



Effects of Bilateral Repetitive Transcranial Magnetic Stimulation on Post-Stroke Dysphagia



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ABSTRACT

Background: Optimal protocol of repetitive transcranial magnetic stimulation (rTMS) on post-stroke dysphagia remains uncertain with regard to its clinical efficacy.

Objective: The aim of the present study is to investigate the effects of high-frequency rTMS at the bilateral motor cortices over the cortical representation of the mylohyoid muscles in the patients with post-stroke dysphagia.

Methods: This study was a single-blind, randomized controlled study with a blinded observer. Thirty-five stroke patients were randomly divided into three intervention groups: the bilateral stimulation group, the unilateral stimulation group, and the sham stimulation group. For the bilateral stimulation group, 500 pulses of 10 Hz rTMS over the ipsilesional and 500 pulses of 10 Hz rTMS over the contralesional motor cortices over the cortical areas that project to the mylohyoid muscles were administered daily for 2 consecutive weeks. For the unilateral stimulation group, 500 pulses of 10 Hz rTMS over the ipsilesional motor cortex over the cortical representation of the mylohyoid muscle and the same amount of sham rTMS over the contralesional hemisphere were applied. For the sham stimulation group, sham rTMS was applied at the bilateral motor cortices. Clinical swallowing function and videofluoroscopic swallowing studies were assessed before the intervention (T0), immediately after the intervention (T1) and 3 weeks after the intervention (T2) using Clinical Dysphagia Scale (CDS), Dysphagia Outcome and Severity Scale (DOSS), Penetration Aspiration Scale (PAS), and Videofluoroscopic Dysphagia Scale (VDS).

Results: There were significant time and intervention interaction effects in the CDS, DOSS, PAS, and VDS scores ($p < 0.05$). In the direct comparison of the changes in the swallowing parameters among the three groups, the change in CDS scores at T1 and T2 showed a significantly higher improvement in the bilateral stimulation group than in two other groups ($p < 0.05$). There was a significantly larger change in the DOSS, PAS, and VDS scores at T1 in the bilateral stimulation group than in two other groups ($p < 0.05$). **Conclusions:** The results of the present study provide substantial evidence that 10 Hz rTMS at the bilateral motor cortices over the cortical areas projecting to the mylohyoid muscles is effective as an additional treatment strategy to traditional dysphagia therapies.

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Abbreviations: CDS, Clinical Dysphagia Scale; DOSS, Dysphagia Outcome and Severity Scale; FMA, Fugl–Meyer Assessment; K-MBI, Korean Modified Barthel Index; K-MMSE, Korean Mini-Mental State Exam; MEP, motor evoked potentials; NIBS, non-invasive brain stimulation; PAS, Penetration Aspiration Scale; RMT, resting motor threshold; rTMS, repetitive transcranial magnetic stimulation; tDCS, transcranial direct current stimulation; VDS, Videofluoroscopic Dysphagia Scale; VFSS, Videofluoroscopic Swallowing Study.

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Author contributions to the manuscript

Dr. EH Park contributed to data analysis, interpretation of the data, and drafting the manuscript. Dr. MS Kim contributed to patient selection and data acquisition. Dr. WH Chang contributed to design and conceptualization of the study, critical revision of the manuscript for important intellectual content. MS. SM Oh contributed to data acquisition. BS. YK Kim contributed to data acquisition. MS. AH Lee contributed to data acquisition. Dr. YH Kim contributed to design and conceptualization of the study, analysis and interpretation of the data, and critical revising the manuscript for important intellectual content.

Introduction

Dysphagia, a common and critical consequence of stroke [1], is a major risk factor of pneumonia following stroke. Furthermore, it is also associated with prolonged hospital stay, increased mortality, and poor long-term outcomes [1,2]. Traditional dysphagia therapies include postural interventions, swallowing maneuvers, and exercises. Although these interventions have been used in clinics worldwide, evidence of their effectiveness is still scarce [3–5]. Transcranial magnetic stimulation (TMS) is a method used to modulate brain activities in a specific cortico-subcortical network [6]. Repetitive transcranial magnetic stimulation (rTMS) has been widely applied to treat and improve post-stroke symptoms, including motor impairment, cognitive impairment, and dysphagia. However, the effects of rTMS on post-stroke dysphagia have been incongruously reported according to various stimulation parameters, such as frequency, intensity, and stimulation site.

