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The Effects of Task-oriented Mirror Therapy on the Upper Extremity Function and Brain Activation in Chronic Stroke Patients

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Abstract

Background/Objectives: This study was conducted to examine how task-oriented mirror therapy changes the upper extremity function and brain activation in chronic stroke patients.

Method/Statistical Analysis: This study applied mirror therapy to two stroke patients and used a paired t-test to examine the differences before and after treatment and the Telescan program to examine the brain activation.

Findings: As a result of examining the upper extremity function after mirror therapy, the Fugl-Meyer Assessment scores improved from 21.0±1.41 before treatment to 24.5±1.71 after treatment, and the Wolf Motor Function test scores also improved from 27.0±5.66 to 33.5±6.36. The brain activity also increased after treatment.

Improvements/Applications: The use of mirror therapy in stroke patients improved the recovery of upper extremity function and increased the brain activation.

Keywords: *Stroke, mirror therapy, neuroplasticity, upper extremity function, brain activation.*

Introduction

Strokes cause problems related to sensation, vision, perception, cognitive thinking, and language, and most patients experience difficulties in moving or activities due to motor impairment[1]. The less severe the initial disability, the more prognosis the stroke is. The degree of recovery is very difficult due to the large individual differences, and the motor dysfunction remains in about 50% or more patients, and the upper extremity dysfunction is particularly prominent[2]. About 30%-66% of stroke patients have difficulties in daily activities due to paralyzed hands and are unable to recover their motor function. Therefore, paralysis of upper extremity in stroke patients is one of the fatal effects in daily living[3].

In order to promote recovery of impaired motor function or to acquire new motor function, plasticity changes of the brain nerves involved in motor functions are essential[4]. The ultimate goal of treatment in stroke patients is to restore brain function by improving neural plasticity, to restore normal posture and motion, and to reduce abnormalities in posture and muscle tone to ensure efficient movement[5].

Recently, various treatment strategies based on neuroplasticity have been used to recover from

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strokes, such as action observation, imagery training, mirror therapy, virtual reality, robot-assisted therapy, and constraint-induced movement therapy[6]. These intensive task-trainings have been shown to improve motor function in stroke patients, but have been shown to be generally costly and time consuming[7]. Among these treatment method, mirror therapy is a simple, economical, and effective method which places a mirror between the arms or legs so that the normal movement of the non-affected side is shown to provide normal movement on the affected side[8]. This is possible through the mechanism called mirror neurons, and Ramachandran invented the 'mirror box' to help alleviate phantom limb pain[9]. It can also increase motivation and efficiency by providing task-oriented treatment during mirror therapy[10]. The task-oriented approach is lead to the active use of damaged upper limbs by improving the ability of daily living and by providing a more effective treatment method composed of various functional activities[11]. In addition, this study suggest that as a mediation for the improvement of cognitive function and daily living behavior of stroke patients, it can actively try to solve problems by providing functional tasks[12].

Mirror neurons were initially found in several brain regions of the monkey, premotor cortex(PMC), inferior parietal lobule(IPL), and superior temporal sulcus, a mechanism called the mirror neuron system[13]. Previous studies using functional magnetic resonance imaging (fMRI) found that networks similar to mirror neuron systems exist in humans[14], and suggested that these networks engage in new motor skills through observational learning and facilitate skill acquisition after strokes[15].

Recent advances in brain science and brain mapping technologies have led to the development of neurophysiological changes and motor function recovery mechanisms by functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and electroencephalogram (EEG)[16]. EEG is a simple, relatively inexpensive, and noninvasive method that provides useful information for directly observing functional changes in the cerebral cortex[17]. EEG measurement can be applied to patients with various diagnoses such as brain damage, alcoholism, and depression to examine the functional state of the brain in real-time while focusing on a specific task[18].

Human thoughts and actions depend on brain activity and are shown in the form of brain waves[19]. To improve the recovery of the upper limbs of stroke patients, the damaged regions of the brain must be reconstructed[20]. Therefore, the purpose of this study is to examine how task-oriented mirror therapy changes the upper extremity function and brain activation in chronic stroke patients.

