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ORIGINAL ARTICLE

Evaluating Dysphagia in Patients With Cervical Spinal Cord Injury Using the Modified Barium Swallow Impairment Profile

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Abstract

Background/Purpose: **To clarify the characteristics of dysphagia in patients with cervical spinal cord injury (CSCI) by using modified barium swallow impairment profile (MBSImP) scoring in a videofluoroscopic swallowing study (VFSS).**

Methods: **This retrospective study included the data of 10 patients with CSCI (9 men and 1 woman) with dysphagia admitted to the rehabilitation ward of a university medical hospital who had undergone VFSS. The patients' oral, pharyngeal, and esophageal impairments were evaluated using the MBSImP.**

Results: **Comprising the MBSImP overall score, the median oral impairment total score (OT) was 10.5 (interquartile range [IQR]: 9—11), the median pharyngeal impairment total score (PT) was 11.0 (IQR: 8—13), and the median esophageal impairment score (EI) was 2 (IQR: 1—2). Although all three phases were affected, they were of lower clinical severity in this scoring system.**

Conclusion: **All patients had impairments in the oral phase, pharyngeal phase, and esophageal phase. The MBSImP was useful for evaluating swallowing impairment in patients with CSCI.**

Keywords: Dysphagia, Cervical spinal cord injury, MBSImP

1. Introduction

Approximately 30 %—40 % of patients with cervical spinal cord injury (CSCI) develop dysphagia.[1,2] The common symptoms and signs of dysphagia in patients with CSCI include difficulty swallowing, coughing after swallowing, changes in voice after swallowing, pneumonia, and nasal or eye watering during meals.[2,3] Although swallowing function varies over time after CSCI, it improves within 6 months in most patients.[4,5] Nevertheless, the complications of dysphagia, such as pulmonary sequalae and malnutrition, negatively affect the health or quality of life of patients with CSCI.[1,2,6] Early detection of signs and symptoms of dysphagia in patients with CSCI is crucial to preventing these complications.

In patients with CSCI, dysphagia is typically evaluated by bedside swallowing evaluations (BSE) or by performing an instrumental evaluation, such as a videofluoroscopic swallowing study (VFSS). Common abnormal findings in previous

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VFSS investigations in patients with CSCI include delayed swallowing reflex, inadequate elevation of the larynx, inadequate opening of the cricopharyngeal muscle, limited movement of the tongue base, and impaired muscle function of the pharyngeal wall.[3,7,8] However, most studies focus solely on the prevalence of swallowing difficulties or heavily emphasize specific abnormal outcomes (such as pharyngeal dysphagia), lacking a complete description of the various stages of the swallowing process in these patients.[2,3,9] To obtain a more comprehensive understanding of the characteristics of dysphagia in CSCI, we use the modified barium swallow impairment profile (MBSImP) to evaluate and describe the impairment of each swallowing phase observed in the VFSS of patients with CSCI. To our knowledge, this study is currently the first research to provide a comprehensive assessment and description of CSCI dysphagia using MBSImP.

2. Material and method

2.1. Participants

In this retrospective study, we reviewed the VFSS records of patients with CSCI with signs and symptoms of dysphagia who were admitted to the rehabilitation ward of a university medical hospital from January 2020 to December 2022. Dysphagia signs and symptoms include difficulty swallowing, a need for tube feeding, cough, wet voice, increased pulmonary secretions after meals, or a history of pneumonia. The following inclusion criteria were applied: (1) having CSCI and having undergone a VFSS while being admitted to the medical center hospital, (2) having an injury duration of <6 months, and (3) being <85 years of age. We excluded patients with (1) signs or symptoms of dysphagia before the diagnosis of CSCI, (2) brain or brain stem injuries, and (3) craniofacial abnormalities or other diseases that can cause dysphagia, such as head and neck tumors.

2.2. Oral intake ability

The oral intake ability of the patients just before the VFSS was evaluated using the functional oral intake scale (FOIS),[10] which is a 7-point scale ranging from 1 (*nothing by mouth*) to 7 (*total oral diet with no restrictions*); the points correspond to the swallowing function of a patient with dysphagia, with lower levels indicating lower functional oral intake ability.

