EVALUATION OF THE EFFECTIVENESS OF TREATING DYSPHAGIA WITH PHARYNGEAL SENSORY IMPAIRMENT USING THERMAL-TACTILE ORAL STIMULATION (TTOS) AT THE NATIONAL REHABILITATION HOSPITAL

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ABSTRACT

Objectives: To evaluate the effectiveness of Thermal-Tactile Oral Stimulation (TTOS) combined with Neuromuscular Electrical Stimulation (NMES) compared to NMES alone in patients with severe dysphagia and pharyngeal sensory impairment. **Materials and Methods:** A controlled clinical intervention study was conducted on 50 patients with severe dysphagia (Fiberoptic Endoscopic Dysphagia Severity Scale - FEDSS ≥ 5) and pharyngeal sensory loss at the National Rehabilitation Hospital from March 2025 to October 2025. Patients were divided into two groups based on logistical feasibility: The Control Group (n=25) received NMES alone, and the Intervention Group (n=25) received NMES combined with TTOS. Outcomes were assessed after 3 weeks using Fiberoptic Endoscopic Evaluation of Swallowing (FEES) focusing on the Penetration-Aspiration Scale (PAS), FEDSS, Pharyngeal Residue, and Functional Oral Intake Scale (FOIS). **Results:** Baseline clinical characteristics were similar between groups (p>0.05). After 3 weeks, the Intervention Group showed statistically significant improvement compared to the Control Group. The rate of patients with no pharyngeal residue (Level 0) was 36% in the Intervention Group vs. 12% in the Control Group (p=0.037). PAS scores for liquids were significantly lower in the Intervention Group (3.64±2.46 vs. 5.32±1.88; p=0.022), as were PAS scores for semi-solids (2.56±2.29 vs. 3.64±2.27; p=0.033). The FEDSS score decreased significantly to 3.88±1.16 compared to 4.72±1.14 in the control group (p=0.010). Notably, the rate of total oral intake (FOIS > 3) in the intervention group reached 60% compared to 28% in the control group (p=0.037). **Conclusion:** The combination of TTOS and NMES is significantly more effective than NMES alone for treating severe dysphagia with pharyngeal sensory loss, leading to improved swallowing safety, reduced residue, and higher rates of return to oral intake.

Keywords: *Dysphagia, Pharyngeal Sensory Impairment, TTOS, NMES, FEES, Stroke, Rehabilitation.*

I. INTRODUCTION

Dysphagia is a common and severe sequela in patients with acquired brain injury, particularly stroke [1]. While motor deficits are frequently identified, a critical yet often overlooked pathophysiological mechanism is the impairment of pharyngeal sensation. The integrity of the sensory system is paramount for the swallowing process; sensory loss diminishes the airway protective reflex, leading to delayed swallowing initiation, silent aspiration, and a high risk of aspiration pneumonia [2].

In current rehabilitation practice, treatment methods such as Neuromuscular Electrical Stimulation (NMES) are widely used. NMES primarily targets motor recovery by strengthening the suprahyoid and pharyngeal muscles. However, for patients with significant sensory impairment, strengthening muscles alone may be insufficient to trigger the swallowing reflex in a timely manner if the sensory feedback loop remains broken [3].

Thermal-Tactile Oral Stimulation (TTOS) is a therapeutic intervention utilizing cold stimulation to enhance sensory input. It is hypothesized that the intense sensory barrage provided by cold touch facilitates cortical reorganization (neuroplasticity) and improves pharyngeal sensitivity, thereby "waking up" the swallowing reflex [4]. Although TTOS is an established method, its combined application with NMES has not been widely studied in Vietnam, specifically within the subgroup of patients with severe dysphagia complicated by severe sensory loss.

Therefore, we conducted this study with the aim: "To evaluate the effectiveness of treating dysphagia with pharyngeal sensory impairment using TTOS combined with NMES at the National Rehabilitation Hospital." The study specifically

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focuses on describing the clinical characteristics of this high-risk group and assessing whether the multimodal approach (Sensory + Motor) yields superior outcomes compared to motor stimulation alone.

II. SUBJECTS AND METHODS

2.1. Subjects

The study included 50 patients diagnosed with severe dysphagia receiving inpatient treatment at the National Rehabilitation Hospital from March 2025 to October 2025.

Inclusion Criteria:

- Diagnosed with severe dysphagia, defined as a FEDSS score ≥ 5 (assessed via FEES) [5].
- Presence of pharyngeal sensory impairment, confirmed by the endoscopic touch test.
- Patients or their legal representatives provided consent to participate.

