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ORIGINAL RESEARCH

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Assessment of vocal fold movement through anterior–posterior view of videofluoroscopic swallowing study

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Abstract

Objective: The aim of this study is to assess the value of using videofluoroscopic swallowing study (VFSS) for assessing vocal fold paralysis.

Methods: This was a retrospective study of patients who underwent VFSS with a vocal fold testing maneuver from June 2020 to February 2022, and who had undergone laryngoscopy within 2 weeks before or after VFSS. The vocal fold testing maneuver consisted of making an 'e' sound for about 2–3 seconds during VFSS anterior–posterior (AP) view. The diagnostic value of the VFSS was evaluated by a trained reviewer, who assessed the presence and laterality of vocal fold paralysis by examining videos of the patients performing the vocal fold testing maneuver. Intra-rater reliability was determined by evaluation of the videos by the same reviewer 2 weeks later, and inter-rater reliability was determined by evaluation by a second reviewer.

Results: Seventy patients were enrolled in the study. The positive predictive value was 91.43% and the intra-rater and inter-rater reliabilities, as determined by Cohen's kappa value, were 0.746 and 0.824 respectively.

Conclusions: The presence and laterality of vocal fold paralysis were identified accurately and reliably by the reviewers, showing that VFSS can be used to assess vocal fold paralysis.

Level of evidence: 2.

KEYWORDS
AP view, laryngoscopy, VFSS, vocal fold paralysis

1 | INTRODUCTION

Vocal fold paralysis presents as vocal fold immobility due to neurologic injury. Common symptoms of vocal fold paralysis include dysphonia, hoarseness, breathiness, and throat pain.[1] Although the vocal fold is regarded as an organ of phonation, it also plays an important role in airway protection during deglutition. Thus, vocal fold paralysis can cause dysphagia and laryngeal aspiration, even leading to aspiration pneumonia or respiratory failure.[2,3] Vocal fold immobility has been associated with a 15% higher incidence of aspiration when compared

with a population already being evaluated for dysphagia.[4] A study on videofluoroscopic swallowing study (VFSS) showed that of patients with unilateral vocal fold paralysis, 31.3% showed penetration, and 23.4% showed aspiration.[5] Currently, a flexible fiberoptic laryngoscope is used as a gold standard to evaluate vocal fold movement, supplemented by other methods, such as laryngeal electromyography and laryngeal ultrasound. Treatments of vocal fold paralysis include voice therapy and surgical methods, such as open laryngeal framework surgery and injection laryngoplasty.[1,6]

VFSS is a diagnostic tool routinely used to evaluate dysphagia, as it can objectively evaluate the oral, pharyngeal, and esophageal phase of swallowing.[7] Although the details of VFSS may vary among institutions, patients are usually positioned lateral to the fluoroscope. They are instructed to eat and drink foods of different viscosity, during which their swallowing in oral, pharyngeal, and esophageal phases are determined by an evaluator. Parameters measured include bolus formation, bolus transit time, Penetration-Aspiration Scale, and residue. The anterior–posterior (AP) view is occasionally used to assess the laterality of bolus flow and pharyngeal residue, and can also provide information about the dimensions and location of diverticulum.[8]

VFSS findings in patients with vocal fold paralysis include improper lip closure and bolus formation, delayed triggering of pharyngeal swallow, and prolonged pharyngeal transit time.[9,10] Previous case series described patients with an AP view on VFSS with findings indicative of vocal fold paralysis.[11] The present study therefore evaluated the ability of VFSS in assessing vocal fold movements and identifying vocal fold paralysis in a larger number of patients.

2 | MATERIALS AND METHODS

2.1 | Participants

This retrospective study evaluated patients who underwent VFSS at a Tertiary hospital in Seoul, Korea, from June 2020 to April 2022. The study protocol was approved by the Institutional Review Board of the hospital (No. 2022-0959) and received an exemption for consent as a retrospective chart review. Patients were included if they had undergone laryngoscopy within 2 weeks before or after VFSS, and if they had performed a vocal fold testing maneuver during VFSS. Patients with vocal fold paresis were excluded from the study. Baseline demographic and clinical characteristics of the included patients; the presence and laterality of vocal fold paralysis (left, right, or both), as determined by laryngoscopy; and the etiology of vocal fold paralysis were recorded.