2.3. VFSS profiles

The VFSS was performed in the lateral and anterior projections, with the patient sitting upright. The patients were instructed to ingest each of 2 mL and 5 mL mixed barium fluid (Baritop-120, barium sulfate 120 W/V% 300 mL/bottle) of different consistencies: thin (international dysphagia diet standardization initiative [IDDSI] level 0), nectar-thick (IDDSI level 1), honey-thick (IDDSI level 4), paste (IDDSI level 5), and 2 × 2 cm cookies coated with honey-thick barium. VFSS video clips of all patients were reviewed by two experienced and qualified MBSImP specialists (a physician and a speech-language pathologist). The MBSImP is a standardized tool used to quantify functional swallowing impairments observed through a VFSS, and it contains 17 components in three main categories: oral impairment (6 components: component 1. Lip closure, 2. Tongue control during bolus hold, 3. Bolus preparation/mastication, 4. Bolus transport/lingual motion, 5. Oral residue, and 6 initiation of pharyngeal swallow), pharyngeal impairment (10 components: component 7. Soft palate elevation, 8. Laryngeal elevation, 9. Anterior hyoid excursion, 10. Epiglottic movement, 11. Laryngeal vestibular closure, 12. Pharyngeal stripping waves, 13. Pharyngeal contraction, 14. Pharyngoesophageal segment opening, 15. Tongue base retraction, and 16. Pharyngeal residue), and esophageal impairment (1 component: component 17. Esophageal clearance upright position).[11,12] Each component is scored using a set of ordinal scales, for example, 0–2 points (component 9, 10, 11, 12), 0–3 points (component 2, 3, 8, 13, 14), and 0–4 points (component 1, 4, 5, 6, 7, 15, 16, 17). The higher the score for each component, the more severe the swallowing impairment. The overall impression (OI) score of the MBSImP was applied for the worst scores (maximum scores) of each component rather than scoring every single consistency of the

bolus tested during the VFSS. The oral impairment total score (OT) and pharyngeal impairment total score (PT) refer to the sum of the OI scores of oral impairment and pharyngeal impairment, respectively. The exception is that a score of 1 for components 1, 5, 15 and 16 are treated as 0 when calculating the total score. Because the MBSImP does not evaluate the severity of penetration or aspiration, these were assessed using the Penetration−Aspiration Scale (PAS).[13] PAS is an 8-point scale that describes the depth of food entering the airway and whether the material entering the airway is expelled from the airway. For example, 1 point indicates that food has not entered the airway, 2−5 points indicate that food has entered the airway but is above the vocal folds, and 6−8 points indicate that food has run below the vocal folds. Higher scores indicate a more severe penetration or aspiration, with the highest point of 8 indicating that food has been flowing below the vocal cords and has not made an effort to expel it.

2.4. Ethical considerations

The stud was approved by the Institutional Review Board of the relevant institution (IRB approval number: CSMUH No. CS1-22201).

2.5. Statistical analysis

Statistical analysis was performed using SAS Enterprise Guide 8.3 (SAS Institute Inc., Cary, NC, USA). Means, standard deviation (SD), medians and interquartile range (IQR) were used only for descriptive analysis because there were too few patients for other statistical analysis.

3. Results

We included the data of 10 patients (9 men and 1 woman) aged 61−75 years. Their demographic characteristics are presented in Table 1. Five patients each had the American Spinal Injury Association (ASIA) impairment scales C and D when undergoing VFSS. All patients had undergone surgery for CSCI. Of them, seven patients had significantly impaired oral intake capacity and required tube feeding (two with a FOIS score of 1, four with a FOIS score of 2, and one with a FOIS score of 3), and three had mildly impaired oral intake ability and did not require tube feeding (two with a FOIS score of 5 and one with a FOIS score of 6). All patients received swallowing training, except for two patients whose FIOS was 5 and 6. Table 2 presents the OT, PT, and scores of esophageal impairment (EI), with

Table 1. Patient demographic characteristics.

