Article

Discovery Medicine 2024; 36(180): 91–99
https://doi.org/10.24976/Discov.Med.202436180.8

Modified Gugging Swallowing Screen: A New Bedside Evaluation Tool for Swallowing Function in Patients with Open Partial Laryngectomy before Oral Feeding: A Single-Centre Retrospective Study

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Published: 20 January 2024

Background: Dysphagia is a prevalent complication following partial laryngectomy. We aimed to introduce a novel bedside evaluation tool, the modified Gugging Swallowing Screen (GUSS), and evaluate its reliability and validity in patients with open partial laryngectomy before oral feeding.

Methods: We conducted a retrospective analysis of 120 patients with laryngeal cancer, including 40 hospitalized patients who underwent open partial laryngectomy. On the same day before oral feeding, we performed the modified GUSS, videofluoroscopic swallowing study (VFSS), and fiberoptic endoscopic evaluation of swallowing (FEES) to evaluate swallowing function. Two independent trained nurses assessed all patients for interrater reliability of modified GUSS. We compared the results of the modified GUSS with VFSS for predictive validity, and VFSS results for solid, semisolid, and liquid intake for content validity.

Results: The results of VFSS and FEES showed a strong correlation and consistency ($r_s = 0.952$, $p < 0.01$; $\kappa = 0.800$ to 1.000, $p < 0.01$). The modified GUSS exhibited substantial to excellent interrater reliability across all classification categories ($r_s = 0.961$, $p < 0.01$; $\kappa = 0.600$ to 1.000, $p < 0.01$) and demonstrated excellent consistency and predictive validity compared to VFSS ($r_s = -0.931$, $p < 0.01$; $\kappa = 0.800$ to 1.000, $p < 0.01$). Content validity revealed that the risk of aspiration during solid intake was lower than that during semisolid intake ($p < 0.01$), and the risk of aspiration during semisolid intake was lower than that during liquid intake ($p < 0.01$), therefore confirming the subtest sequence of the modified GUSS.

Conclusions: We successfully modified GUSS for patients with open partial laryngectomy. Moreover, the new bedside screening tool was validated as an effective tool for evaluating swallowing function and the risk of aspiration in patients with open partial laryngectomy before oral feeding.

Keywords: bedside assessment scales; swallowing function; dysphagia; aspiration; open partial laryngectomy

Introduction

Laryngeal carcinoma ranks among the most prevalent malignant tumors in the head and neck region [1]. Currently, surgery remains the cornerstone and most effective treatment approach. Partial laryngectomy aims to achieve a comprehensive excision of the neoplasm, reconstruct the anatomical crossing of the respiratory and digestive tracts, and restore laryngeal functionality [2].

Dysphagia is a common complication following partial laryngectomy. The persistence of severe dysphagia can lead to recurring episodes of aspiration pneumonia, malnutrition, and cachexia [3,4]. In dire circumstances, interventions like gastrostomies or total laryngectomies may become necessary. Thus, assessing the swallowing function of patients who have undergone partial laryngectomy at an early stage is paramount, especially before they commence oral feeding [5]. The evaluation of swallowing function prior to oral feeding has been an established standard of care for years, with common assessment tools including the Watian drinking water and Fujishima Ichiro swallowing evaluation standard. However, most of the tools primarily focus on the assessment of liquid swallowing, which fails to provide a comprehensive picture of the ability of the patient to handle other textures [6]. Consequently, many of these tools are ill-suited for evaluating the swallowing function of patients post-partial laryngectomy.

The primary diagnostic tool recognized as the gold standard for dysphagia identification is the videofluoroscopic swallowing study (VFSS) [7]. Additionally, the fiberoptic endoscopic evaluation of swallowing (FEES) compares favorably with VFSS results [8]. However, the

Table 1. Use of functional investigations including videofluoroscopic swallowing study (VFSS), fiberoptic endoscopic evaluation of swallowing (FEES).