Materials and Method

1. **Participants:** The participants of this study were two males, and the study was performed after explaining the purpose and method of the study and obtaining a consent from the participants. The participants were selected by the following criteria: (1) Patients who survived beyond 6 months after stroke onset, (2) patients without unilateral neglect and visual impairment, (3) Patients who can follow instructions and communicate with MMSE-K scores above 24, (4) patients with no previous exposure to mirror therapy. This study excluded (1) those who have other neurological damage or surgical conditions other than stroke and (2) those who take antipsychotic drugs.

2. **Intervention:** The mirror therapy was performed by placing a mirror in the median sagittal plane of the participant, then placing the paralyzed arm behind the mirror, and moving the paralyzed arm along with the reflected movement of the normal arm. The participants carried out the tasks with the normal hand during mirror therapy. The tasks involved 6 different movements: (a) wrist flexion and extension, (b) finger opposition, (c) hand grasp and release, and (d) using chopsticks. Each task was performed for 5 minutes for a total of 30 minutes and the treatment was performed 4 times a week for one month.

3. **Measure:** The Fugl-Meyer Assessment (FMA) was used to evaluate functional changes in the sub-regions of the upper extremity. The Brunnstrom Approach was used to distinguish detailed movements by classifying the functions of stroke patients into 50 categories. Zero to 2 points are given according to the performance level, and out of a total of 100 points, the test corresponding to arms consists of 33 items for 66 points and 34 points for legs.

   The Wolf Motor Function Test (WMFT) is a tool developed to evaluate the upper extremity function in stroke patients, which consists of a total of 17

items (2 items for muscle strength measurement, 15 items for functional tasks). Each item is performed for 2 minutes, and functional ability score is evaluated on a 6-point scale (0-5).

EEG was performed by attaching electrodes on the participant's scalp before they received mirror therapy. The electrodes were attached according to international standards (10%-20%). The electrodes were attached after removing sweat and wiping grease layers with alcohol swabs before the EEG measurements to improve the signal quality. The brain activation was confirmed through brain mapping by visually examining changes in the regions of the brain during mirror therapy.

4. **Data analysis and statistics:** This study used a paired t-test to examine the effects of mirror therapy on upper extremity function and used the Telescan program (LAXTHA Inc.) to examine brain activation during mirror therapy.

Results

1. **The effect of mirror therapy on upper extremity function:** As a result of examining the upper extremity function of the participants, the functional changes of FMA and WMFT are as follows.

As shown in [Table 1], the FMA scores improved from 21.0±1.41 before treatment to 24.5±1.71 after treatment and showed a statistically significant difference. The WMFT scores also improved from 27.0±5.66 to 33.5±6.36 and showed a statistically significant difference.

Table 1. Comparison of FMA & WMFT scores before and after mirror therapy

Evaluation	Pre-test	Post-test	t	P
FMA	21.0±1.41	24.5±1.71	-2.33	.02*
WMFT	27.0±5.66	33.5±6.36	-3.11	.04*

The values are mean±standard deviation, FMA, WMFT. $p<0.05$ by paired t-test.

2. **The effect of mirror therapy on brain activation:** The results of examining the brain activation of the participants are as follows.

As shown in [Figures 1 and 2], both participants exhibited higher brain activation after mirror therapy.