Patients	Sex	Age (years)	Injury level	Neurologic Level	ASIA level[a]	Surgical intervention	VFSS days after SCI	FOIS	ST
1	M	74.5	C3−C4	C5	C	ACDF	21	1	Y
2	M	67.7	C1−C3	C1	D	Laminectomy Transpedicle screw	131	2	Y
3	M	65.7	C5−C6	C5	D	Laminectomy Transpedicle screw	60	3	Y
4	M	71.2	C1−C2	C1	D	ACDF Laminectomy Transpedicle screw	68	5	N
5	M	75.9	C6−C7	C7	C	Laminectomy Transpedicle screw	85	2	Y
6	F	73.6	C3−C6	C3	C	ACDF, TM cadge	98	6	N
7	M	61.4	C4−C5	C5	D	ACDF	62	2	Y
8	M	69.7	C6−C7	C6	D	ACDF Laminectomy	65	5	Y
9	M	74.4	C4−C7	C4	C	Laminectomy	165	1	Y
10	M	62.3	C3−C6	C4	C	ACCF Laminectomy TM cadge	92	2	Y

M: male, F: female, ACDF: anterior cervical discectomy and fusion, ACCF: anterior cervical corpectomy with fusion, TM: trabecular metal, FOIS: functional oral intake scale, ST: swallowing training, Y: with swallowing training, N: without swallowing training, [a]: ASIA level when undergoing VFSS.

Table 2. Mean and median of Functional oral intake scale (FOIS), oral impairment total score (OT), pharyngeal impairment total score (PT) and esophageal impairment score (EI) of MBSImP.

	Mean, SD (median, IQR)
OT (0–22)	9.5, 2.6 (10.5, 9–11)
PT (0–29)	11.2, 3.8 (11.0, 8–13)
EI (0–4)	1.5, 0.8 (2, 1–2)
FOIS	2.9, 1.8 (2, 2–5)

SD: standard deviation; IQR: interquartile range.

the median scores for OT 10.5 (interquartile range [IQR]: 9–11), PT 11.0 (IQR: 8–13), and EI 2 (IQR: 1–2), respectively.

3.1. Oral impairment (Table 3)

Only 10 % of the patients exhibited impaired lip closure (only included patient with a score of 2, as the score of 1 of Component 1 is treated as 0 during the calculation). Eighty percent of the patients had bolus hold impairment (20 % with scores of 1: contrast spread in the mouth floor or oral cavity, and 60 % with a score of 2: less than half of contrasts passing through the tongue-palate seal before the tongue propulsion starts, for Component 2). Sixty percent of the patients had been scored as the most severely impaired bolus preparation/mastication (score of 3 for Component 3) due the safety concerns and cookies were not tested (as the MBSImP scoring guide, if the cookie is not tested due to safety concerns related to oral preparation or oral clearance, the patient should be scored 3). Seventy percent of the patients had impaired bolus transport/lingual motion (30 % with scores of 2: slow tongue motion, and 40 % with scores of 3: repetitive tongue motion, for Component 4). Sixty percent of the patients had only some residues remaining in the oral cavity (score of 2 for Component 5), 10 % of the patients (Patient 6) had most of the bolus remaining in the oral cavity after swallowing (score 3 for Component 5). Most of the patients (80 %) had significantly impaired initiation of pharyngeal swallowing, indicating that anterior hyoid movement occurred when the bolus was located in the pyriform sinus (score of 3 for Component 6).

3.2. Pharyngeal impairment (Table 4)

Only 10 % of the patient (Patient 1) had contrast material escape to the nasopharynx (score of 2 for Component 7), the others showed normal nasopharynx closure. All patients had various degrees of impaired

Table 3. Oral impairment summary.

Components (score range)	Score 0 % (n)	Score 1 % (n)	Score 2 % (n)	Score 3 % (n)	Score 4 % (n)
1. Lip closure (0–4)	50 % (5)	40 % (4)	10 % (1)	0 % (0)	0 % (0)
2. Tongue control during bolus hold (0–3)	20 % (2)	20 % (2)	60 % (6)	0 % (0)	–
3. Bolus preparation/mastication (0–3)	10 % (1)	30 % (3)	0 % (0)	60 % (6)	–
4. Bolus transport/lingual motion (0–4)	30 % (3)	0 % (0)	30 % (3)	40 % (4)	0 % (0)
5. Oral residue (0–4)	0 % (0)	30 % (3)	60 % (6)	10 % (1)	0 % (0)
6. Initiation of pharyngeal swallow (0–4)	10 % (1)	0 % (0)	10 % (1)	80 % (8)	0 % (0)

n: case numbers.

Table 4. Pharyngeal impairment and esophageal impairment summary.

