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Original Article

Effect of neuromuscular electrical stimulation on facial muscle strength and oral function in stroke patients with facial palsy

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Abstract. [Purpose] The aim of this study was to investigate the effect of neuromuscular electrical stimulation on facial muscle strength and oral function in stroke patients with facial palsy. [Subjects and Methods] Nine subjects received the electrical stimulation and traditional dysphagia therapy. Electrical stimulation was applied to stimulate each subject's facial muscles 30 minutes a day, 5 days a week, for 4 weeks. [Results] Subjects showed significant improvement in cheek and lip strength and oral function after the intervention. [Conclusion] This study demonstrates that electrical stimulation improves facial muscle strength and oral function in stroke patients with dysphagia.
Key words: Dysphagia, Electrical stimulation, Facial palsy

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INTRODUCTION

Facial muscles such as the buccinator, orbicularis oris, and risorius play an important role in the oral phase of swallowing and are also involved in facial expression. However, neurological disorders such as stroke cause paralysis of the opposite sides of the body, thereby affecting the facial muscles[1)]. The impairment of the facial muscles in patients with central facial palsy (CFP) is typically more pronounced in the lower than in the upper face. As a result, weakened facial muscles cause problems in the oral phase of swallowing, such as decreased mastication and bolus control, oral residue, and drooling, as well as facial expression.

Neuromuscular electrical stimulation (NMES) provides electrical stimulation over the skin in the anterior throat or facial region. NMES is effective in muscle strengthening, prevention of muscle atrophy, and neuromuscular re-education[2, 3)]. However, most studies have reported applying it on the swallowing-related muscles located on the front side of the neck in patients with pharyngeal dysphagia to examine the effects on swallowing function[4, 5)]. Therefore, there is insufficient evidence on the effects of NMES on patients with oral phase dysphagia accompanied by CFP. The present study aimed to investigate the effects of NMES on the facial muscles and oral phase of swallowing in patients with oral phase dysphagia who have CFP following a stroke.

SUBJECTS AND METHODS

Nine stroke patients with dysphagia (age, 60.78 ± 4.76 years; 5 males and 4 females) were eligible for this study. The inclusion criteria for participation were as follows: 1) oral dysphagia with CFP from a stroke that was confirmed by a videofluoroscopic swallowing study (VFSS), 2) onset <3months, and 3) a Mini-Mental State Examination score of ≥24. The exclusion criteria were as follows: 1) implanted cardiac pacemaker, 2) severe communication disorder such as severe aphasia, 3) unstable medical condition, and 4) skin problems that could affect the electrode placement. All subjects provided written

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Table 1. Test results before and after NMES

	Before NMES (n=9)	After NMES (n=9)
MCS (kPa)	14.3 ± 3.4	18.4 ± 2.8*
MLS (kPa)	10.6 ± 2.7	13.4 ± 2.7*
VDS (points)	27.0 ± 5.0	22.2 ± 4.3*

Values are shown as mean ± standard deviation. *Significantly different ($p<0.05$). NMES: neuromuscular electrical stimulation; MCS: maximal cheek strength; MLS: maximal lip strength; VDS: videofluoroscopy dysphagia scale

informed consent before participation according to the ethical standards of the Declaration of Helsinki.

NMES was performed using the VitalStim (Chattanooga Group, Hixson, TN, USA). One set of electrodes was placed on the paretic facial region according to the device manufacturer's instructions. The electrical stimulation unit provided 1 channel of bipolar electrical stimulation at a fixed 80-Hz pulse rate and a fixed biphasic pulse duration of 700 μs. The intensity was increased gradually at an interval of 0.5 mA for the experimental group. The stimulation intensity was increased until subjects felt a grabbing sensation in their facial muscles; a therapist confirmed the visible muscle contraction. The stimulation intensity was set differently for each participant, from 9.0 to 14.0 mA (average, 13.2 mA). Subjects received the treatment for 30 minutes/session, 5 sessions/week, for 4 weeks.

The Iowa Oral Performance Instrument (IOPI Medical LLC, Carnation, WA, USA) was used to measure maximal cheek strength (MCS) and maximal lip strength (MLS) in all subjects. MCS and MLS were measured based on a previous study[6]. A VFSS was performed to analyze swallowing function. The Videofluoroscopy Dysphagia Scale (VDS) was used to quantify the functional recovery of swallowing. VDS is a functional evaluation scale that comprehensively reflects the overall swallowing function in stroke patients[7, 8]. In this study, 7 subtests of oral stage function were analyzed such as lip closure, bolus formation, mastication, apraxia, tongue to palate contact, premature bolus loss, and oral transit time.

The outcomes were analyzed using a statistical software program (SPSS version 20), with descriptive statistics presented as mean ± standard deviation. The significance level was set at $p<0.05$.

RESULTS

MCS and MLS improved following intervention from 14.3 ± 3.4 to 18.4 ± 2.8 kPa and from 10.6 ± 2.7 to 13.4 ± 2.7 kPa, respectively. The oral phase VDS score statistically significantly decreased from 27.0 ± 5.0 to 22.2 ± 4.3 points (Table 1).

DISCUSSION

The present study aimed to investigate the effects of NMES on facial muscle strength in patients with oral phase dysphagia who have CFP following a stroke. The study demonstrated improvement in the strength of the MCS and MLS. In the present study, the electrodes are placed on the lower part of the face to stimulate the buccal branch of the facial nerve, as well as the trigeminal nerve. This not only stimulates the nerves, but also stimulates motion via muscle contraction, and the buccal branch of facial nerve controls both MCS and MLS.

NMES involves electrical stimulation of the muscles using surface electrodes and leads to muscle contraction by depolarization of nerve fibers. Such continued muscle contraction has a positive influence on muscle activation and can be effective for muscle strengthening, reduction of spasm, atrophy prevention, and retraining[2]. NMES increases recruitment of motor units, which is closely associated with an increase in muscle strength.

Facial muscles directly affect the oral phase of the swallowing process. The present study showed significant improvement in the oral phase parameters of the VDS. The oral phase parameters of the VDS include lip closure, bolus formation, and mastication, for which performance of the facial muscles is important. Facial muscles are involved in mastication of food and in formation of intraoral pressure during the oral phase and play a role in preventing the leaking of food via lip closure[9]. Therefore, the present study demonstrated that improvement in the strength of facial muscles contributed to improvement in the oral phase of swallowing.

This study has some limitations. First, because sample size may have influenced the results, they cannot be generalized. Second, because this study was conducted in subacute patients, the effects of natural recovery, considering the rapid nature of neurological recovery, cannot be excluded. Third, the absence of follow-up after the end of intervention did not allow for determination of the long-term effects.

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