Research Article

Mirror Therapy Rehabilitation for Lower Limb of Acute Stroke Patients

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Received: 10 August 2020; Revised: 13 November 2020; Accepted: 3 March 2021; Published online: 11 May 2021

Abstract
This paper aims to study the effectiveness of mirror therapy (MT) for treatment of acute stroke patients. The subjects of 20 acute stroke patients who possessed the ability to respond to verbal instructions were randomly blinded and allocated to a control group (n = 10, 59.2 ± 2.28 years) and a mirror group (n = 10, 53.8 ± 6.14 years). Both groups were treated by intervention of traditional rehabilitation therapy and compared with MT. The intervention of MT was taken 60 minutes per day, 5 days per week for 12 weeks. Measures of intervention effectiveness were taken before treatment and after treatment by therapist using Brunnstrom stages, Fugl-Meyer Assessment (FMA) lower extremity score, and Brunnel Balance Assessment (BBA) balance. Data were analyzed using an independent sample t-test. The results revealed that, after 12 weeks of treatment, subjects of both groups gained statistically significant improvements in all measured variables ($p < 0.05$). The participants of the MT group had improvement on the FMA score (31.0 ± 1.20 versus 28.7 ± 0.58) compared with the control group. MT is inexpensive and easily applicable in conjunction with traditional physiotherapy for home care programs. Consequently, MT proves to be an effective approach for rehabilitation of patients with post-acute stroke.

Keywords: Acute stroke, Mirror therapy, Rehabilitation therapy, Lower limb

1 Introduction

Stroke or cerebrovascular accidents, in according to the WHO's report, is ranked the second leading cause of death and the third leading cause of disability. It is considered one of the most frequently occurring disabling diseases in the world [1]. In the global trend, the number of the elderly people has been increased, and there is also an increase in the incidence of stroke. In accordance with the 2013 Thailand population health survey, the prevalence of stroke is more significant, while the highest portion is at the age group of 70–79 years [2]. An ischemic stroke occurs when blood vessels and ischemia are injured. It affects the cognition, communication, feelings, activities of daily living (ADL), motor control, and movement [3]. Motor function of the lower limb after a stroke is often impaired, causing limitations in functional mobility [4], [5]. In addition to mobility disorders, it can negatively affect the quality of life of the patient.

Mirror neurons are now being discovered as evidence of neuropsychology experiments and analysis of images from the brain. The stroke patients have been reported for their improvements in neural system of motor control and extremities function [6], [7]. The physical therapy techniques have been developed to induce motor recovery based on neuroplasticity, such as constraint-induced movement therapy, mirror therapy, motor imagery, robotic training, and virtual training, which have different underlying neural mechanisms. Mirror therapy (MT) was beneficial and low cost. Ramachandran is the first one who invents mirror therapy (MT). He applies MT to treat patients who suffer from 'learned paralysis' of phantom-limb pain (PLP) [8].

In 1999, Ramchantharan *et al.* described the benefits of regeneration in hemiparesis and hemineglect according to the rhythm [9]. It is considered a promising therapy from a clinical perspective and MT has also been investigated to rehabilitation paralyzed upper limbs and lower limbs in stroke patients. The visual information was used to encourage patients to concentrate on the movements of their normal limbs [10], [11]. Besides, Altschuler *et al.* [12] showed that mirror therapy is effective for the Range of Motion (ROM), the velocity of motion, and the accuracy of upper limbs for stroke patients. Sathian *et al.* [13] found that the mirror therapy was effective for treatment of arm weakness because it could help reform motion and grip strength after the treatment of 2 weeks. Stevens *et al.* [14] also applied Mirror therapy to rehabilitate chronic stroke patients for 3–4 weeks. There was a positive result with a good score, assessed by the Fugl Meyer Assessment, and active range of motion, motion velocity, and hand dexterity.

Uthra Mohan's study [15] performed traditional rehabilitation therapy 60 minutes with mirror therapy 30 minutes, 6 days per week, for 2 weeks. Sütbeyaz's study [16] performed traditional rehabilitation therapy 60 minutes with mirror therapy 30 minutes, 5 days per week, for 4 weeks. Both studies found that the mirror group showed the better performance in motor recovery and balance than the control group.

MT technique can be easily applied for the treatment of a motor disorder. This requires only the setting of a mirror in a position of the sagittal plane in between the limbs. The patient will imagine regaining control over a missing limb. The subject performs movements with the normal limb reflected in the mirror and interpreted by the brain [17], [18]. Consequently, MT combined with traditional stroke rehabilitation programs can help to improve lower limb motor recovery and motor functioning in sub-acute stroke patients.

