

## Authors:

Naoyuki Takeuchi, MD, PhD  
Masahiko Toshima, MD  
Takayo Chuma, MD  
Yuichiro Matsuo, MD  
Katsunori Ikoma, MD, PhD

Stroke

## Affiliations:

From the Department of Rehabilitation Medicine, Hospital of Hokkaido University, Sapporo, Japan (NT, TC, YM, KI); and Carres Sapporo, Hospital of Tokeidai, Sapporo, Japan (MT).

## Correspondence:

All correspondence and requests for reprints should be addressed to Naoyuki Takeuchi, Department of Rehabilitation, Hospital of Hokkaido University, North 14 West 5 Sapporo 060-0814, Japan.

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## CASE REPORT

# Repetitive Transcranial Magnetic Stimulation of the Unaffected Hemisphere in a Patient Who Was Forced to Use the Affected Hand

## ABSTRACT

Takeuchi N, Toshima M, Chuma T, Matsuo Y, Ikoma K: Repetitive transcranial magnetic stimulation of the unaffected hemisphere in a patient who was forced to use the affected hand. *Am J Phys Med Rehabil* 2008;87:74–77.

We present a case report of a 56-yr-old chronic stroke patient with right hemiparesis who was treated with repetitive transcranial magnetic stimulation (rTMS) therapy. Before stroke, the patient had suffered an accident that led to paralysis and contracture of the left upper limb, and, subsequently, he was forced to use only his right upper limb for routine activities, despite right hemiparesis. We performed subthreshold rTMS (1 Hz, 25 mins) and sham stimulation of the contralesional primary motor cortex (M1) at different times. Immediately after rTMS, the patient was able to write characters with increased speed and accuracy, and this effect continued for more than 7 days; however, this was not the case after sham stimulation. Moreover, the writing practice after rTMS improved the patient's pinch force.

**Key Words:** Repetitive Transcranial Magnetic Stimulation, Rehabilitation, Constraint-Induced Movement Therapy, Stroke

Recent reports have demonstrated that repetitive transcranial magnetic stimulation (rTMS; 1 Hz) of the contralesional primary motor cortex (M1) improved the functioning of the affected hand in chronic stroke patients.<sup>1–4</sup> Inhibition of the excitability of the contralesional M1 by using 1-Hz rTMS results in a decrease in transcallosal inhibition from the contralesional to the ipsilesional M1 and an increase in the excitability of the ipsilesional M1; this ultimately leads to improved motor function in the affected hand.<sup>1</sup> It is expected that this method will be used as a new rehabilitation therapy for stroke patients; however, approaches to enhance and sustain the effects of rTMS are unclear.

We present a chronic stroke patient who was forced to use his affected hand for routine activities because of contracture of the unaffected hand. An improvement in the functioning of the affected hand was observed after the use of 1-Hz rTMS; this suggests that a combination of rTMS and motor training, such as forced limb use, can improve motor function in stroke patients. Therefore, we

studied whether rTMS therapy could improve the functional ability of this patient.

## CASE REPORT

A 56-yr-old, right-handed male developed cortical cerebral hemorrhage (in the left precentral gyrus) 8 mos ago. He had suffered a fracture of the left forelimb and secondary infection of the left forelimb at 6 yrs of age, and subsequently he had been unable to move his left upper limb because of contracture of the wrist and elbow; however, he was able to move his left fingers. Therefore, he was forced to use his right upper limb despite the right hemiparesis caused by stroke. After physical and occupational therapy, he was able to walk and eat with a spoon, using his right hand. During testing of our protocol, his Fugl–Meyer score<sup>5</sup> was determined to be 60/66 (arm), 23/24 (hand), and 17/34 (leg). His modified Ashworth score<sup>6</sup> was 1/3 (arm), 1/3 (hand), and 1/3 (leg). The patient did not exhibit apraxia, aphasia, agnosia, or memory deficit. He provided written, informed consent, and the protocol for the use of rTMS was approved by the local ethical committee of the Hokkaido University Graduate School of Medicine.