Name: _____ Date: _____ Time: _____			
Modified Gugging Swallowing Screen (GUSS)			
1. Indirect Swallowing Test			
	YES	NO	
Vigilance (The patient must be alert for at least 15 minutes)	1☐	0☐	
Cough and/or throat clearing (Voluntary cough, patient should cough or clear their throat twice)	1☐	0☐	
Saliva Swallowing:			
Swallowing successful	1☐	0☐	
Drooling	1☐	0☐	
Voice change	1☐	0☐	
SUM: (5)			
• 1–4 = Investigate further; 5 = Continue with part 2			
2. Direct Swallowing Test (Material: water, food thickener-Resource Espesante® (Nestle, Munich, Germany), bread)			
In the following order: 1→ 2→ 3→			
	SOLID#	SEMISOLID&	LIQUID*
DEGLUTITION:			
Swallowing not possible	0☐	0☐	0☐
Swallowing delayed (>2 sec) (Solid textures >10 sec)	1☐	1☐	1☐
Swallowing successful	2☐	2☐	2☐
COUGH (involuntary): (before, during, or after swallowing—until 3 minutes later)			
YES	0☐	0☐	0☐
NO	1☐	1☐	1☐
DROOLING:			
YES	0☐	0☐	0☐
NO	1☐	1☐	1☐
VOICE CHANGE: (listen to the voice before and after swallowing—patient should speak ”O”)			
YES	0☐	0☐	0☐
NO	1☐	1☐	1☐
SUM: (5)	(5)	(5)	(5)
• 1–4 = Investigate further; 5 = Continue Semisolid | 1–4 = Investigate further; 5 = Continue Liquid | 1–4 = Investigate further; 5 = Normal			
SUM: (Indirect Swallowing Test AND Direct Swallowing Test) _____(20)			

#: Clinical: Dry bread about 1 cm × 1 cm × 0.5 cm. &: prepared by mixing water and Resource Espesante® (Nestle, Munich, Germany) according to International Dysphagia Diet Standardisation Initiative (IDDSI) level 4 (pureed/extremely thick). *: 3, 5, 10, 20 mL water—if there are no symptoms, continue with 50 mL water. Assess and stop the investigation when one of the criteria is observed.

two methods have their respective limitations, such as radiation exposure and logistical inconveniences [9]. Michaela Trapl introduced a simple and convenient bedside assessment tool for swallowing function known as the Gugging Swallowing Screen (GUSS) in stroke patients [6]. It has proven to be a swift and reliable means of identifying stroke patients at risk of dysphagia and aspiration. This tool facilitates a graded assessment of the patient's swallowing abilities, measures the severity of dysphagia, and enables dietary recommendations. The high reliability and validity of the Chinese version of this scale for stroke patients have also been demonstrated in China [10]. To the best of our knowledge, GUSS has not been used to assess swallowing function after partial laryngectomy. We designed this study based on the clinical practicability of the GUSS, its high reliability and validity in stroke patients, and its inclusion of solid and semisolid foods.

Furthermore, we have adapted and modified the GUSS to better suit the needs of patients with open partial laryngectomy. We analyzed the reliability and validity of this modified GUSS to demonstrate whether it effectively evaluates the swallowing function of patients in the early postoperative stage after open partial laryngectomy.

Materials and Methods

Study Materials

Between September 2018 and February 2020, a total of 120 patients underwent surgical procedures for laryngeal carcinoma, including open and transoral laser microsurgery, at the Otorhinolaryngology, Head and Neck Surgery Department of Ningbo Medical Center Lihuili Hospital. This research project received approval from the Ethics Committee of Ningbo Medical Center Lihuili Hos-

Table 2. Modified penetration-aspiration scale (MPAS).

Score	Criteria	Dysphagia	Aspiration
1	Material does not enter the airway.	No	Minimal risk
2	Material enters the airway, contacts the neoglottis, stimulates cough reflex, and is ejected completely.	Mild	Low risk
3	Material enters the airway, contacts the neoglottis, stimulates cough reflex, and is not completely ejected.	Moderate	Moderate risk
4	Material enters the airway, passes below the neoglottis, stimulates cough reflex, and is ejected completely.		
5	Material enters the airway, passes below the neoglottis, stimulates cough reflex, and is not completely ejected.	Severe	High risk
6	Material enters the airway, passes below the neoglottis, and no effort is made to reject.		

pital (SC-05/20170824/1.0), and informed consent was obtained from all patients following the principles outlined in the Declaration of Helsinki.

Preoperative assessments included the following: direct laryngoscopy and biopsy to assess vocal fold mobility and assist in tumor staging and classification, enhanced computed tomographic scans (CT) to determine tumor and lymph node invasion, spirometry (FEV1) to measure pulmonary function, and lung CT scans. Swallowing function assessments were conducted using videofluoroscopic swallowing studies (VFSS).