2.2 | Videofluoroscopic study

VFSS was performed by three physicians and one radiology technician using the EasyDiagnost Eleva (Philips, Amsterdam, Netherlands). The study settings were FOV (Field of View) 12 in, SID 150, and frame rate 15 fps. The routine VFSS evaluation protocol consisted of the administration of barium mixed with foods and drinks of different viscosity to patients seated on a chair or lying in a supine position on a bed. Following evaluation on a lateral view, patients were moved to an AP view to test vocal fold mobility by performing VFSS during a vocal fold testing maneuver, which consisted of making an 'e' sound for about 2–3 s, three or more times (Figure 1). All examinations were recorded and saved in the database of the tertiary hospital. These videos of patients performing the vocal fold testing maneuver were evaluated by a reviewer, who assessed the presence and laterality (left, right, or bilateral) of vocal fold paralysis. They assessed each patient's vocal fold appearance in resting state and symmetry of vocal fold movement during phonation. Intra-rater reliability was determined by evaluation of the videos by the same reviewer 2 weeks later, and inter-rater reliability was determined by evaluation by a second reviewer. The reviewers were physicians with more than 1 year of experience in VFSS interpretation. These reviewers had also undergone training sessions on vocal fold anatomy, movement, and findings in VFSS AP view. All reviewers were blinded, and the sequence of videos was randomized during each session.

2.3 | Statistical analysis

All statistical analyses were performed using SPSS ver 21.0. The results determined by the reviewers were compared with the actual patient diagnosis, as confirmed by laryngoscopy. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the videofluoroscopic evaluations were calculated relative to the actual diagnoses. Cohen's kappa method was used to calculate inter-rater and intra-rater reliability.

3 | RESULTS

A total of 70 patients were included in this study (Table 1), 37 (52.9%) without and 33 (47.1%) with vocal fold paralysis; of the 33 patients with vocal fold palsy, 3 (9.1%) had right-sided, 28 (84.8%) had left-sided, and 2 (6.1%) had bilateral vocal fold paralysis. None of these patients underwent injection laryngoplasty before evaluation. Etiologic evaluation showed that 18 patients (54.5%) had operation/intubation-related vocal fold paralysis, 14 (42.4%) had cancer/radiation-related vocal fold paralysis, and 1 (3.0%) had idiopathic vocal fold paralysis without any recognizable cause. The reviewer was able to diagnose in 66 (94.3%) of the 70 patients correctly, with a specificity of 91.89% and a sensitivity of 96.97%, a PPV of 91.43%, and an NPV of 97.14%. Cohen's kappa values for intra- and inter-rater agreements were 0.746 and 0.824, respectively (Table 2). Table 3 shows concordance rates depending on different types of vocal fold paralysis. Addition of the three evaluation trials showed that, the concordance rates in normal in individuals and in patients with right-sided, left-sided, and bilateral vocal fold paralysis were 93.7% (104/111), 88.9% (8/9), 95.2% (80/84) and 66.7% (4/6), respectively. No adverse events were reported during the study.