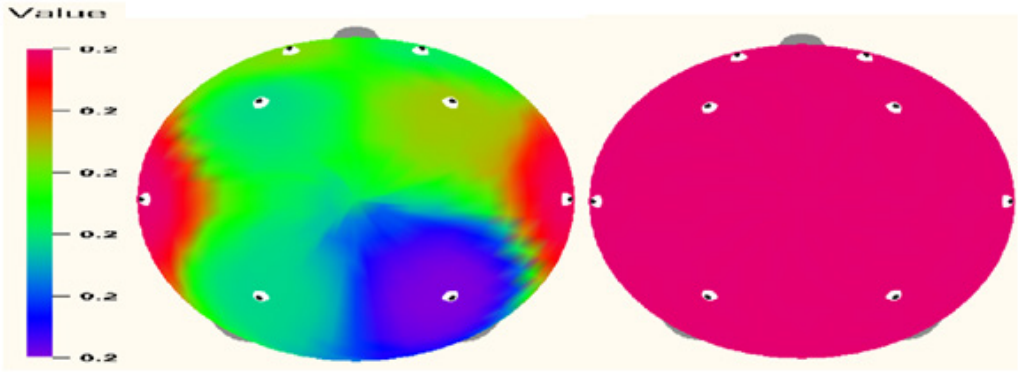

Figure 1. Brain activation before and after mirror therapy in participant 1

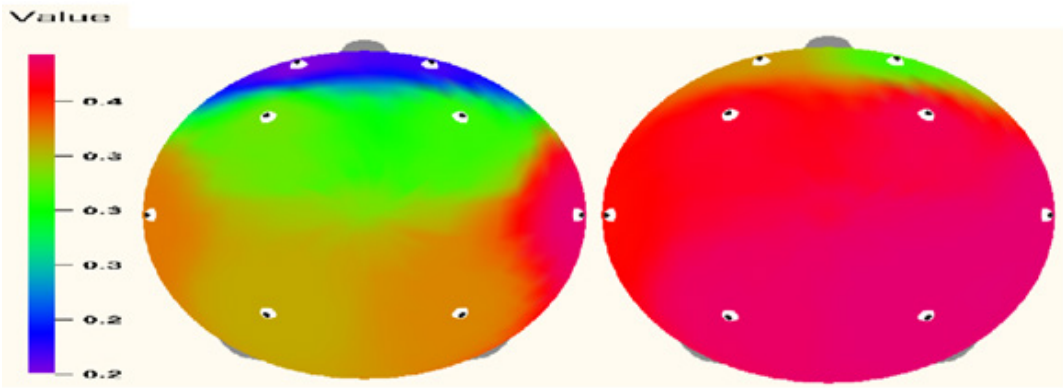

Figure 2. Brain activation before and after mirror therapy in participant 2

Discussion

Stroke is one of the leading diseases that cause problems in the upper extremity. This makes it difficult to perform tasks such as stretching, grasping, manipulating, and moving objects, and causes problems in daily activities[21]. Mirror therapy is a treatment method to recover the function of paralyzed limbs by observing the movement of the normal limbs reflected in the mirror. Many previous studies have shown recovery of upper limb functions by mirror therapy. However, patients get bored due to repeating simple movements during the treatment and the treatment effects are not always consistent[22]. Therefore, this study provided tasks combining simple and functional movements to improve the effects of recovering upper limb functions and to increase the concentration of the participants.

Similar to the results of this study, there are reports showing that stroke patients recovered FMA upper extremity functions by receiving mirror therapy including traditional occupational therapy. Both patients who received simple mirror therapy and those who received task-oriented mirror therapy showed improved upper limb functions, and the latter showed about 10% more improvement compared to the former. The functional improvement of complex movements was limited when the therapy was focused on simple movements, but task-oriented mirror therapy continuously improved upper extremity function[23]. Since the hands of an individual are connected in time and space[24], the effect of the treatment can be generalized by properly using both hands during task-oriented treatment[10]. Although mirror therapy does not involve the movement of paralyzed limbs, it has similar neurological effects and produces benefits similar to those from bilateral movement.

The brain activation also increased during mirror therapy. Leocani et al. (2001) reported that increased beta-wave activity during movement influences the activation of the cerebral cortex[25], and described that the area of the cerebrum first activated gradually activates other areas of the cerebrum while performing the task[26].

The limitation of this study is that it cannot be generalized because of the small number of participants. However, it was found that task-oriented mirror therapy increased both the upper extremity function and the brain activity of stroke patients. Ultimately, the reconstruction of the brain is necessary to improve the function of stroke patients. Mirror therapy increased the brain activation, so additional method to improve motor function should be considered.

Conclusion

This study was performed to examine how task-oriented mirror therapy changes the upper extremity function and brain activation in stroke patients. As a result of examining the upper extremity function of two stroke patients after mirror therapy, both patients showed improved FMA and WMFT scores and increased brain activation. Therefore, more functional movements need to be included rather than simple movements in the task-oriented mirror therapy of stroke patients to improve the quality of life.

Ethical Clearance: Kangwon National University

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Conflict of Interest: Nil

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