Inclusion criteria for study participation study were as follows: (1) diagnosis of laryngeal carcinoma, classified according to the 8th Edition of the Union for International Cancer Control-American Joint Committee on Cancer (UICC-AJCC) Tumor-Node-Metastasis (TNM) staging system [11]; (2) patients who had undergone open partial laryngectomy; (3) normal preoperative swallowing function; (4) good pulmonary function (FEV1 $\geq$80%); (5) willingness to participate in the study and provision of signed informed consent. Exclusion criteria were: (1) patients who had undergone nearly total laryngectomy or transoral laser microsurgery; (2) those with significant intraoperative or postoperative complications.

Study Methods

Post-surgery, patients maintained a status of nasal feeding and tracheotomy. During this period, no swallowing rehabilitation procedures were introduced. On the day preceding the initiation of oral feeding, assessments were conducted using the modified GUSS, VFSS, and FEES, all of which evaluated swallowing function. In addition, the individuals conducting these examinations were different from one another and were unaware of the scores from the other assessments.

Modified GUSS

GUSS [6] consists of indirect and direct swallowing tests, including sequential semisolid, liquid, and solid swallowing trials. These 4 subtests must be performed in order. Higher scores indicate better performance, with each subtest carrying a maximum score of 5 points. Successful completion of two repetitions within each subtest is required to achieve the full score, allowing the patient to progress to the next subtest. If the result of a subtest falls below 5 points, the examination is stopped, and either VFSS or FEES is recommended.

Based on our clinical observations, postoperative laryngeal aspirations were most frequently associated with liquid intake, followed by semisolid and solid intake. To make the evaluation suitable for patients with partial laryngectomy, we adjusted the sequence of the direct swallowing test to solid, semisolid, and liquid swallowing while keeping other evaluation measures consistent. Patients at the bedside were asked to swallow a 1 cm $\times$ 1 cm $\times$ 0.5 cm piece of dry bread (solid), followed by semisolid prepared by mixing water and Resource Espesante® (Nestle, Munich, Germany) according to the International Dysphagia Diet Standardisation Initiative (IDDSI) level 4 (pureed/extremely thick) [12], and finally liquid. All procedures were executed at the bedside, and the data were independently evaluated by two trained nurses in our Department of Otolaryngology, Head and Neck Surgery (Table 1).

Videofluoroscopic Swallowing Study (VFSS)

We conducted VFSS properly (D2RS, STEPHANIX, La Ricamarie, France), using Iohexol Injection® (50 mL: 17.5 g, Yangtze River Pharmaceutical Co., Taizhou, China) instead of barium. The patient was positioned upright and underwent a sequence of swallowing tests, including solid (dry bread) about 1 cm $\times$ 1 cm $\times$ 0.5 cm, semisolid (a mixture of Iohexol Injection and Resource Espesante® from Nestle, Germany) prepared according to IDDSI level 4, and liquid (Iohexol Injection). Two trained Ear, Nose and Throat (ENT) specialists and one experienced radiologist executed these tests in all cases. Data were evaluated using a modified penetration aspiration scale (MPAS) (Table 2) for partial laryngectomy. This scale, which we have used and described in previous publications [2,3,13,14], assigns higher scores to indicate worse performance. In addition, solid and semisolid trials were also performed in all cases. However, once the score for solid or semisolid trials was more than or equal to 5, the liquid trial was halted.

Fiberoptic Endoscopic Evaluation of Swallowing (FEES)

The patient sat upright, and the nasal cavity was topically anesthetized. A fiber laryngoscope (Nasopharyngoscope EV-N 4mm: 320 mm, XION, Berlin, Germany)

Table 3. Patients characteristics.