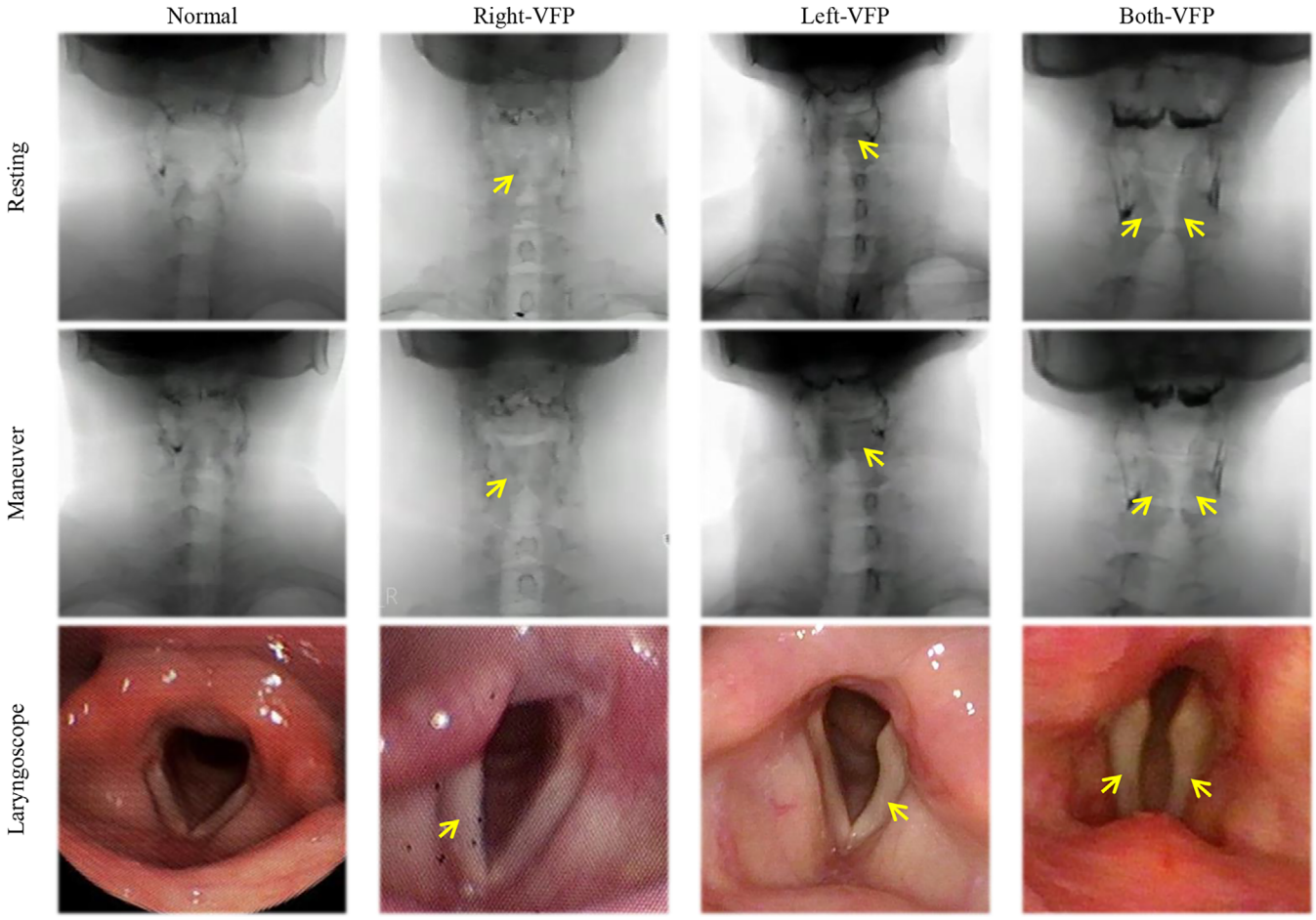

FIGURE 1 Videofluoroscopic swallowing study findings in the resting state and during vocal fold testing maneuver, and laryngoscope findings of patients. The vocal fold testing maneuver was to make an 'e' sound for 2–3 s, three or more times. Patients with vocal fold paralysis showed asymmetry in the resting state and decreased or no movement during the maneuver. Vocal fold movement was decreased or absent in laryngoscope evaluation (yellow arrows).

TABLE 1 Baseline characteristics of the study subjects.

Characteristics	Normal	Right-VFP	Left-VFP	Bilateral-VFP	Total
Number of patients (%)	37(52.9%)	3(4.3%)	28(40%)	2(2.9%)	70
Age (years)[a]	62.6 ± 16.5	61.0 ± 11.8	64.1 ± 13.4	60.5 ± 13.4	
Sex (%)					
Male	27/37 (73.0%)	2/3 (66.7%)	19/28 (67.9%)	1/2 (50%)	49/70 (70%)
Female	10/37 (27.0%)	1/3 (33.3%)	9/28 (32.1%)	1/2 (50%)	21/70 (30%)
Etiology					
Operation/intubation	-	2	14	2	18
Tumor/radiation	-	1	13	0	14
Idiopathic	-	0	1	0	1

[a]Values are presented as mean ± SD.

TABLE 2 Assessment accuracy and reliability.

Concordance	Specificity	Sensitivity	Positive predictive value	Negative predictive value	Intra-rater reliability[a]	Inter-rater reliability[a]
66/70	91.89%	96.97%	91.43%	97.14%	0.746	0.824

[a]Values are presented as Cohen's kappa value.

TABLE 3 Concordance by type.

Tester	Normal	Right-VFP	Left-VFP	Bilateral-VFP
Reviewer 1	34/37	3/3	28/28	1/2
Reviewer 2	36/37	3/3	26/28	1/2
Reviewer 1–2	34/37	2/3	26/28	2/2
Total	104/111	8/9	80/84	4/6

4 | DISCUSSION

The results of this study indicate that use of the vocal fold maneuver in the AP view was accurate and reliable in assessing vocal fold movement. Vocal fold paralysis patients showed asymmetry in resting state and decreased movements during vocal fold maneuver, as shown in the video (Videos S1 and S2). Evaluation was correct in 94.3% (66/70) of the study subjects, with high specificity, sensitivity, PPV, and NPV. Cohen's kappa values for intra-rater and inter-rater reliability were 0.746 and 0.824, respectively, indicating substantial to almost perfect agreement.[12] Although the numbers of patients varied greatly in sidedness of vocal fold paralysis, concordance analyses showed that the reviewers were generally able to diagnose these patients correctly.