A day before simulation, the patient familiarized himself with the task of writing and pinch force evaluation. Subsequently, the patient participated in two sessions that tested the influences of noninvasive cortical stimulation in the form of rTMS and sham stimulation. The rTMS session was conducted a week after the sham session to rule out the placebo effect of sham stimulation. The pinch force was measured before stimulation (pre) and after stimulation (post-1, immediately after stimulation; post-2, 30 mins after stimulation; and post-3, 7 days after stimulation). For more than 1 mo before the study, the patient practiced writing characters for more than 15 mins/day, because his chief complaint was related to the impairment of his writing ability. However, he was unable to write efficiently, and his ability of writing was stabilized. Therefore, in addition to the evaluation of the pinch force, we evaluated his writing performance, and we conducted further writing practices after rTMS. The patient practiced writing his address for 15 mins after the stimulation and for 15 mins/day until the post-3 session. We selected five Chinese characters (a part of his address) that he had frequently practiced writing before this study. The maximum pinch force of the affected hand was determined, using a pinch gauge (Pinch Meter SPR-641; Sakai Medical, Tokyo, Japan). To measure the pinch force, the subject was instructed to use only his thumb and index finger. In each session, 10 pinch force measurements were averaged.

rTMS was performed using a 70-mm figure-eight coil and a Magstim Rapid stimulator (Mag-

stim Company, Dyfed, UK). The coil was placed tangentially over the contralesional M1 at the optimal site for the first dorsal interosseous muscle. The optimal site was defined as the location where stimulation at a slightly suprathreshold intensity elicited the largest magnetically evoked potentials in the first dorsal interosseous. Electromyographic activity was recorded, using silver–silver chloride electrodes positioned in a belly tendon montage on the skin overlying the first dorsal interosseous, and the signal was amplified, filtered (50–2000 Hz), and digitized at a sampling rate of 5000 Hz for offline analysis (Neuropack, Nihon Koden, Tokyo, Japan). The resting motor threshold was defined as the lowest stimulator output that could induce magnetically evoked potentials with a peak-to-peak amplitude greater than 50 mV in at least half of the 10 trials. rTMS was applied for 25 mins at a frequency of 1 Hz and an intensity of 90% resting motor threshold. Sham stimulation was applied with the coil positioned perpendicular to the scalp of the contralesional M1 at the same frequency and intensity as real rTMS.

The pinch force was evaluated, using analysis of variance for repeated measures with time (pre, post-1, post-2, and post-3) and conditions (rTMS and sham). A post hoc analysis was performed, using the Bonferroni correction. The significance level was set at 0.05.

The patient did not exhibit any adverse side effects during the course of this study. After rTMS, he could write characters with increased speed and accuracy (Fig. 1). A repeated-measures analysis of variance demonstrated a significant interaction between the time and conditions ( $P = 0.004$ ) and a significant effect of time ( $P < 0.001$ ) on the pinch force. Post hoc tests revealed that the pinch force did not change immediately after rTMS (pre,  $5.37 \pm 0.27$  kg; post-1,  $5.51 \pm 0.23$  kg); however, it improved with subsequent writing practice (pre *vs.* post-2 [ $5.92 \pm 0.21$  kg],  $p = 0.002$ ; pre *vs.* post-3 [ $5.90 \pm 0.18$  kg],  $P = 0.003$ ). No significant change in the pinch force was observed during the sham session (pre,  $5.38 \pm 0.21$  kg; post-1,  $5.28 \pm 0.27$  kg; pre,  $5.40 \pm 0.28$  kg; post-1,  $5.37 \pm 0.27$  kg). The Fugl–Meyer and modified Ashworth scores of the patient did not change after rTMS.

## DISCUSSION

This is the first report demonstrating the use of 1-Hz rTMS for improving the functioning of the affected hand of a chronic stroke patient who had suffered contracture in the unaffected hand.

Recent reports have demonstrated that the application of 1-Hz rTMS to the contralesional M1 improves the functioning of the affected hand in stroke patients.<sup>1–4</sup> In the present study, the improvement in the functioning of the affected hand

A) Sample	北海道札幌
B) Pre-rTMS	北海道札幌
C) Immediately after rTMS	北海道札幌
D) 30 minutes after rTMS	北海道札幌
E) 7 days after rTMS	北海道札幌