Variable	Patients, n (%)
Gender	
Male	40 (100.0%)
Female	0
Age	
Average	62.9 yrs
Median	63.0 yrs
Range	46–82 yrs
T stage	
T1a	12 (30.0%)
T1b	12 (30.0%)
T2	13 (32.5%)
T3	3 (7.5%)
N stage	
N0	34 (85.0%)
N1	4 (10.0%)
N2	2 (5.0%)
Surgery	
LFC	8 (20.0%)
VPL	11 (27.5%)
SAHPL	7 (17.5%)
SCPL-CHEP	14 (35.0%)~
Neck Dissection	
No	27 (67.5%)
Left	3 (7.5%)
Right	5 (12.5%)
Bilateral	5 (12.5%)

LFC, laryngofissure cordectomy; VPL, vertical partial laryngectomy; SAHPL, supraglottic horizontal partial laryngectomy; SCPL-CHEP, supracricoid partial laryngectomy-cricohyoidoepiglottopexy. ~ 2 patients were reserved for just one cricoarytenoid joint.

was inserted through the nasal cavity to the oropharynx. Anatomic conformation of the residual laryngeal tissue, such as mucosal edema, epiglottic activity, arytenoid cartilage movement, vocal fold mobility, and arytenoid cartilage hypertrophy, were observed. The patient then swallowed a colored solid (dry bread) about 1 cm × 1 cm × 0.5 cm, colored semisolid prepared by mixing water and Resource Espesante® from Nestle, Germany, according to IDDSI level 4, and colored liquid in sequence. After the patient swallowed, the examiner inserted the fiber laryngoscope into the hypopharynx and larynx, including under the neoglottis, to check whether the food penetrated the larynx or across the neoglottis. The examiner also assessed whether the food induced a cough reflex and estimated how much food was coughed out. The procedures of all cases were performed by two trained ENT specialists and one experienced fiber laryngoscope examiner. Data from FEES were evaluated using MPAS [2,3], with higher scores indicating worse performance. Solid and semisolid trials were both assessed in all cases. However, once the score of the solid or semisolid trials reached 5 or more, the liquid trial was halted.

Statistical Considerations

Dysphagia was classified into four degrees based on the penetration aspiration scale (PAS): no dysphagia (PAS score = 1 to 2), mild dysphagia (PAS score = 3 to 4), moderate dysphagia (PAS score = 5 to 6), and severe dysphagia (PAS score =7 to 8). These corresponded to minimal, low, moderate, and high risks of aspiration [14]. We compared the hierarchical entries of MPAS (Table 1) and PAS. MPAS was similarly classified into four degrees: no dysphagia (MPAS score = 1) with a minimal risk of aspiration, mild dysphagia (MPAS score = 2) with a low risk of aspiration, moderate dysphagia (MPAS score = 3 to 4) with a moderate risk of aspiration, and severe dysphagia (MPAS score = 5 to 6) with a high risk of aspiration. The highest score in solid, semisolid, or liquid swallowing trials was taken as the final score. The correlation and consistency of VFSS and FEES were tested using Spearman's rank correlation coefficient and Kappa statistics, respectively, to determine the credibility of VFSS results. The proportion of overall agreement (P0) was a raw agreement index. A r_s or κ coefficient between 0.4 and 0.8 was considered significant, while values >0.8 were considered excellent.

Dysphagia severity of the modified GUSS was also graded into four degrees, same as GUSS. Scores ranging from 0 to 9 points were rated as severe dysphagia with a high risk of aspiration, 10 to 14 points as moderate dysphagia with a moderate risk of aspiration, 15 to 19 points as mild dysphagia with a low risk of aspiration, and 20 points as no dysphagia [6]. The reliability for modified GUSS was calculated using Spearman's rank correlation coefficient and Kappa statistics and the proportion of overall agreement (P0) as a raw agreement index. Sensitivity, specificity, positive, and negative predictive values were determined by comparing the results of modified GUSS with the results of VFSS. Spearman's rank correlation coefficient was also used to predict the correlation between the results of modified GUSS and the number of days from oral feeding to gastric tube extubation. The test validity of the values of r_s or κ coefficient was the same as described earlier. Wilcoxon signed-rank tests were used to distinguish the risks of aspiration caused by solid, semisolid, and liquid intake. Statistical analyses were performed using SPSS 17.0 (IBM Corp., Armonk, NY, USA), and descriptive analyses were performed based on the characteristics of the data.

Results

Patient Characteristics

A total of 40 patients who met the inclusion criteria participated in the study and completed the swallowing evaluation. All of these patients were male and ranged in age from 46 to 82 years, with an average age of 62.9 and a median age of 63.0. Based on the 8th Edition UICC-AJCC TNM staging system, 33 (82.5%) patients had glottic type tumors, while 7 (17.5%) patients had supraglottic type tu-

Table 4. Cross-classification of scores for VFSS and FEES.