Stimulating either the ipsilesional or contralesional hemisphere remains a controversial issue. Applying 3 Hz [7] and 10 Hz [8] rTMS over the cortical representation of the esophageal or mylohyoid muscle in the ipsilesional hemisphere showed a significant improvement as compared to the sham stimulation in dysphagia after stroke. On the other hand, both 1 Hz [9,10] rTMS and 5 Hz [11] rTMS at the contralesional motor cortex over the cortical representative of the pharyngeal or mylohyoid muscles showed an improvement on the swallowing function. Moreover, depending on the stimulating site, previous systematic reviews reported different results regarding the effect of non-invasive brain stimulation (NIBS). Specifically, one review reported no significant difference according to the stimulation site [12], while another review found a significantly better effect size resulting from the contralesional stimulation as compared to the ipsilesional stimulation [13]. The latter review included a combined brain and peripheral stimulation study, which applied 5 Hz rTMS over the contralesional hemisphere in combination with the pharyngeal electrical stimulation [14]. Overall, due to the diverse stimulation methods used and, consequently, the diverse results reported in previous studies, it is difficult to conclude that contralesional rTMS is superior to ipsilesional rTMS in terms of improving the swallowing function.

Inconclusiveness of the results of previous studies may be due to the neurologic innervation of the swallowing muscles receiving cortical projections from bilateral hemispheres as compared to the hand muscles receiving cortical projections from the contralateral hemisphere [15,16]. Based on the facilitation of cortical excitabilities at bilateral hemispheres by stimulating the ipsilesional hemisphere [7], the present study was designed to confirm the effect of facilitatory rTMS over bilateral hemispheres and to compare it with that of the unilateral stimulation. Specifically, we hypothesized that 10 Hz rTMS over bilateral cortical representation of the mylohyoid muscles may induce a better facilitatory effect on the bilateral mylohyoid muscles; therefore, we expected it to induce a better recovery of the swallowing function in the patients with post-stroke dysphagia than the unilateral hemispheric stimulation.

Materials and methods

Participants

The data were collected prospectively for post-stroke dysphagia in the inpatient rehabilitation clinic of a tertiary hospital. Thirty-five patients were assessed for eligibility according to the following inclusion criteria: (1) subacute stroke (unilateral ischemic or hemorrhagic stroke, duration after stroke <3 months) documented by computed tomography (CT) or magnetic resonance imaging (MRI); (2) swallowing problems lasting over 2 weeks after stroke; and (3) aspiration and/or penetration confirmed by the videofluoroscopic swallowing study (VFSS). The exclusion criteria were as follows: (1) a history of swallowing problems caused by other underlying neurological diseases, such as Parkinson's disease, dementia, or motor neuron disease; (2) a history of intractable seizure; or (3) metallic implants in the brain.

Thirty-five stroke patients were randomly divided into three intervention groups: the bilateral stimulation group, the unilateral stimulation group, and the sham stimulation group. Two patients were not able to complete this study. One patient in the bilateral stimulation group dropped out due to a personal reason unrelated to this study. One patient in the sham stimulation group dropped out due to aggravation of pneumonia. Therefore, a total of thirty-three patients completed the study (see Fig. 1).

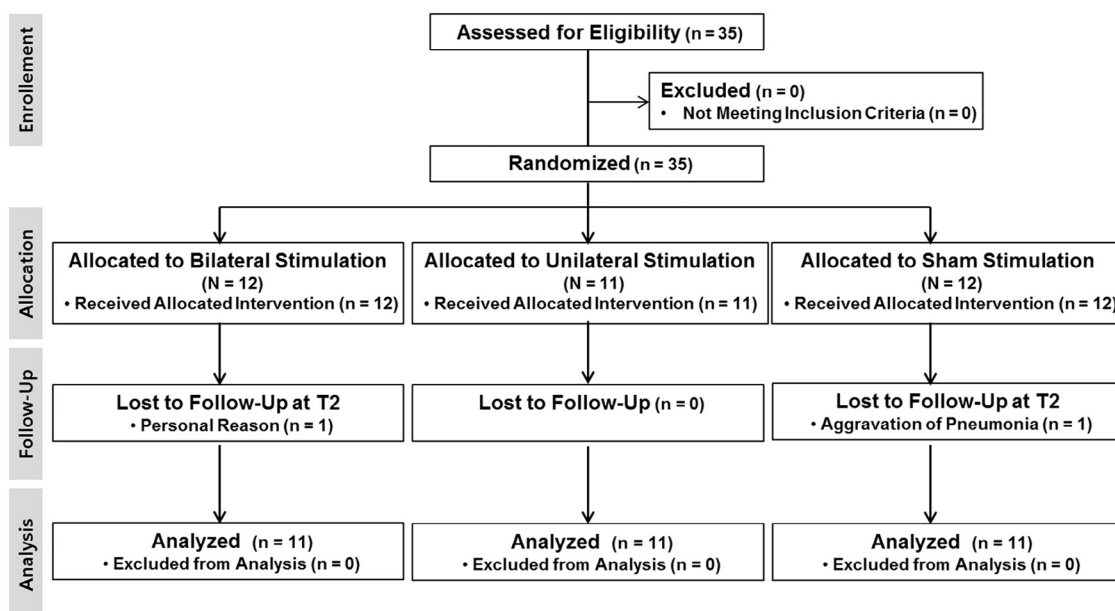


Figure 1. Consort flow chart. T0: baseline before the intervention; T1: immediately after the intervention; T2: 3 weeks after cessation of the intervention.

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