Components (score range)	Score 0 % (n)	Score 1 % (n)	Score 2 % (n)	Score 3 % (n)	Score 4 % (n)
7. Soft palate elevation (0–4)	90 % (9)	0 % (0)	10 % (1)	0 % (0)	0 % (0)
8. Laryngeal elevation (0–3)	0 % (0)	90 % (9)	10 % (1)	0 % (0)	–
9. Anterior hyoid excursion (0–2)	0 % (0)	40 % (4)	60 % (6)	–	–
10. Epiglottic movement (0–2)	10 % (1)	80 % (8)	10 % (1)	–	–
11. Laryngeal vestibular closure (0–2)	20 % (2)	70 % (7)	10 % (1)	–	–
12. Pharyngeal stripping wave (0–2)	10 % (1)	70 % (7)	20 % (2)	–	–
13. Pharyngeal contraction (0–3)[a]	57 % (4)	14 % (1)	29 % (2)	0 % (0)	–
14. Pharyngoesophageal segment opening (0–3)	0 % (0)	90 % (9)	10 % (1)	0 % (0)	–
15. Tongue base retraction (0–4)	0 % (0)	10 % (1)	50 % (5)	40 % (4)	0 % (0)
16. Pharyngeal residue (0–4)	0 % (0)	20 % (2)	30 % (3)	50 % (5)	0 % (0)
17. Esophageal clearance upright position (0–4)[b]	13 % (1)	25 % (2)	62 % (5)	0 % (0)	0 % (0)

n: case numbers, [a]: total 7 patients, [b]: total 8 patients.

laryngeal elevation (90 % with a score of 1: partial superior movement of the larynx; and 10 % with a score of 2: minimal superior movement of the larynx, for Component 8) and anterior hyoid excursion (40 % with a score of 1: partial anterior hyoid movement; and 60 % with a score of 2: absence of anterior hyoid movement, for Component 9). Eighty percent of the patients had partial inferior movement of the epiglottis (score of 1), and 10 % of the patients did not have epiglottic movement (score of 2, Patient 5) during swallowing (Component 10).

Seventy percent of the patients had incomplete laryngeal closure (score of 1 for Component 11), and 10 % of the patients (Patient 1) did not have laryngeal vestibule closure (score of 2). Regarding PAS, most patients with a PAS score $\geq$2 fall into the category of impaired laryngeal closure (score of Component 11 $\geq$ 1). 10 % of the patients had a PAS score of 2, 30 % had a PAS score of 3 (contrast entered the airway but remained above the vocal folds; not ejected from the airway), 30 % had a PAS score of 5 (contrast entered the airway and contacted the vocal folds; not ejected from the airway), and 10 % had a PAS score of 8 (contrast entered the airway and crossed the vocal folds; no cough response; Fig. 1). Seventy percent of the patients exhibited decreased posterior pharyngeal stripping waves (score of 1, Component 12), and 20 % of the patients exhibited absent pharyngeal stripping waves (score of 2, Patients 1 and 8). During the MBSImP scoring process, an anterior–posterior view (AP view) of the VFSS is required to assess pharyngeal contraction. In this retrospective study, the AP view of VFSS video clips was not available or poor quality in three patients (Patients 1, 2, and 6). Of the remaining patients, 14 % of the patients with a score of 1: incomplete contraction, and 29 % of the patient with a score of 2: unilateral bulging of the pharyngeal wall, for Component 13.

In the pharyngeal swallowing phase, 90 % of the patients had partial distention of the opening of the pharyngoesophageal segment (score of 1 for Component 14), and 10 % of the patients (Patient 1) had minimal distention of the pharyngoesophageal segment. Most of the patients had impaired retraction of the tongue base (Component 15, 50 % with a score of 2: narrow column of contrast between the tongue base and the posterior pharyngeal wall; and 40 % with a score of 3: wide column of contrast between the tongue base and the posterior pharyngeal wall. Score of 1 is treated as 0 during the calculation). After swallowing, most of the patients had various degrees of pharyngeal residue stasis (Component 16), 50 % of the patients with a score of 3: the majority of contrast remaining in the pharynx; 30 % of the patients with a score of 2: the collection of contrast is efficient to extract in the pharynx (score of 1 is treated as 0 during the calculation).