Exclusion Criteria:

- Uncooperative patients due to cognitive deficits or agitation.
- Acute pharyngitis, high fever, or active infection at the stimulation site.
- Trismus (inability to open the mouth sufficiently for stimulation).
- Patients are currently on mechanical ventilation.

2.2. Methods

2.2.1. Study Design

This was a non-randomized, controlled clinical intervention study.

2.2.2. Sample Size and Grouping Strategy

A total of 50 eligible patients were recruited and divided into two groups: The Control Group (n=25) and the Intervention Group (n=25).

- **Grouping Method:** Due to logistical constraints within the hospital setting, a convenience sampling method was employed for group allocation rather than strict randomization. All patients meeting the inclusion criteria were initially counseled to receive the combined therapy.
  - **The Intervention Group** consisted of patients who were able to be transported to the ENT Department for the TTOS procedure (dependent on caregiver availability, health status permitting movement, and scheduling alignment).
  - **The Control Group** consisted of patients who met the medical criteria but could not undergo the additional TTOS procedure due to objective factors (e.g., adverse weather preventing transport between buildings, lack of caregivers to assist with transport, or scheduling conflicts with the endoscopy room).
  - *Note:* Despite non-randomized allocation, statistical analysis of baseline characteristics (Age, Gender, NIHSS, Baseline FEDSS/PAS) was performed to ensure no significant differences existed between the two groups at the start of the study.

2.2.3. Intervention Protocol

- **Control Group:** Received standard rehabilitation including Cervical Neuromuscular Electrical Stimulation (NMES).
  - *NMES Protocol:* Performed using the VocaStim device (Physiomed). Electrodes were placed on the submental and hyoid region.
  - *Doseage:* Stimulation lasted 15 minutes/day, administered by speech therapists at the Rehabilitation Department.
- **Intervention Group:** Received NMES (same protocol as above) combined with Thermal-Tactile Oral Stimulation (TTOS).
  - *TTOS Protocol:* Performed by trained nurses at the ENT/Examination Department. A size 00 laryngeal mirror was chilled in a cup of ice to reach a temperature of approximately -1°C to 3°C. The chilled mirror was used to stimulate the anterior faucial pillars, buccal mucosa, and tongue base using a firm stroking motion [6].
  - *Dosage:* Stimulation was performed 5 times per set, with each set lasting 2 minutes, for a total duration of 15 minutes per session. This was conducted 3 sessions per week for 3 consecutive weeks.

2.2.4. Assessment Methods

Dysphagia was evaluated using Fiberoptic Endoscopic Evaluation of Swallowing (FEES) by an experienced ENT specialist who was blinded to the patient's group allocation and previous assessment history to ensure objectivity.

a) Evaluation of Pharyngeal Sensation (Touch Test) [2]:

We utilized the "Touch Test" to assess sensory integrity. This procedure involves the endoscopist using the tip of the flexible endoscope to lightly touch specific structures in the laryngopharynx, including the lateral

pharyngeal wall, the posterior pharyngeal wall, and the arytenoids.

• **Scoring System:** The response of the patient is graded as follows:

○ **0 = Normal:** Immediate swallow response, cough, or laryngeal adductor reflex.

○ **1 = Reduced:** Weak or delayed response.

○ **2 = Absent:** No observable response.

• Scores are summed for a total sensory score (range 0-12), where 8-12 indicates severe sensory loss.

b) Outcome Indices:

• **PAS (Penetration Aspiration Scale):** An 8-point scale assessing the depth of airway invasion and the patient's response. Higher scores indicate worse safety.

• **FEDSS (Fiberoptic Endoscopic Dysphagia Severity Scale):** A 6-point scale assessing overall dysphagia severity and aspiration risk [5].

• **Residue Scale:** Assesses the amount of food residue remaining in the valleculae and pyriform sinuses after swallowing.

• **FOIS (Functional Oral Intake Scale):** A 7-level scale assessing the patient's ability to eat orally (Level 1 = NPO/Total Tube Feeding; Level 7 = Total Oral Diet without restrictions).

2.3. Data Analysis

Data was analyzed using SPSS 20.0 software. Continuous variables (non-normal distribution) were compared using the Mann-Whitney U test. Categorical variables were compared using Fisher's exact test. Statistical significance was set at $p < 0.05$.

2.4. Research ethics

The study protocol was reviewed and approved by the Scientific Committee of the National Rehabilitation Hospital according to Decision No 248/QD-BVPHCN. Patients' personal information will be kept confidential. All collected data will be used for research purposes only.

III. RESULTS

3.1. General Characteristics and Disease Subtypes

The study population consisted of 50 patients (Mean age: ~60 years), predominantly male (84%). Baseline characteristics were well-balanced between the two groups.