Several factors may have hindered the reviewers from correctly assessing vocal fold movements. For example, the quality of the videos may have been insufficient. Although the reviewers completed training sessions, greater experience could have resulted in better outcomes. Both reviewers mentioned that foreign bodies, such as nasogastric tubes or metals from cervical fixation surgery, obstructed the visualization of vocal folds, limiting appropriate evaluations.

Vocal fold paralysis is indicative of vocal fold hypomobility resulting from neurologic injury, such as weakness of the recurrent laryngeal nerve and/or the superior laryngeal nerve.[1] Vocal fold paralysis can be caused by a variety of etiologies, such as neoplasm including lung cancer, surgical trauma, intubation injury, and radiation-induced cranial nerve paralysis. Surgery, neoplasm, and idiopathic paralysis have been reported to be the three main causes of vocal fold paralysis, with left-sided paralysis being more common than right-sided paralysis.[13] Similar findings were observed in the present study.

Laryngoscopy is considered the standard method of diagnosing vocal fold paralysis. Movements of the vocal fold can be assessed using a laryngoscope with a camera to approach the vocal fold and directly observe its movements. Findings such as decreased vocal fold adduction, decreased vocal fold abduction and adduction movements, and slow/sluggish vocal fold motion are indicative of vocal fold paralysis.[14] Other signs such as decreased vocal fold tone or asymmetric mucosal wave phase were also related, and using such laryngoscopic signs for diagnosing vocal fold disability showed high positive predictive value. Other methods, such as laryngeal ultrasound and laryngeal EMG, may be used supplementarily to aid in the diagnosis of vocal fold paralysis and in predicting patient prognosis.[15,16] Transcutaneous laryngeal ultrasound showed high sensitivity and high NPV in visualizing the vocal fold, implying its value as screening tool. This method, however, had limitations in old, male patients, as thyroid cartilage calcification results in lower image quality leading to difficulties assessing vocal folds.[17]

As mentioned above, VFSS is a tool frequently utilized to assess patient's ability to swallow and ability to protect airway during swallowing. As vocal fold paralysis is associated with aspiration and penetration during swallowing, it would be optimal if all patients can go through proper evaluation of vocal fold function. However, not all dysphagia patients, even those with symptoms of vocal fold paralysis such has hoarseness, go through laryngoscopy evaluations in current practice. Our method of adding additional maneuver during VFSS can rapidly evaluate vocal fold movement and act as a screening tool for vocal fold palsy, leading to faster referral for laryngoscopy evaluation and eventually leading to faster initiation of treatment such as vocal therapy or injection laryngoplasty, improving patient prognosis.[6] The method is non-invasive and can indirectly visualize vocal fold movements, even in patients with structural problems that might impede direct visualization of the vocal fold. Radiation exposure during VFSS has been an issue in terms of safety, but many studies showed that VFSS can be performed in minimal radiation exposure. Estimated radiation exposure in terms of entrance skin dose was 7.8 mGy in 5 min and average dose of 12.79 mGy per each VFSS evaluation.[18] As the time to perform this test is less than 1 min, patients can get their evaluation with only slight additional radiation exposure.

The present study had several limitations. First, the numbers of patients tested, and reviewers were relatively small, 70 and 2, respectively. Further studies on greater numbers of patients and reviewers may be necessary to assess the validity of this method. Second, this study only included patients with vocal fold paralysis confirmed by laryngoscopy, suggesting the need for further studies of patients with vocal fold paresis, and the effect of injection laryngoplasty in VFSS has not been determined to date. In addition, the VF maneuver utilized in the present study, making an 'e' sound for 2–3 s, adducts the vocal fold, enabling determination of vocal fold movements. However, other maneuvers may better show the movements of vocal folds. For example, a study on various maneuvers during transcutaneous laryngeal ultrasonography to assess vocal folds found that the valsalva maneuver was preferred.[19] Further studies on different maneuvers during VFSS may identify the optimal maneuver to identify vocal fold paralysis.

5 | CONCLUSION

The present study demonstrated that using a special maneuver in AP view of VFSS has strong value in assessing vocal fold movements. Asymmetry of the vocal fold in the resting state and abnormal movements of the vocal fold during phonation in VFSS imply the occurrence of vocal fold paralysis. This method can be used supplementarily or as a screening tool in assessing vocal fold paralysis, but additional studies may be necessary to increase the reliability of this method.

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CONFLICT OF INTEREST STATEMENT

No conflicts of interest have been reported by the authors of this article.

DATA AVAILABILITY STATEMENT

Raw data were generated at Asan Medical Center. Derived data supporting the findings of this study are available from the corresponding author on request.

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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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