3.3. Esophageal impairment (Table 4)

Because the AP view of the VFSS video clips was not available for two patients, only eight

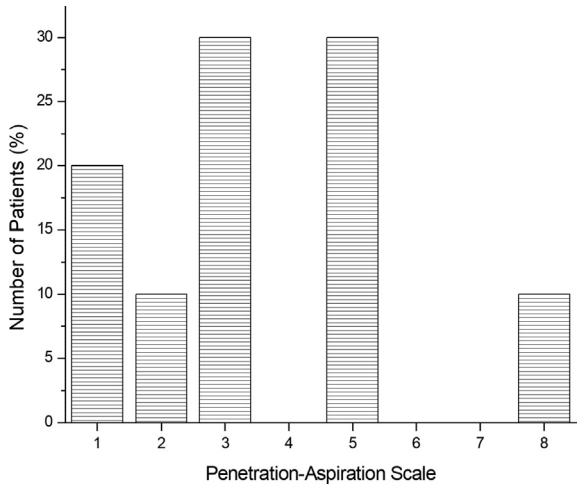

Fig. 1. Result of penetration-aspiration scale.

patients completed the esophageal impairment profile. Of them, 25 % of the patients had some esophageal retention without retrograde flow (score of 1 for Component 17), and 62 % of the patients had esophageal retention with retrograde flow below the pharyngoesophageal segment (score of 2).

4. Discussion

Possible mechanisms that cause dysphagia in patients with CSCI include: cervical spinal nerves injury (C1−C3), lower cranial nerve (CN) injury due to brain stem compression (include CN IX, X, XII), upper airway structural change due to injury, soft tissue edema, change in cervical spinal curvature, complication after spinal surgery (i.e. hardware compression, pharyngeal structural change, sensory impairment), paralysis of respiratory muscles (which causes decreased lung volume, impaired swallowing-respiration coordination and impaired airway clearance ability), vocal fold dysfunction, and autonomic dysfunction or upper esophageal mucosa trauma cause esophageal dysfunction.[14,15] Risk factors associated with dysphagia include older age, direct laryngeal injury, posterior pharyngeal wall swelling (caused by anterior cervical spine surgery, vertebral fracture, or soft tissue injury), higher levels of injury severity and use of tracheostomy tube.[1−3,7,15] However, most of these studies only provide statistical proportions of abnormalities without detailed descriptions of the functional abnormalities of each phase of swallowing. In this retrospective study, our objective was not to precisely quantitatively evaluate the VFSS findings (such as oral transit time, duration of pharyngeal transit time, or upper esophageal sphincter opening) but qualitatively and functionally evaluate the swallowing impairments in patients with CSCI by using the MBSImP.

Studies have shown that patients with CSCI have the highest difficulty in the oral and pharyngeal phases of swallowing.[3,7,8] In our study, most patients had impairments in all three swallowing phases (median OT, PT, and EI scores of 10.5, 11.0, and 2, respectively; Table 2). Although each component of the MBSImP is scored on an ordinal scale, with higher scores indicating more pronounced impairments, the assessment tool itself does not directly classify the scores into clinical categories such as mild, moderate, or severe. To improve the applicability of the MBSImP in clinical practice, Beall et al. grouped the OI scores of the MBSImP through latent class analysis to reflect severity,[16] with OT scores of 0−10, 14−18, and 22 indicating latent class 1, 2, and 3, respectively, and PT scores of 0−13, 18−24, and 26 indicating latent class 1, 2, and 3, respectively. Consequently, the median scores of OT (10.5) and PT (11.0) in our study corresponded to latent class 1, reflecting a lower severity of dysphagia. However, the functional oral intake capacity of our patients exhibited significant disability, with the patients having a median FOIS of 2 (IQR 2−5; Table 2). Only 3 out of 10 patients did not use a feeding tube. The possible reason is that although with lower total MBSImP scores (OT and PT scores), the presence of significant obstacles in certain components, such as bolus preparation, hyoid anterior excursion, or laryngeal closure, can lead to apparent swallowing difficulties in clinical settings and then prompt the need for tube feeding or modifications of eating habits in clinical practice. Consequently, the patient's FOIS score is likely to be lower. Because of the small sample size, we could not perform statistical analysis to reveal the relationships between the FOIS and MBSImP.