Table 1. Baseline Clinical Characteristics and Disease Subtypes

Baseline Characteristics	Control Group (n=25)	Intervention Group (n=25)	p
Age	61.56±17.6	58.96±15.6	0.473
Gender (Male/Female)	20/5	22/3	0.702
NIHSS	14.88±5.84	14.44±6.05	0.795
Duration (months)	3.4±3.5	3.44±3.4	0.734
Disease Subtypes			
Ischemic stroke	7	2	-
Hemorrhagic stroke	6	2	-
Traumatic Brain Injury	5	13	-
Other (Hypoxia/Anoxia)	2	1	-
Recurrent stroke	5	7	-

There were no statistically significant differences in age, NIHSS, Duration from stroke to treatment, between groups at baseline. The distribution of disease subtypes was comparable, with stroke (ischemic and hemorrhagic) being the most common etiology, followed by Traumatic Brain Injury (TBI).

3.2. Baseline Dysphagia Severity

Both groups presented with severe dysphagia at admission.

Table 2. Baseline Dysphagia Metrics

Baseline Characteristics	Control Group (n=25)	Intervention Group (n=25)	p
Touch Test Score	8.04±2.47	8.4±2.21	0.540
PAS Liquids	6.20±1.47	6.08±1.47	0.794
PAS Semi-solid	5.32±1.95	5.36±1.65	0.819
FEDSS	5.44±0.51	5.36±0.49	0.568
FOIS	1.96±0.61	1.80±0.58	0.349

• **FEDSS:** All patients had a score ≥ 5.

• **FOIS:** All patients were at Level 1, 2, or 3 (dependent on tube feeding).

• **PAS:** High scores indicating severe aspiration risk (Liquids: ~6.1; Semi-solids: ~5.3).

• Touch Test means in groups > 8. There were no significant differences in FEDSS, FOIS, PAS, and Touch Test scores between the two groups.

3.3. Treatment Outcomes after 3 Weeks

3.3.1. Improvement in Pharyngeal Residue

The intervention group showed a marked reduction in pharyngeal residue compared to the control group.

Table 3. Comparison of Residue Levels Post-Treatment

Residue Level	Control Group (n=25)	Intervention Group (n=25)	p
Level 0 (No residue)	3 (12.0%)	9 (36.0%)	0.037
Level 1 (Reduced)	19 (76.0%)	15 (60.0%)	
Level 2 (Absent/Severe)	3 (12.0%)	1 (4.0%)	

The rate of complete clearance (Level 0) was three times higher in the TTOS group (36%) compared to the NMES-only group (12%).

3.3.2. Improvement in Airway Safety (PAS) and Severity (FEDSS)

The combined intervention significantly improved airway safety for both liquid and semi-solid consistencies.

Table 4. Comparison of PAS and FEDSS Scores Post-Treatment

Outcome (Post-treatment)	Control Group (n=25)	Intervention Group (n=25)	p
PAS Liquids	5.32±1.88	3.64±2.46	0.022
PAS Semi-solid	3.64±2.27	2.56±2.29	0.033
FEDSS	4.72±1.14	3.88±1.16	0.010

The intervention group achieved significantly lower PAS scores, indicating reduced penetration and aspiration events.

3.3.3. Improvement in Functional Oral Intake (FOIS)

This is the most clinically relevant outcome, reflecting the patient's ability to eat.

Table 5. Comparison of Oral Intake Rates Post-Treatment

FOIS Classification	Control Group (n=25)	Intervention Group (n=25)	p
Total Oral Intake	7 (28.0%)	15 (60.0%)	0.037
Partial Oral Intake	13 (52.0%)	9 (36.0%)	
Total Tube Feeding	5 (20.0%)	1 (4.0%)	

60% of patients in the TTOS+NMES group returned to total oral intake, compared to only 28% in the NMES group.

IV. DISCUSSION

4.1. Characteristics of the Study Population

The demographic profile of our study aligns with global epidemiological data on stroke and brain injury. The predominance of male patients (84%) is consistent with risk factors for stroke and TBI. The mean age of approximately 60 years reflects a typical stroke rehabilitation cohort, though slightly younger than some Western studies, likely due to the inclusion of TBI patients.

Crucially, our study specifically targeted a "severe" cohort (FEDSS ≥ 5) with confirmed pharyngeal sensory impairment (Touch Test score > 8). This distinguishes our work from studies that include mild-to-moderate dysphagia. The high baseline NIHSS scores (~14.6) and high PAS scores indicate that these patients had significant neurological damage and were at high risk for aspiration pneumonia. This baseline similarity between the two groups ($p>0.05$) strengthens the validity of the post-intervention comparisons.

