



# Anodal tDCS of the swallowing motor cortex for treatment of dysphagia in multiple sclerosis: a pilot open-label study

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## Abstract

Swallowing difficulties are a common symptom of multiple sclerosis (MS). The early detection and treatment of dysphagia is critical to prevent complications, including poor nutrition, dehydration, and lung infections. Recently, transcranial direct current stimulation (tDCS) has been proven to be effective in ameliorating swallowing problems in stroke patients. In this pilot study, we aimed to assess safety and efficacy of transcranial direct current stimulation (tDCS) in the treatment of dysphagia in MS patients. We screened 30 patients by using the 10-item DYsphagia in MULTiple Sclerosis (DYMUS) questionnaire, and patients at risk for dysphagia underwent a clinical and fiberoptic endoscopic evaluation of swallowing (FEES). Six patients who presented with mild to moderate dysphagia underwent the experimental procedures. These consisted of 5 sessions of anodal tDCS applied in consecutive days over the right swallowing motor cortex. Patients were followed-up at 1 week, 1 month and 3 months after treatment, and changes in the Dysphagia Outcome and Severity Scale (DOSS) score between baseline and post-tDCS were assessed. Our results showed that in all patients, the tDCS treatment determined a mild but significant clinical benefit (one-point improvement in the DOSS score) lasting up to 1 month. In conclusion, our preliminary results show that anodal tDCS has therapeutic potential in the treatment of swallowing problems in patients suffering with MS. However, future double-blind, randomized, and sham-controlled studies are needed to confirm the present findings.

**Keywords** Dysphagia · Multiple sclerosis · Transcranial direct current stimulation · Swallowing · Motor cortex · tDCS

## Main text

Dysphagia is a frequent symptom in patients with multiple sclerosis (MS), affecting up to 30% of patients at any stage of the disease. Both the oral and the pharyngeal phases of swallowing may be affected. The pathophysiology of swallowing dysfunction is complex, including, either alone or in combination, damage of the corticobulbar fibers, lesion of the brainstem swallowing centre, or impairment of the

lower cranial nerves inputs [1]. Though early recognition of swallowing problems and proper management are crucial to prevent serious complications, little is known about the best treatment strategies for MS patients with dysphagia [2].

In this open-label pilot study, we aimed to examine efficacy and safety of transcranial direct current stimulation (tDCS) for treatment of MS patients with mild to moderate dysphagia. In recent years, tDCS has become one of the most increasingly used methods of brain stimulation, thanks to its ability to induce focal, lasting but reversible, changes in cortical excitability. It has been shown that anodal tDCS applied to the swallowing cortex can increase the corticobulbar drive to the oropharyngeal muscles in the healthy humans [3, 4] and have a therapeutic potential in post-stroke dysphagia [5, 6]. In this study, 30 consecutive MS patients diagnosed according to the McDonald revised criteria were screened for swallowing difficulties using the 10-items DYsphagia in MULTiple Sclerosis (DYMUS) questionnaire [7]. Patients showing at least one abnormal item underwent bedside examination (BSE) and

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fiberoptic endoscopic evaluation of swallowing (FEES). The Dysphagia Outcome and Severity Scale (DOSS) was used to assess swallowing of both liquids and solid foods and to rate the occurrence of airway invasion. Only patients with mild to moderate dysphagia (DOSS levels between 5 and 3) were considered eligible to undergo the experimental procedures. Six patients (2F/4M, mean age  $50 \pm 9.6$  years, mean disease duration  $24.3 \pm 17.1$  years, mean EDSS  $5.2 \pm 0.8$ ; 2 patients had a relapsing remitting form, 4 a secondary progressive form) that met the inclusion criteria agreed to participate in the study. At the time of the experiment only one patient presented with gadolinium enhancing lesions on brain MRI scan (two active lesions: one in the right frontal and one in the left parietal region). The study protocol was approved by the local Ethics Committee, and written informed consent was obtained from all subjects prior to the experiment according to the Declaration of Helsinki. Each patient underwent tDCS for 5 consecutive days. In each session, current was delivered for 20 min at a 2 mA intensity through a pair of electrodes in  $5 \times 5$  cm saline-soaked synthetic sponges by means of a battery-driven constant current stimulator (BrainSTIM Transcranial Stimulator, Italy). The current was ramped up or down over the first and last 30 s of stimulation. The anode electrode was positioned over the right swallowing motor cortex, and centered over the hotspot for eliciting motor evoked potentials (MEPs) from the resting contralateral submental muscle complex as assessed by transcranial magnetic stimulation (TMS). Throughout the period of the examination, the subjects were given audiovisual feedback of EMG activity to help maintain submental muscles relaxation (Table 1).