Many studies have investigated MT, to improve the functional condition of patients with stroke. Most studies focused on visual stimulation using repeated lower limb motions, and few studies attempted to evaluate subjects motor recovery and balance. Accordingly, the primary objective of this study was to evaluate the effects of the MT rehabilitation for 12 weeks on the lower limb's motor recovery in acute stroke patients. The outcome was measured in terms of motor recovery (Brunnstrom stages), Fugl Meyer Assessment (FMA) for lower limb and balance (Brunnel Balance Assessment [BBA]).

2 Materials and Methods

2.1 *Subjects*

The subjects for this study were inpatients of the Stroke Rehabilitation Unit of Thammasat University Hospital and network hospitals between September 2017 to June 2019. Stroke was diagnosed with acute stroke by a neurologist and confirmed by computed tomography or magnetic resonance imaging. They were selected using the following inclusion and exclusion criteria as listed below.

The inclusion criteria were: 1) sufficient cognitive ability to follow instructions (Mini-Mental State Examination score > 23); 2) hemiplegia during the first 3 months after stroke; 3) a score above 2 on the Brunnstrom stages of motor recovery of the lower extremity.

The exclusion criteria were: 1) muscular-skeletal disorder and operation of the lower limb; 2) limited range of motion of the lower limb; 3) unilateral neglect, hemianopia, or apraxia; and 4) psychological or emotional problems.

There were 60 cases of stroke patients selected by using the inclusion criteria to assess their eligibility by a physiotherapist. Subjects were informed of the study objective, whereas their consent was taken for selection of the participation in the study, as well as for obtaining their written informed consent to the Research Ethics Committee of Thammasat University (No. MTU-EC-IM-0-082/59).

2.2 *Estimation of sample size*

The sample size was calculated with n4Studies [19] using data from Broderick *et al.* [20] from the prevalence

Figure 1: Control group.

Figure 2: Mirror group.

of the Fugl-Meyer assessment of the lower limbs, a significance level 0.05, and powers 0.8. The required sample size was calculated as 30 participants (15 subjects in each group).

2.3 *Methodology*

Subjects for the trial were stroke patients who were admitted for 48 hours with stable vital sign. After measuring Brunnstrom by a physiotherapist and signing informed consent, the subjects were randomly divided into 2 groups; the control group (Figure 1) and the mirror group (Figure 2). All assessments were carried out by the same investigator, who was blinded to the group allocation.

The mirror therapy treatment was conducted using a modified version of that described in the study of Sütbeyaz *et al.* [16]. The patients were guided to take a sitting position in front of a mirror with a 60 cm × 70 cm placed in the midline between legs. Accordingly, the patient was facilitated by viewing a mirror reflection of the moving leg to imagine to make movement of the weak leg. The exercises were performed in a semi-seating position on the bed. The practices were consisted of 1) hip with knee flexion-extension, 2) ankle dorsiflexion-plantar flexion, and 3) hip abduction-adduction. Both groups were treated with assisted mirror therapy, 60 min/day (traditional rehabilitation therapy 30 min, followed by the mirror therapy 30 min), 5 days/week, for 12 weeks. The treatment included the therapy of normal limb position and lower limb-facilitation technique, training of balance, gait, and activities of daily living.

The measures of the rehabilitation treatment result were taken at 0 weeks, and 12 weeks (follow-up). Tools for assessment of the motor recovery and balance before and after treatment included Brunnstrom stage, Fugl Meyer Assessment (FMA), and Brunnel Balance Assessment [BBA]).

Brunnstrom stage of recovery consists of 6 sequential stages of motor recovery for the lower limb. The Fugl Meyer Assessment (FMA) lower extremity scores, with a maximum index of 34, were used to evaluate the motor functioning, balance sensation, and joint functioning. Scores from 0 to 2 were given to each item according to the performance on the motor function evaluation; 0 = cannot perform, 1 = performs partially, 2 = performs fully. While, the Brunnel Balance Assessment (BBA), measuring the functional balance, was set to have a hierarchical series of 12 points, specifying functional performance tests ranging from supported sitting balance to advanced stepping tasks. There were 3 sections of the assessment including sitting, standing, and stepping. This scale represented good reliability, criterion, and predictive validity in stroke [21], [22].

Analysis of general characteristics of stroke patients was made using descriptive statistics, i.e., Means and Standard Deviation. The Kolmogorov-Smirnov test was used to determine distribution normalities for the baseline. The t-test, significance of p-value < 0.05, was also used for a comparison of the before treatment value to the after treatment value.

3 Results

The subjects of 20 stroke patients who completed the 12 weeks trial ranged from 35 to 79 years. While, the control group (n = 10) (7 males and 3 females, had a mean age of 59.2), and the mirror group (n = 10) (6 = males and 4 females, had a mean age of 53.8). A summary of the clinical characteristics of the subjects (n = 20) is presented in Table 1. Baseline comparisons revealed that age, sex, dominance, time since stroke, type of stroke, paretic side, and Brunnstrom stage of recovery were not different between the groups at baseline (*p*-value > 0.05).