			FEES, highest score of MPAS				
			Risk of aspiration	High risk	Moderate risk	Low risk	Minimal risk
			Severity rating	Severe dysphagia	Moderate dysphagia	Mild dysphagia	No dysphagia
	Risk of aspiration	Severity rating	Scores	5–6	3–4	2	1
VFSS, highest score of MPAS (n = 40)	High risk	Severe dysphagia	5–6	19	0	0	0
	Moderate risk	Moderate dysphagia	3–4	0	1	0	0
	Low risk	Mild dysphagia	2	0	2	9	2
	Minimal risk	No dysphagia	1	0	0	0	7

Table 5. Cross-classification of modified GUSS scores by two raters.

			Modified GUSS scores of the second rater				
			Risk of aspiration	High risk	Moderate risk	Low risk	Minimal risk
			Severity rating	Severe dysphagia	Moderate dysphagia	Mild dysphagia	No dysphagia
	Risk of aspiration	Severity rating	Scores	5–6	3–4	2	1
Modified GUSS scores of the first rater (n = 40)	High risk	Severe dysphagia	5–6	16	0	0	0
	Moderate risk	Moderate dysphagia	3–4	0	2	1	0
	Low risk	Mild dysphagia	2	0	0	14	0
	Minimal risk	No dysphagia	1	0	0	3	4

Table 6. Cross-classification of scores for modified GUSS and VFSS.

			VFSS, highest score of MPAS				
			Risk of aspiration	High risk	Moderate risk	Low risk	Minimal risk
			Severity rating	Severe dysphagia	Moderate dysphagia	Mild dysphagia	No dysphagia
	Risk of aspiration	Severity rating	Scores	5–6	3–4	2	1
Modified GUSS scores (n = 40)	High risk	Severe dysphagia	0–9	16	0	0	0
	Moderate risk	Moderate dysphagia	10–14	2	0	0	0
	Low risk	Mild dysphagia	15–19	1	1	13	0
	Minimal risk	No dysphagia	20	0	0	0	7

Table 7. Sensitivity, Specificity, and Predictive Values of modified GUSS.

		Sensitivity	Specificity	PPV	NPV	Prevalence
Predictive values of modified GUSS	Severe dysphagia	84.2%	100.0%	100.0%	87.5%	47.5%
	Risk of aspiration~	90.0%	100.0%	100.0%	90.9%	50.0%
	Dysphagia$	100.0%	100.0%	100.0%	100.0%	82.5%

PPV, positive predictive value; NPV, negative predictive value. Sensitivity, specificity, and predictive values of modified GUSS were compared with "gold standard" VFSS results. ~ including moderate and severe dysphagia. $ including mild, moderate, and severe dysphagia.

mors. The distribution among the T stage was as follows: 12 (30.0%) patients with T1a, 12 (30.0%) patients with T1b, 13 (32.50%) patients with T2, and 3 (7.50%) patients with T3. Regarding the N stage, 34 (85.0%) patients had N0, 4 (10.0%) had N1, and 2 (5.0%) patients had N2. In terms of surgical procedures, 8 (20.0%) patients underwent laryngofissure cordectomy (LFC), 11 (27.5%) patients underwent vertical partial laryngectomy (VPL), 7 (17.5%) patients underwent supraglottic horizontal partial laryngectomy (SAHPL), and 14 (35.0%) patients underwent supracricoid partial laryngectomy-cricohyoidoepiglottopexy (SCPL-CHEP), with 2 of them having only one cricoarytenoid joint preserved. Additionally, 3 (7.5%) patients underwent left lateral neck dissection, 5 (12.5%) patients underwent right lateral neck dissection, 5 (12.5%) patients underwent bilateral neck dissection, and 27 (67.5%) patients did not require neck dissection during the surgery (Table 3).

Correlation and Consistency of VFSS and FEES

In the VFSS results, 7 (17.5%) patients exhibited no signs of dysphagia, 13 (32.5%) had mild dysphagia, 1 (2.5%) patient presented moderate dysphagia, and 19 (47.5%) patients had severe dysphagia based on the MPAS dysphagia classification. The FEES findings revealed that 9 (22.5%) patients had no dysphagia, 9 (22.5%) displayed mild dysphagia, 3 (7.5%) had moderate dysphagia, and 19 (47.5%) suffered severe dysphagia based on the MPAS dysphagia classification.