The decision to target the right side was based on evidence that the right hemisphere may be mainly involved in the control of the pharyngeal swallow reflex [8]. Patients were followed-up by means of BSE and FEES performed at one week, one month and three months after starting tDCS treatment. Changes in DOSS and DYMUS scores between baseline and post-tDCS were recorded (Table 1). Because of the low number of patients evaluated, statistical analysis was not performed on these data.

Our results showed that in all patients the tDCS treatment determined a one-point improvement in the DOSS score at 1 week and 1 month after treatment, with return to baseline

at 3 months follow-up (Table 1). When interviewed at the end of the study, all patients reported a clinical improvement of dysphagia after the tDCS interventions. Two out of the six patients who needed diet adjustment for one consistency transiently returned to normal diet. In the remaining four patients, an objective, though slight, improvement of penetration phenomena and retention in pharynx was observed at FEES. Changes in the DYMUS score between baseline and 1-month follow-up are shown in Tab. 1. No significant side effects were noted throughout the study period.

An interesting finding of the present study is that we observed a sustained, albeit mild, clinical improvement of swallowing function in all patients treated. This in spite of the heterogeneity of multiple sclerosis lesions in different patients. In this regard, a first consideration may be that we enrolled patients with only mild to moderate dysphagia, in whose it is conceivable that the neural network subserving the swallowing function was relatively preserved and thus susceptible to be modulated by non-invasive brain stimulation. Second, it is known that widespread brain regions in both hemispheres are involved in volitional and automatic swallowing and, indeed, evidence has been provided that, when applied to the swallowing motor cortex of one side, tDCS can enhance the corticobulbar drive from both hemispheres [9, 10]. Thus, it may be hypothesized that in the MS patients, the anodal stimulation of the right swallowing motor cortex activated a widespread network also involving the contralateral hemisphere, thus compensating for the impairment due to focal brain injuries.

This study has several limitations, such as the small sample size, the absence of a placebo-controlled and double-blind design, and the clinical heterogeneity of the patients enrolled. Moreover, we did not evaluate whether more beneficial effects could be observed by using tDCS in conjunction with targeted rehabilitation strategies. In conclusion, though findings of this study are encouraging and could suggest a therapeutic potential of tDCS for treatment of dysphagia in MS, these must be considered very preliminary, needing to be confirmed in larger double-blind, randomized, sham-controlled clinical trials ideally carried out in subgroups of patients as homogeneous as possible from a clinical point of view.

**Table 1** Changes in the Dysphagia Outcome and Severity Scale (DOSS) and in the 10-item DYsphagia in Multiple Sclerosis (DYMUS) questionnaire scores between baseline and post-tDCS treatment. RR-MS: relapsing remitting multiple sclerosis; SP-MS: secondary progressive multiple sclerosis

Patient	Sex	Age (yrs)	Diagnosis	DOSS score				DYMUS score	
				Baseline	1 week	1 month	3 months	Baseline	1 month
1	F	34	RR-MS	4	5	5	4	9	8
2	M	55	SP-MS	5	6	6	5	9	8
3	M	58	SP-MS	5	6	6	5	8	5
4	M	62	SP-MS	4	5	5	4	6	6
5	M	42	RR-MS	5	6	6	5	8	7
6	F	49	SP-MS	4	5	5	4	6	5

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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