**FIGURE 1** *The patient was able to write characters with increased speed and accuracy immediately after repetitive transcranial magnetic stimulation (rTMS). A, Sample: Five Chinese characters. B, Before rTMS: Total writing time was 39.1 secs. C, Immediately after rTMS (post-1): Total writing time was 34.1 secs. D, Thirty minutes after rTMS (post-2): Total writing time was 33.8 secs. E, Seven days after rTMS (post-3): Total writing time was 34.1 secs.*

after rTMS persisted for more than 7 days. However, it remains uncertain whether the effect of a single rTMS for stroke patients can be sustained<sup>4</sup> or not.<sup>1</sup> rTMS at 1 Hz can increase the excitability of the ipsilesional M1 by reducing transcallosal inhibition from the contralesional M1.<sup>1,3</sup> The increase in the excitability of the motor cortex was considered essential for motor learning.<sup>7,8</sup> Considering these findings, the increased excitability of the ipsilesional M1 after rTMS may contribute to reorganization of the ipsilesional M1 after motor learning. Therefore, interventions such as motor training after rTMS might be important for sustaining the effects of rTMS. In the present study, it is possible that motor function testing and writing practice after rTMS might have served as forms of motor training and helped to sustain the effects of rTMS.

In stroke patients, constraint-induced movement therapy (CIMT) can enhance the functional recovery of the affected limb by enforcing its use.<sup>9,10</sup> The beneficial effects of this therapy are associated with an increase in the excitability of the affected motor cortex. The immobilization of the unaffected arm that induces a reduction in the excitability of the unaffected motor cortex is also considered important.<sup>9</sup> The application of 1-Hz rTMS to the contralesional

M1 can induce downregulation of the contralesional M1<sup>1</sup> and upregulation of the ipsilesional M1.<sup>3</sup> Therefore, the mechanism of action of 1-Hz rTMS and CIMT may be related.<sup>11</sup> Considering that the conceptual basis for CIMT is that stroke patients must use only their affected hand for routine activities,<sup>12</sup> our patient underwent a type of CIMT because he was forced to use his affected hand, because of contracture of the unaffected hand. In our study, rTMS improved the motor function of the patient's affected hand, suggesting that rTMS therapy might enhance the effect of CIMT in stroke patients.

This study has some limitations that should be considered. First, the potential effect of rTMS-independent motor learning should be considered because of the crossover design of this study. However, the motor function of the affected hand was improved after rTMS and motor training, but not after sham stimulation and motor training. Moreover, it was considered that the motor function of the affected hand had reached a plateau because of the motor training before stimulation. Therefore, it was unlikely that motor training after sham stimulation had influenced the functional improvement of the affected hand after rTMS. Second, the patient might feel the difference between the active and sham stimulation. This sham stimulation produced no cortical stimulation, but it produced the auditory artifact as control stimulation.<sup>13</sup> We used a stimulation intensity of 90% resting motor threshold that did not induce contraction of the hand muscles. Moreover, the patient was naïve to rTMS and reported that he had received active treatment after sham stimulation. Therefore, it is unlikely that the difference between sham and rTMS influenced the results of this study. However, further investigation using a double-blind study with more subjects is required to evaluate the effects of rTMS.

Our results demonstrate that rTMS of the contralesional M1 can lead to improved motor function of the affected hand in chronic stroke patients with contracture of the unaffected hand. Further, the results of this study suggest that the combination of rTMS and CIMT might be useful in facilitating the recovery of stroke patients.

## REFERENCES

1. Takeuchi N, Chuma T, Matsuo Y, Watanabe I, Ikoma K: Repetitive transcranial magnetic stimulation of contralesional primary motor cortex improves hand function after stroke. *Stroke* 2005;36:2681-6
2. Mansur CG, Fregni F, Boggio PS, et al: A sham stimulation-controlled trial of rTMS of the unaffected hemisphere in stroke patients. *Neurology* 2005;64:1802-4
3. Fregni F, Boggio PS, Valle AC, et al: A sham-controlled trial of a 5-day course of repetitive transcranial magnetic stimulation of the unaffected hemisphere in stroke patients. *Stroke* 2006;37:2115-22
4. Boggio PS, Alonso-Alonso M, Mansur CG, et al: Hand function improvement with low-frequency repetitive transcranial