The overall MPAS scores from VFSS and FEES demonstrated a strong positive correlation ($r_s = 0.952$, $p < 0.01$), and the overall severity ratings displayed significant consistency ($\kappa = 0.848$, $p < 0.01$, P0 = 0.900). VFSS and FEES raters confirmed that 19 patients experienced severe dysphagia in the sample ($\kappa = 1.000$, $p < 0.01$, P0 = 1.000). However, the VFSS rater classified 20 patients (50.0%) as having either severe or moderate dysphagia, while the FEES rater classified 22 patients as having either severe or moderate dysphagia (55.0%) ($\kappa = 0.900$, $p < 0.01$, P0 = 0.950). Additionally, the VFSS rater identified 7 patients (17.5%) with no dysphagia, while the FEES rater found 9 (22.5%) patients with no dysphagia ($\kappa = 0.844$, $p < 0.01$, P0 = 0.950) (Table 4).

Interrater Reliability

The overall modified GUSS scores from two raters exhibited a strong positive correlation ($r_s = 0.961$, $p < 0.01$), and the overall severity ratings from the two raters revealed significant consistency ($\kappa = 0.849$, $p < 0.01$, P0 = 0.900). Both raters confirmed that 16 (40.0%) patients in the sample were experiencing severe dysphagia ($\kappa = 1.000$, $p < 0.01$, P0 = 1.000). The first rater classified 19 (47.5%) patients as having either severe or moderate dysphagia, while the second rater classified 18 (45.0%) patients as having either severe or moderate dysphagia ($\kappa = 0.950$, $p < 0.01$, P0 = 0.975). Furthermore, the first rater identified 7 (17.5%) patients with no dysphagia, while the second rater found 4 (10.0%) patients with no dysphagia ($\kappa = 0.688$, $p < 0.01$, P0 = 0.925) (Table 5).

Predictive Validity

The overall scores of the modified GUSS and VFSS demonstrated a strong negative correlation ($r_s = –0.931$, $p < 0.01$), and the overall severity ratings from the results of the modified GUSS and VFSS exhibited excellent agreement ($\kappa = 0.848$, $p < 0.01$, P0 = 0.900). Using the modified GUSS, the rater identified 16 patients (40.0%) with severe dysphagia, whereas the VFSS rater found 19 (47.5%) patients with severe dysphagia. Predictive values of severe dysphagia by modified GUSS showed that the sensitivity was 84.2%, specificity 100.0%, positive predictive value 100.0%, and negative predictive value of 87.5% when compared with VFSS ($\kappa = 0.848$, $p < 0.01$, P0 = 0.925). The modified GUSS rater classified 18 (45.0%) patients as having severe or moderate dysphagia, while the VFSS rater classified 20 (50.0%) patients as having severe or moderate dysphagia. Predictive values of severe and moderate dysphagia by modified GUSS indicated 90.0% sensitivity, 100.0% specificity, 100.0% positive predictive value, and 90.9% negative predictive value when compared with VFSS ($\kappa = 0.900$, $p < 0.01$, P0 = 0.950). Both raters confirmed that 7 (17.5%) patients had no dysphagia in the sample. Predictive values of dysphagia by modified GUSS showed 100.0% sensitivity, specificity, positive predictive value, and negative predictive value when compared with VFSS ($\kappa = 1.000$, $p < 0.01$, P0 = 1.00) (Tables 6,7). Additionally, it was observed that the results of modified GUSS were significantly negatively correlated with the number of days from starting oral intake to the removal of the gastric tube ($r_s = –0.664$, $p < 0.01$).

Content Validity

All 40 patients completed the solid and semisolid trials of VFSS. However, due to severe dysphagia (MPAS scores equal to or greater than 5), only 22 patients completed the liquid trial. In the solid trial, we identified 14, 4, 1, and 21 patients corresponding with high to minimal risks of aspiration, while in the semisolid trials, 18, 2, 7, and 13 patients falling into these risk categories. Additionally, in the semisolid trials, we found 2, 7, and 13 corresponding to moderate to minimal risks of aspiration. In contrast, in the liquid trials, 1, 1, 13, and 7 patients had high to minimal aspiration risks. The overall median scores for solid (1; interquartile range, 1 to 5) were lower than those for semisolid (2.5; interquartile range, 1 to 5), indicating a higher risk of aspiration or more severe dysphagia with semisolid foods (n = 40, $p < 0.01$) (Fig. 1). Similarly, the overall median scores for semisolids (1; interquartile range, 1 to 2) were lower than those for liquids (2; interquartile range, 1 to 2), suggesting a higher risk of aspiration or more severe dysphagia with liquid intake (n = 22, $p < 0.01$) (Fig. 2).