4.2. The Role of Sensory Impairment in Dysphagia

Our findings reinforce the critical role of sensation in swallowing safety. As noted by Labeit et al. (2023), pharyngeal sensory impairment is an independent predictor of poor secretion management and delayed swallowing reflexes [2]. When sensation is lost, the "sensory feedback loop" is broken. Patients fail to detect the presence of bolus or saliva in the pharynx (valleculae or pyriform sinuses), leading to a lack of "clearing swallows." This accumulation of residue, as observed in our baseline data, eventually spills into the airway, causing silent aspiration. Standard motor therapies (like NMES alone) may strengthen the muscles, but if the patient cannot feel the need to swallow, the stronger muscles are not recruited effectively to protect the airway.

4.3. Mechanisms of Thermal-Tactile Oral Stimulation (TTOS)

The superior results in the intervention group can be attributed to the physiological mechanisms of TTOS.

• **Peripheral Activation:** The application of cold stimulus (-1°C to 3°C) to the anterior faucial pillars stimulates the thermal receptors (likely TRP channels) supplied by the glossopharyngeal and trigeminal nerves. This provides a potent sensory barrage to the brainstem swallowing center.

• **Cortical Reorganization**: Beyond simple reflex activation, TTOS facilitates neuroplasticity. Teismann et al. (2009) demonstrated via magnetoencephalography that TTOS increases the cortical representation of swallowing [4]. Similarly, Magara et al. (2018, 2021) showed that cold stimulation induces immediate and lasting excitability in the pharyngeal motor cortex [3].

By incorporating TTOS, we likely "primed" the central nervous system, making the subsequent neuromuscular stimulation (NMES) and voluntary swallowing attempts more effective. This explains the significant reduction in swallowing delay and the improved PAS scores observed in our intervention group.

4.4. Synergy of Combined TTOS and NMES

The most significant finding of this study is the statistical superiority of the combined protocol (TTOS + NMES) over NMES alone across all key metrics: Residue (p=0.037), PAS (p=0.022), FEDSS (p=0.010), and FOIS (p=0.037).

• **Airway Safety (PAS):** The reduction of PAS for liquids to 3.64 in the intervention group (vs. 5.32 in control) suggests that the combined therapy restored the timeliness of the airway closure reflex. This aligns with Lim et al. (2009), who found that the synergy of sensory and motor stimulation reduces aspiration more effectively than single-modality treatments [7].

• **Residue Clearance:** The intervention group had a 36% rate of "No Residue" compared to 12% in the control group. This supports the hypothesis that restoring sensation allows patients to detect residue and perform spontaneous clearing swallows, a function that muscle training alone does not fully restore.

•**Comparison with other studies:** Our results differ slightly from Cakmak et al. (2022), who found no significant difference between traditional therapy and NMES [8]. However, our study design was different (NMES vs. NMES+TTOS) and focused specifically on *sensory-impaired* patients. In this specific subgroup, the addition of a sensory-focused therapy (TTOS) appears to be the "missing link" required for recovery.

4.5. Clinical Implications: Return to Oral Intake (FOIS)

From a clinical perspective, the improvement in FOIS scores is the most impactful result. 60% of patients in the intervention group achieved total oral intake (FOIS > 3) after just 3 weeks, compared to only 28% in the control group. Furthermore, only 4% of the intervention group remained totally tube-dependent, versus 20% in the control group.

This dramatic increase in tube weaning rates has profound implications for patient quality of life, nutritional status, and healthcare costs. It suggests that for severe dysphagia patients with sensory loss, a multimodal approach should be the standard of care to accelerate the transition from tube feeding to oral feeding.

4.6. Limitations

This study has limitations. The allocation was non-randomized due to hospital logistics, which could introduce selection bias, although baseline characteristics were statistically similar. The sample size (n=50) is relatively small, and the study was conducted at a single center. Additionally, long-term follow-up beyond 3 weeks is needed to confirm the sustainability of the neural plastic changes.

V. CONCLUSION

The combined treatment of Thermal-Tactile Oral Stimulation (TTOS) and Neuromuscular Electrical Stimulation (NMES) demonstrates superior effectiveness compared to NMES alone in patients with severe dysphagia and pharyngeal sensory impairment. The addition of TTOS significantly reduces pharyngeal residue, improves airway safety (lower PAS scores), and, most importantly, doubles the rate of patients returning to total oral intake. These findings support the integration of sensory-focused interventions into dysphagia rehabilitation protocols, particularly for patients with confirmed sensory deficits.

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