

Intervention Effect of Bite-and-Jaw-Lifting Swallowing Training on Stroke Patients with Dysphagia

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Abstract: (1) Background: Dysphagia is a common complication after stroke, which seriously affects patients' nutritional status and increases the risk of aspiration pneumonia. This study aimed to investigate the effect of bite-and-jaw-lifting swallowing training on swallowing function in stroke patients with dysphagia; (2) Methods: A total of 76 hospitalized stroke patients with dysphagia receiving rehabilitation treatment in the dysphagia department of a rehabilitation hospital in Hebei Province from September 2025 to February 2026 were enrolled as research subjects. The patients were divided into the experimental group and the control group using the random number table method, with 38 cases in each group. The control group received routine rehabilitation nursing, while the experimental group received routine rehabilitation nursing combined with bite-and-jaw-lifting swallowing training. The Water Swallow Test, modified Mann Assessment of Swallowing Ability, and surface electromyography were adopted to evaluate outcomes before and after intervention.; (3) Results: Seventy-two patients completed the study. After 4 weeks of intervention, the total effective rate of the Water Swallow Test, scores of modified Mann Assessment of Swallowing Ability, mean value and peak value of surface electromyography in the experimental group were significantly better than those in the control group, with statistically significant differences (all $P < 0.001$).; (4) Conclusions: bite-and-jaw-lifting swallowing training can significantly improve swallowing function and enhance the contraction strength of swallowing-related muscle groups in stroke patients with dysphagia.

Keywords: stroke; dysphagia; bite-and-jaw-lifting; swallowing training; rehabilitation nursing

1. Introduction

Post-stroke dysphagia (PSD) is a prevalent complication after stroke, with an incidence ranging from 50% to 80%[1]. The decreased strength of swallowing muscles not only easily leads to aspiration and aspiration pneumonia, but may also cause asphyxia, which seriously impairs the rehabilitation progress and quality of life of patients[2]. Traditional swallowing rehabilitation techniques are commonly limited in clinical practice by several drawbacks, including accidental tongue biting, increased cervical burden, and low patient compliance[3].

In recent years, novel training protocols of mouth-opening swallowing and laryngeal elevation have been proposed by foreign scholars. Relevant studies have verified that biting a lingual wedge with mandibular force can effectively avoid the deficiencies of conventional training, activate swallowing-related muscle groups more safely, and thereby improve swallowing function[4,5]. Nevertheless, these innovative methods have been rarely applied in domestic clinical settings.

Accordingly, this study proposed a novel bite-and-jaw-lifting swallowing training protocol based on electromyographic biofeedback in accordance with the clinical characteristics of Chinese stroke patients. Integrating mouth-opening biting and mandibular elevation, this training protocol reduces cervical strain while improving swallowing function. Meanwhile, electromyographic feedback equipment is adopted to real-time monitor muscle contraction and provide intuitive visual feedback for patients. This study aimed to verify the clinical efficacy of the proposed protocol, so as to provide a safe, simple and effective novel rehabilitation intervention for stroke patients with post-stroke dysphagia.

2. Subjects and Methods

2.1 Study Subjects

Participants were stroke patients with dysphagia who received rehabilitation treatment at a rehabilitation hospital in Hebei Province from September 2025 to February 2026. Participants were stroke patients with dysphagia who received rehabilitation treatment at a rehabilitation hospital in Hebei Province from September 2025 to February 2026. **Inclusion criteria:** ①Patients met the stroke diagnostic criteria specified in the *2019 Chinese Guidelines for the Diagnosis of Major Cerebrovascular*

Diseases[6], with definite stroke diagnosis confirmed by cranial computed tomography (CT) or magnetic resonance imaging (MRI), and complete medical records; ②Aged ≥ 18 years old; ③Water Swallow Test grade ≥ 3 ; ④Stable vital signs and clear consciousness[7]; ⑤No contraindications to electromyographic biofeedback therapy. **Exclusion criteria:** ①Patients with dysphagia caused by other neurological diseases, such as Parkinson's disease and dementia; ②Patients with severe respiratory, cardiovascular, digestive, or endocrine system diseases. **Dropout criteria:** ①Patients who withdrew from the study during the intervention for any reason; ②Patients who failed to complete the treatment according to the established protocol. G*Power 3.1.9 software was used for sample size calculation. The grade of the Water Swallow Test was set as the primary outcome indicator. The preliminary experiment results showed that the effect size (d) between the experimental and control groups was 0.85. A two-tailed test was adopted with $\alpha = 0.05$ and statistical power $(1 - \beta) = 0.90$. A minimum of 30 participants were required for each group. Considering a 20% dropout rate, a total of 76 patients were finally enrolled. SPSS 25.0 software was used to generate a random number table. Participants were randomly divided into the experimental group and the control group at a 1:1 ratio (38 cases in each group) using the opaque sealed envelope method. Blind design was applied for data collectors and data analysts. All patients and their families provided written informed consent prior to participation.