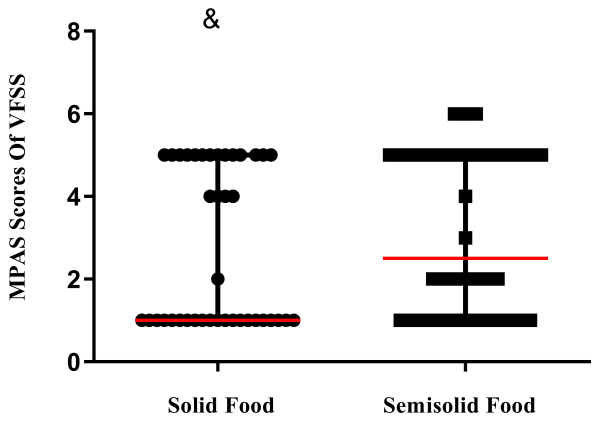

Fig. 1. Scatter plots of overall median MPAS scores of VFSS for solid and semisolid swallowing tests in 40 patients. Red lines represent the medians, bars indicate interquartile ranges, and "&" indicates $p < 0.01$.

Discussion

The prevalence of laryngeal cancer has been on the rise in China [15], leading to an increasing number of patients undergoing partial laryngectomy [5]. This procedure affects the structure, local nerves, muscles, and coordination of the larynx and pharynx, resulting in dysphagia [16]. Notably, transoral laser microsurgery has minimal impact on swallowing function. Hence, only open partial laryngectomy was included in this study.

The most severe dysphagia typically emerges in the weeks following surgery. While numerous patients can

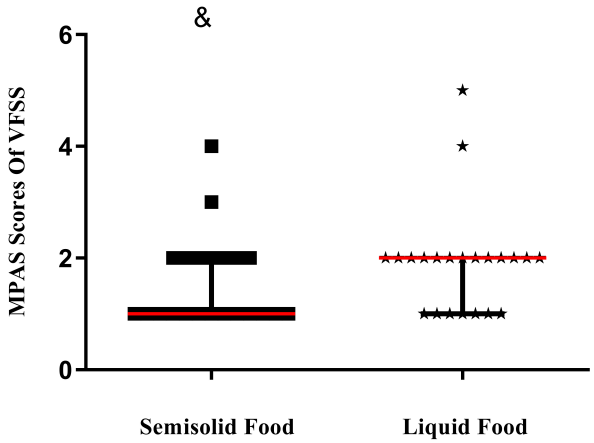

Fig. 2. Scatter plots of overall median MPAS scores of VFSS for semisolid and liquid food swallowing tests in 22 patients. Red lines represent the medians, bars indicate interquartile ranges, and "&" indicates $p < 0.01$.

improve through oral intake training, residual swallowing challenges can significantly affect the long-term quality of life. These challenges include recurrent pneumonia, alterations in eating habits, and even reduced social communication [2]. Therefore, it is imperative to evaluate and rehabilitate the swallowing abilities of the patients after open partial laryngectomy, especially in the early postoperative period.

VFSS is the gold standard for swallowing examinations [4,7,17]. In recent years, FEES has demonstrated excellent consistency with VFSS and has become a standard assessment tool for dysphagia evaluations in numerous studies [2,3]. Traditional VFSS uses barium as a contrast agent despite the associated drawbacks, particularly if barium is aspirated into the trachea and lungs, which can be challenging to remove and may cause damage to lung function. Ioiohexol solution, a non-ionic contrast agent, offers advantages such as high water solubility, low viscosity, low osmotic pressure, and low toxicity [18]. Therefore, this study improved VFSS by using Iohexol Injection instead of barium. In our study, we carried out VFSS and FEES, respectively, and compared their results to determine the reliability of VFSS data. The results showed a strong correlation and consistency between VFSS and FEES, confirming VFSS as the chosen standard for our research. Additionally, FEES was considered a reliable standard for evaluating swallowing function after open partial laryngectomy.