- nial magnetic stimulation of the unaffected hemisphere in a severe case of stroke. *Am J Phys Med Rehabil* 2006;85:927-30
5. Fugl-Meyer AR, Jaasko L, Leyman I, Olsson S, Steglind S: The post-stroke hemiplegic patient. 1. A method for evaluation of physical performance. *Scand J Rehabil Med* 1975;7:13-31
  6. Bohannon RW, Smith MB: Interrater reliability of a modified Ashworth scale of muscle spasticity. *Phys Ther* 1987;57:206-7
  7. Pascual-Leone A, Tarazona F, Keenan J, Tormos JM, Hamilton R, Catala MD: Transcranial magnetic stimulation and neuroplasticity. *Neuropsychologia* 1999;37:207-17
  8. Muellbacher W, Ziemann U, Wissel J, et al: Early consolidation in human primary motor cortex. *Nature* 2002;415:640-4
  9. Liepert J, Miltner WHR, Bauder H, et al: Motor cortex plasticity during constraint-induced movement therapy in stroke patients. *Neurosci Lett* 1998;250:5-8
  10. Kobayashi M, Hutchinson S, Theoret H, Schlaug G, Pascual-Leone A: Effects of constraint-induced movement therapy on patients with chronic motor deficits after stroke: a replication. *Stroke* 1999;30:586-92
  11. Kobayashi M, Hutchinson S, Theoret H, Schlaug Pascual-Leone AG: Repetitive TMS of the motor cortex improves ipsilateral sequential simple finger movements. *Neurology* 2004;62:91-8
  12. Dobkin BH: Strategies for stroke rehabilitation. *Lancet Neurol* 2004;3:528-36
  13. Lisanby SH, Gutman D, Luber B, Schroeder C, Sackeim HA: Sham TMS: intracerebral measurement of the induced electrical field and the induction of motor-evoked potentials. *Biol Psychiatry* 2001;49:460-3

## BOOK REVIEW

### *EBM Guidelines für Allgemeinmedizin*

Edited by Ikka Kunnamo, editor in chief, and editors Erwin Rebhandl, Susanne Rabady, Frank Mader. 1427 pages. Published 2006 by Verlagshaus der Ärzte, Wien, Austria. Printed in Slovenia. ISBN 3-901 488-27-8.

Like all other physicians, general practitioners have to cope with a rapidly growing amount of new medical knowledge. The textbook *Evidence Based Medicine for General Practice*, is the German translation of *Evidence Based Medicine Guidelines*<sup>1</sup> and is intended to support general practitioners in their clinical decisions, with the latest evidence available.

The book is organized into 48 chapters, thus reflecting both the WHO-ICD 10 classification and medical specialties. Each chapter is well structured and covers, in accordance with the ICD-10, the epidemiology and pathophysiology of respective human conditions and diseases. Therapeutic and management strategies are described profoundly and comprehensively, including prevention and rehabilitation procedures (although primarily as a therapeutic option or concept). A wealth of illustrations assists the user who may not be familiar with the physical appearance of a particular disease or condition. Using the GRADE Working Group recommendations,<sup>2</sup> the level of evidence is provided for both the treatment and for diagnostic tests, which makes this book unique.

The book shares an inherent weakness of textbooks: it does not provide cutting-edge knowledge, because it cannot take into account the most recent research. From

a physical medicine and rehabilitation specialist's perspective, the book fails to provide general practitioners with the necessary information to optimally promote the functioning and health of their patients. Surprisingly enough, physical medicine is categorized as a subspecialty of orthopedics. The conceptual framework of preventive and rehabilitation medicine, as well as its salutogenetic approach to promote patients' functioning and health, remains undescribed. It is hard to comprehend why preventive and rehabilitative exercise and training, therapeutic interventions administered as physical medicine, and rehabilitation treatment modalities are summarized in a chapter entitled *Sports Medicine*.

In summary, this textbook, featuring the traditional medical perspective, can be recommended to both general practitioners and medical specialists seeking optimal diagnosis and treatment for their patients.

Rating: \*\*\*

Gerold Ebenbichler  
Katharina Kersch-Schindl  
University Clinics of PM&R  
Vienna Medical University  
Vienna, Austria  
Thomas Brockow  
Karl Ludwig Resch  
German Institute of Health Research  
Bad Elster, Germany

#### REFERENCES

1. Kunnamo I (ed): *Evidence Based Medicine Guidelines*. Helsinki, Duodecim Medical Publications Ltd, 2005
2. Atkins D, Best D, Briss PA, et al : Grading quality of evidence and strength of recommendations. *BMJ* . 2004;328:1490

DOI:10.1097/PHM.0b013e31815e6dd0