2.2 Methods

2.2.1 Control group

Patients in the control group received routine rehabilitation therapy and nursing care. The interventions included conventional basic management such as medication administration as prescribed, dietary guidance, condition monitoring, psychological support and health education. Meanwhile, routine swallowing rehabilitation training was performed, including airway protection maneuvers (e.g., Mendelsohn maneuver, Shaker exercise), oral sensory and motor training (e.g., cold stimulation, strength training of lip, tongue and buccinator muscles), feeding training, and conventional physical therapy such as neuromuscular electrical stimulation.

2.2.2 Experimental group

On the basis of routine rehabilitation therapy and nursing care delivered to the control group, patients in the experimental group additionally received bite-and-jaw-lifting swallowing training. This training protocol integrated electromyographic biofeedback technology, mouth-opening dry swallow and laryngeal elevation maneuvers. Fully considering the physiological characteristics and tolerance of Chinese stroke patients, adaptive modifications were made to key training parameters including wedge thickness, mandibular contraction strength and holding duration. The detailed training procedures and parameter settings are shown in Table 1.

Table 1 Preliminary design of specific procedures for bite-and-jaw-lifting swallowing training

Training Items		Specific Methods	Intervention Frequency
bite-and-jaw-lifting swallowing training	Laryngeal elevation training(Forehead-pressing swallowing maneuver)	Participants were instructed to lower the head to gaze at the abdomen and press the forehead with the wrist for 5 seconds.	5 seconds per time, 30 times per day, 6 days per week, for a continuous 4 weeks
	Mandibular pulling-pushing maneuver	Participants were instructed to firmly pull the mandible toward the chest and push the mandible upward with the thumb for 5 seconds.	5 seconds per time, 30 times per day, 6 days per week, for a continuous 4 weeks.
	Mouth-opening swallowing training	Patients were asked to protrude the tongue as far as possible. A wedge of approximately 10 mm, assembled with around six wooden tongue depressors fixed by adhesive tape, was placed between the patient's first molars. The therapist stabilized the patient's tongue using gloves or gauze. Patients performed swallowing movements while maintaining the tongue position.	4 minutes per session, once per day, 6 days per week, for a continuous 4 weeks.
	Electromyographic biofeedback	Electromyographic biofeedback device (Heal Force Bio-Meditech Holdings Limited, Model: HF3000) was used. The skin around the patient's oropharyngeal region was cleaned. Electrode patches were attached bilaterally on both sides of the midpoint of the line connecting the hyoid bone and mandible. Parameters were set according to individual patient conditions. Patients sat in a comfortable chair and kept the body relaxed. Patients were instructed to perform swallowing maneuvers while changes in electromyographic signals were observed and recorded. The instrument converted sEMG signals into visual and auditory cues. Patients adjusted swallowing movements and controlled wedge thickness, as well as the timing and force of laryngeal elevation based on feedback signals. The electromyographic biofeedback device was applied synchronously at the initiation of the above maneuvers.	

Note: The specific swallowing training methods, duration and frequency were adjusted according to individual patient conditions.

2.3 Outcome Measures

2.3.1 Kubota Water Swallowing Test (KWST)

It was used as a screening and grading criterion for dysphagia[8]. The severity of dysphagia was classified into grades I–V according to cough, pause and drinking time when patients swallowed 30 mL warm water. Markedly effective was defined as a grade improvement of 2 or more levels; effective was defined as a one-grade improvement; no change or deterioration was regarded as ineffective. The total effective rate = (number of markedly effective cases + number of effective cases) / total number of patients × 100%.

2.3.2 Modified Mann Assessment of Swallowing Ability (MMASA)

This scale was adopted to evaluate patients' swallowing function and consists of 12 items. Items including alertness, cooperation, respiration, auditory comprehension, tongue movement, tongue strength, cough reflex and soft palate function had a maximum score of 10 points (indicating normal status). Items of expressive speech disorder, dysarthria, saliva control and gag reflex had a maximum score of 5 points (indicating normal status). The total score ranged from 0 to 100; higher scores represented less severe dysphagia[9].