Both VFSS and FEES have their limitations, and the development of new evaluation tools is necessary. Most current swallowing assessment tools require patients to swallow liquids directly [19], neglecting the assessment of solid and semisolid food characteristics [20,21]. GUSS, for example, uses three types of food to complete sequential tests, which may not be suitable for patients with partial

laryngectomy. Observations revealed that the risk of aspiration was lower when swallowing solids was compared to semisolids, and the risk of aspiration when swallowing semisolids was lower than with liquids. Therefore, the sequence of trials was modified to minimize the risk of aspiration during the examinations and to determine the ability of patients to intake solids, semisolids, or liquids independently. The modification was essential as it guided the rehabilitation process.

In our research, modified GUSS was classified into 4 grades based on the severity rating of GUSS, corresponding to 4 grades of aspiration risk. This allowed the simultaneous assessment of dysphagia and aspiration. The study found that the severity rating and grades of aspiration risk assessed by modified GUSS were consistent with VFSS. This indicated that modified GUSS effectively identified patients with varying degrees of dysphagia and the associated risks of aspiration, even recommending foods of different characteristics. Notably, the recommendations differed from the original GUSS due to the modified sequence.

Moreover, we demonstrated substantial to excellent interrater reliability for all classification categories of modified GUSS, and the predictive values were acceptable. The no dysphagia category showed 100.0% sensitivity and 100.0% specificity compared to VFSS. On the other hand, the moderate and severe dysphagia grade had 90.0% sensitivity and 100.0% specificity, while the severe dysphagia grade exhibited 84.2% sensitivity and 100.0% specificity. The 100.0% specificities indicate extremely low misdiagnosis rates, while the high sensitivities indicate very low missed diagnosis rates. However, the results revealed that some patients with severe or moderated dysphagia were rated with a lower severity degree, suggesting that they may find it challenging to swallow semisolid and liquid foods but relatively easier to swallow solids. To address this, regular evaluations using modified GUSS were recommended to identify false negative patients.

Moreover, our study revealed that higher modified GUSS scores were associated with a shorter time between oral feeding and gastric tube removal. While no objective criteria were set for removing the gastric tube and the decision was based on subjective assessment of the patients by the doctors, it was expected that the modified GUSS scores could predict the time for gastric tube removal.

Notably, this study had a relatively small sample size due to the increasing use of transoral laser microsurgery, which has reduced the number of open partial laryngectomies. Our study included patients with specific surgical procedures (LFC, VPL, SCPL-CHEP, and SAHPL), and the findings may not represent all patients with open partial laryngectomy. The exclusion of females was due to the low incidence rates of female laryngeal cancer in the region. The study did not consider swallowing efficiency, which can significantly impact quality of life and nutrition.

Conclusions

Building upon the foundation of GUSS, we have introduced a bedside evaluation tool that demonstrates good reliability and validity in assessing swallowing function and risks of aspiration prior to oral feeding during the early period after open partial laryngectomy. This tool, modified GUSS, holds promise for improving patient care and rehabilitation. However, substantial work needs to be done to improve the tool, which includes the need to expand the study with a more extensive and more diverse patient population, explore and implement effective swallowing rehabilitation strategies, provide specific food recommendations based on individual assessment, conduct long-term evaluations to gauge the effectiveness of the tool.

Availability of Data and Materials

All data were from Ningbo Medical Center Lihuili Hospital and were true and reliable. The data are available on request from the corresponding author [Zhenhua Wu], upon reasonable request.

Author Contributions

Conceptualization, ZHW; methodology, QH, YHG and ZHW; writing—original draft, QH; writing—review & editing, ZHW; formal analysis, QH and QJY; investigation, QJY, YZ, ZZW, KZ and RJX; supervision, YS; validation, YS; visualization, YS; data curation, ZHW; resources, ZHW and QH. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Ningbo Medical Center Lihuili Hospital (SC-05/20170824/1.0) and each participating patient provided written informed consent. This study was performed in line with the principles of the Declaration of Helsinki.

Acknowledgment

Not applicable.

Funding

This work was supported by Ningbo Medical and Health Brand Discipline, Grant/Award Number: PPXK2018-02; Ningbo Natural Science Foundation, Grant/Award Number: 2021J289; Zhejiang Province Medical and Health Research Project, Grant/Award Number: 2019KY190, 2021KY309 and 2022KY295.

Conflict of Interest

The authors declare no conflict of interest.

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