in these patients after medialization intervention, there is no change in UES parameters.[10] In contrast, Erdur et al. reported that UES basal and relaxation pressures were significantly lower and mesopharyngeal pressure was higher in patients with UVFP than in the control group.[22] Pienna et al. reported decreases in both pharyngeal and UES pressure in patients with vagal paralysis. In addition, a significant increase in the mesopharyngeal pressure was demonstrated after ML.[23] Pharyngeal clearance was significantly improved in our subjects, which suggests that improvement in glottic closure likely plays a key role in improving the generation of intrabolus pressure by improving subglottic pressure,[24,25] although we did not perform an HRM analysis.

Focusing on the different types of medialization surgery, Hoffman assessed the impact of IL, ML, and ML + AA on phonatory measures and concluded ML + AA resulted in the greatest improvement in vocal function.[26] With regard to swallowing function, a few studies compared the impact of IL to that of ML, but there were no significant differences in swallowing improvement.[2,20,27] Comparative evaluations of the effect of IL and ML + AA on swallowing changes are rarely reported. In our study, contrary to expectations that damage to the thyropharyngeal muscle by AA affects the production of pharyngeal pressure and worsens swallowing function, we found no significant differences in postoperative pharyngeal clearance between IL and ML + AA.

There are several limitations to this retrospective study. The lack of a control group does not allow us to understand the spontaneous recovery of swallowing function in patients with UVFP compared with the intervention group. In addition, there were variations in the timing of the surgical intervention, and a selection bias may also be present. Elderly subjects tend to select IL because its burden is less than that of ML + AA. Moreover, our study was a single-institution study with small sample size. Further studies with larger samples are warranted to verify our findings.

In conclusion, our study proved that vocal fold medialization surgery was effective in improving swallowing function in most patients with UVFP, except for those with high vagal paralysis and insufficient postoperative glottal closure. This study was unique in that it compared the swallowing impact of IL and ML + AA. In patients with recurrent laryngeal nerve palsy who have sufficient glottal closure postoperatively, both treatment modalities have an equivalent effect on swallowing.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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