2.3.3 Surface Electromyography (sEMG)

The VISHEE biofeedback stimulator (NMPA registration No. 20172092324, Nanjing Vishee Medical Technology Co., Ltd.) was used to collect sEMG signals of the suprahyoid muscles. ①Patients were seated upright with the head and neck in a neutral position. Before assessment, the skin under the mandible was cleaned with alcohol swabs to remove grease and dander and reduce impedance. ②A pair of recording electrodes were placed parallel to the muscle fiber direction over the superficial projection of the anterior belly of digastric and mylohyoid muscles on both sides of the submental midline, with an electrode spacing of approximately 2 cm. The reference electrode was placed on the mastoid process behind the ear. ③Patients were instructed to relax. After the baseline stabilized below 5 μ V, patients were asked to perform dry swallows. Three valid swallowing trials were recorded, and the averaged values of mean amplitude and peak amplitude were taken as the final analytical data. This indicator objectively reflects the recruitment capacity and contraction strength of swallowing-related muscle groups [10].

2.4 Statistical Analysis

SPSS 25.0 software was used for statistical analysis. Count data were described as frequency (n) or percentage (%). The χ^2 test or Fisher's exact test was used for between-group comparisons of unordered categorical data, and nonparametric tests were applied for ranked data. The Shapiro-Wilk normality test and Levene's test for homogeneity of variance were performed for measurement data prior to analysis. Normally distributed measurement data with homogeneous variances were expressed as mean $\pm$ standard deviation ($\bar{x} \pm s$). The independent-samples t test was used for between-group comparisons, and the paired t test was adopted for within-group comparisons. All statistical tests were two-tailed, and $P < 0.05$ was considered statistically significant.

3 Results

3.1 Comparison of baseline characteristics between the two groups

A total of 76 patients were initially enrolled in this study. During the trial, one patient in the experimental group withdrew due to financial reasons, and three patients in the control group were lost to follow-up, including one case who refused treatment and two cases transferred to another hospital because of disease deterioration. Finally, 72 patients completed the study: 37 in the experimental group and 35 in the control group. There were no statistically significant differences in baseline characteristics including gender, age, disease course and stroke type between the two groups ($P > 0.05$), indicating good comparability. See Table 2.

Table 2 Comparison of baseline characteristics between the two groups

Group	n	Gender		Age ($\bar{x} \pm s$)	Disease duration			Stroke type		Hemiplegic side	
		Female	Male		1~3 months	3~6 months	>6 months	Cerebral infarction	Intracerebral hemorrhage	Left	Right
Control group	35	12	23	63.00 $\pm$ 11.56	29	4	2	8	27	20	15
Experimental group	37	12	25	58.95 $\pm$ 11.10	34	2	1	11	26	20	17
Statistical value		$\chi^2 = 0.028$		$t = 1.518$	$Z = -1.148$			$\chi^2 = 0.437$		$\chi^2 = 1.227$	
P		0.868		0.134	0.251			0.511		0.541	

3.2 Comparison of clinical efficacy after intervention between the two groups

The Kubota Water Swallowing Test was used to evaluate clinical efficacy. The total effective rate was 91.4% in the control group and 97.3% in the experimental group, with a statistically significant difference between groups ($P < 0.05$). See Table 3.

Table 3 Comparison of clinical efficacy after intervention between the two groups

Group	n	Markedly effective	Effective	Ineffective	Total effective rate	Z	P
Control group	35	18 (51.4)	14 (40.0)	3 (8.6)	33 (91.4)	-6.012	<0.001
Experimental group	37	35 (94.6)	1 (2.7)	1 (2.7)	36 (97.3)		

3.3 Comparison of MMASA scores between the two groups before and after intervention

MMASA scores were significantly increased after intervention compared with baseline in both groups ($P < 0.05$). Moreover, the post-intervention MMASA score of the experimental group was significantly higher than that of the control group, with a statistically significant difference ($P < 0.05$). See Table 4.

Table 4 Comparison of MMASA scores between the two groups before and after intervention

Group	n	Before intervention	After intervention	t	P
Control group	35	66.60 ± 7.08	78.71 ± 6.32	-15.224	<0.001
Experimental group	37	66.70 ± 6.37	86.65 ± 3.31	-22.306	<0.001
t		-0.065	-6.719		
P		0.949	<0.001		

3.4 Comparison of sEMG parameters between the two groups before and after intervention

The mean and peak sEMG values significantly increased after intervention relative to baseline in both groups ($P < 0.05$). Furthermore, the mean and peak sEMG values in the experimental group were significantly higher than those in the control group ($P < 0.05$). See Table 5.