The most significant affected functions of the oral phase include tongue control during bolus hold (60 %, score of 2 of Component 2), bolus preparation/mastication (60 %, score of 3 of Component 3), bolus transport/lingual motion (40 %, score of 3 of Component 4), oral residue (60 %, score of 2 of Component 5), and initiation of pharyngeal swallowing (80 %, score of 3 of Component 6; Table 3). It is important to note that, according to the MBSImP scoring criteria, if a patient's ability to test cookie consumption is not assessed due to safety considerations, the score for Component 3 should be assigned the most severe rating of 3 points. In our study, 60 % of our patients receive a score of 3 for this reason. The above-mentioned oral swallowing actions are associated with complex neuro-muscular control. The relevant sensory and motor innervation includes CN V, VII, IX, X, XII, and C1.,[12,17,18] which are possibly been affected after the CSCI.[14] The

current studies on dysphagia in patients with CSCI predominantly focused on pharyngeal dysphagia. Only a small number of studies mention the impact on the oral phase and the reasons for the influence on the oral phase are seldom addressed.[3,14] This study is the first to provide a detailed assessment and description of oral impairment in patients with Cervical Spinal Cord Injury (CSCI) and dysphagia. Impaired oral phase function can cause difficult bolus management, food retention after swallowing, and an increased risk of penetration or aspiration.[19−21] Because the oral phase is vital in safe and efficient swallowing, it should also be considered when evaluating patients with CSCI, as indicated by our results.

The most involved pharyngeal impairments in this study include: laryngeal elevation (90 %, score of 2 of Component 8), anterior hyoid excursion (60 %, score of 2 of Component 9), epiglottic movement (80 %, score of 1, Component 10), laryngeal vestibular closure (70 %, score of 1 of Component 11), pharyngeal stripping wave (70 %, score of 1 of Component 12), pharyngoesophageal opening (90 %, score of 1 of Component 14), tongue base retraction (50 %, score of 1 of Component 15), and pharyngeal residue (50 %, score of 3 of Component 16; Table 4). To date, research on dysphagia in patients with CSCI focuses primarily on pharyngeal dysphagia, which demonstrated delayed pharyngeal swallowing, decreased hyoid bone excursion, delayed onset of pharyngoesophageal sphincter opening, decreased maximum pharyngoesophageal sphincter opening, and impaired pharyngeal constriction.[3,22,23] Our results are consistent with these studies (but in the MBSImP scoring system, initiation of pharyngeal swallowing is classified as a component of oral impairment). Changes in cervical spinal curvature, spinal surgery, sensory impairment, respiratory muscle dysfunction, phrenic nerve injury, laryngeal trauma, higher level and severity of injury, and tracheostomy are all potential factors associated with pharyngeal dysphagia.[14,15,24] All our patients had undergone cervical surgery, but none of our patients had a tracheostomy tube, and all were at ASIA grades C and D. Therefore, more patients and longer follow-up are required in future studies for those with greater severity of injury (ASIA A and B) and those with tracheostomy. In our patients, most of those with penetration or aspiration had a compromised cough response (PAS scores of 3, 5, and 8, Fig. 1). Airway protective behaviors (such as a cough reflex) are compromised in patients with CSCI, so relying on the cough response alone as an indicator of aspiration/penetration is insufficient.[9,25,26]

Most of our patients had esophageal abnormalities, such as retention and backflow (62 %, score of 2 of Component 17, Table 4). Esophageal dysphagia might cause heartburn, chest pain, a congestion sensation behind the sternum, and even pulmonary complications.[27−29] Stinneford et al. demonstrated decreased esophageal contraction mobility and speed in patients with CSCI.[27] The possible mechanisms of esophageal dysphagia in patients with CSCI may be due to prevertebral swelling, autonomic dysfunction, esophageal traction, or impaired esophageal mucosal blood flow during anterior cervical surgery.[14,30] More studies are warranted to clarify the precise mechanism.

5. Conclusion

In this study, all patients had variable impairments in the oral phase, pharyngeal phase, and esophageal phase. MBSImP is valuable for the comprehensive evaluation and description of swallowing impairment in patients with CSCI. The results of the MBSImP evaluation can serve as a reference for the clinical treatment of dysphagia. However, further study is needed to explore the correlation between MBSImP and FOIS.

6. Study limitation

This was a cross-sectional study, and the number of patients was extremely small, thus precluding generalization of the results to patients with different disease severity and duration. Future large-scale longitudinal studies are warranted to compare the results of the MBSImP and FOIS as well as swallowing impairments.

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Conflicts of interest

All authors have no financial and non-financial conflicts of interest.

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