Table 5 Comparison of mean and peak sEMG parameters between the two groups before and after intervention

Item	Group	n	Before intervention	After intervention	t	P
sEMG mean	Control group	35	13.07 ± 2.63	19.78 ± 3.64	-15.291	<0.001
	Experimental group	37	13.42 ± 3.31	29.56 ± 2.63	-26.334	<0.001
	t		-0.493	-13.114		
	P		0.623	<0.001		
sEMG peak	Control group	35	29.18 ± 3.64	43.94 ± 5.81	-35.152	<0.001
	Experimental group	37	28.61 ± 4.09	60.44 ± 5.86	-45.500	<0.001
	t		0.620	-11.990		
	P		0.537	<0.001		

4 Discussion

4.1 Bite-and-jaw-lifting swallowing training significantly improves clinical swallowing function in stroke patients

The results of this study demonstrated that post-intervention Kubota Water Swallowing Test grades and Modified Mann Assessment of Swallowing Ability scores in the experimental group were markedly superior to those in the control group ($P < 0.05$). The Kubota Water Swallowing Test is widely used to assess the risk of aspiration and choking, while the MMASA score comprehensively reflects patients' overall swallowing capacity from mastication to deglutition. The improvements in both assessments can be mainly attributed to the combination of biting the wedge and mandibular contraction. Drawing on the principle of mouth-opening swallowing proposed by foreign researchers, dry swallowing performed with the mouth open by biting a wedge of fixed thickness effectively increases the upward displacement of the hyoid bone and larynx[11], facilitating better contact between the tongue base and posterior pharyngeal wall. Meanwhile, isometric contraction induced by mandibular or forehead exertion directly strengthens the suprahyoid muscle groups[12]. The coordination of these two movements substantially enhances laryngeal

elevation, achieves better airway protection during swallowing[13], reduces the risk of choking during oral intake, and improves overall swallowing safety.

4.2 Bite-and-jaw-lifting swallowing training combined with biofeedback effectively increases the activity of swallowing-related muscle groups

Surface electromyography serves as a common objective indicator for evaluating muscle strength and activation. In the present study, post-intervention peak sEMG amplitudes in the experimental group were significantly higher compared with the control group ($P < 0.05$). Conventional mandibular resistance training largely relies on patients' proprioception, which frequently leads to incorrect muscle activation or insufficient contraction force[14]. Electromyographic biofeedback was integrated into this protocol to convert invisible muscle contraction into intuitive visual signals displayed on the screen[15]. Such visual feedback helps patients accurately master the contraction skills of muscles surrounding the mandible and hyoid bone. In addition, dry swallowing while biting the wedge with an open mouth elicits stronger muscle contraction than swallowing with the mouth closed[16]. Guided by visual feedback, patients can achieve more adequate muscle activation and consequently gain greater strength of key swallowing muscles.

4.3 Bite-and-jaw-lifting swallowing training exhibits favorable safety and adherence in clinical application

Compared with traditional swallowing muscle-strengthening exercises, the modified protocol adopted in this study is better adapted to the physical status and tolerance of stroke patients in China. Although conventional tongue-protrusion swallowing maneuvers are effective, they carry a high risk of tongue biting and elevated aspiration risk. The classic supine head-lifting exercise imposes high demands on cervical muscle strength, and many elderly stroke patients discontinue training due to neck soreness and fatigue[17]. The bite-and-jaw-lifting swallowing training in this study replaces tongue protrusion with a fixed lingual wedge, which effectively avoids tongue injury. Furthermore, seated mandibular or forehead contraction is adopted instead of supine head lifting, greatly reducing the burden on the cervical spine[18]. Clinical practice has verified that this protocol features simple operation and minimal discomfort for patients, resulting in better treatment adherence. It is suitable for promotion and application in primary hospitals and community rehabilitation settings.

5 Conclusion

This study indicates that bite-and-jaw-lifting swallowing training can effectively improve swallowing function among stroke patients with post-stroke dysphagia and possesses promising clinical application value. Limitations of this study include a relatively short observation period due to time constraints. Future research should expand the sample size and conduct multicenter longitudinal follow-up studies. Gold-standard examinations such as video fluoroscopic swallowing study (VFSS) may be incorporated to further explore the effects of this training protocol on swallowing biomechanics.

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