Table 1: The clinical characteristics of the 20 subjects of the mirror and control groups

	Mirror (n = 10)	**Control (n =1 0)**	***p*-value**
Age (year)	53.8 ± 6.14	59.2 ± 2.28	0.58
Sex (male/ female)	6/4	7/3	
Dominance (right/left)	9/1	10/0	
Time since stroke (day)	3.9 ± 1.38	4.1 ± 1.28	0.43
Type of stroke (ischemic/ hemorrhagic)	7/3	8/2	
Paretic side(right/ left)	5/5	7/3	
Brunnstrom stage	2.4 ± 0.55	2.4 ± 0.52	0.607

Table 2: Brunnstrom stage of recovery Scores, Fugl Meyer Assessment (FMA), and Brunnel Balance Assessment (BBA) within the group for lower limb before treatment (0 weeks) and after treatment (12 weeks)

		Before Treatment (0 week)	**After Treatment (12 weeks)**	***p*-value**
Brunnstrom	Mirror	2.4 ± 0.55	4.3 ± 0.55	0.004*
	Control	2.4 ± 0.52	4.2 ± 0.58	0.003*
FMA	Mirror	20.2 ± 1.3	31.0 ± 1.20	0.001*
	Control	22.6 ± 1.27	28.7 ± 0.58	0.001*
BBA	Mirror	3.25 ± 1.07	5.16 ± 0.93	0.002*
	Control	2.36 ± 1.17	4.06 ± 1.35	0.003*

* Significant difference in gains, $p < 0.05$.

Table 2 presents the measured parameters before and after treatment within both groups. The assessed outcome parameters of Brunnstrom stage of recovery (lower limb), Fugl Meyer Assessment (FMA) of the lower limb, and Brunnel Balance Assessment (BBA) were improved significantly in both groups after treatment. Table 3 presents the measured parameters after treatment in both groups. The Brunnstrom stages showed that there was not a statistically significant difference between the pre- and post- treatment (mirror group; 4.3 ± 0.55 vs. control group; 4.2 ± 0.58; $p > 0.05$). Whereas, the FMA motor score showed that the treatment caused a statistically significant improvement of the mirror group, compared with that of the control group (mirror group; 31.0 ± 1.20 vs. control group; 28.7 ± 0.58; $p < 0.05$). BBA showed a statistically significant improvement after treatment of the mirror group (mirror group; 5.16 ± 0.93 vs. control group; 4.06 ± 1.35; $p < 0.05$).

Table 3: The measured parameters after treatment in both groups

	Mirror (after treatment)	**Control (after treatment)**	***p*-value**
Brunnstrom	4.3 ± 0.55	4.2 ± 0.58	0.066
FMA	31.0 ± 1.20	28.7 ± 0.58	0.032*
BBA	5.16 ± 0.93	4.06 ± 1.35	0.480

* Significant difference in gains between both groups, $p < 0.05$.

4 Discussion

In this study, researchers compared the existing mirror group and control group of patients with acute stroke. At the end of post-treatment intervention, there was a significant improvement in the mirror control groups in motor recovery and balance.

Functional recovery following stroke is mainly dependent on neuroplasticity [23]. The effectiveness of mirror therapy is an additional therapy to treat the lower limb after stroke and restore impairment using brain plasticity. The clinical effects of mirror therapy have brought about mechanisms for motor recovery after stroke. It helps to develop the Motor Relearning Program resulting in an effective restructuring of the motor cortex associated with motor recovery.

Stevens *et al.* [14] also reported that stroke patients who had been treated with mirror therapy for 3 to 4 weeks had an increase in Fugl Meyer assessment (FMA) scores, active range of motion, movement speed, and hand dexterity.

This study is consistent with the research of Uthra Mohan [15], who studied the clinical effectiveness of mirror therapy on the lower limb in patients with acute stroke. This study performed traditional rehabilitation therapy for 60 minutes with mirror therapy 30 minutes, 6 days per week, for 2 weeks. The mirror group was exhibited the better performance in motor recovery, balance, mobility, and ambulation categories than the control group.

Sütbeyaz *et al.* [16], indicated that MT enhanced lower limb motor recovery after practicing MT for a period of 12 months post-stroke. This experiment of MT showed the different effects between conventional rehabilitation therapy and mirror therapy. Treatment of 90 minutes per day was taken with the control group who had practiced the MT for 30 minutes and conventional rehabilitation therapy 60 minutes, 5 days per week, for 4 weeks. The study provided conflicting results with many parameters, and many outcome measures (which can affected lower extremity motor function) that have not been addressed. By the way, the participants repeatedly performed dorsiflexion of the ankles with the non-affected lower limb placed in front of a mirror. Based on the measurement of their functional ambulation categories, it revealed that the mirror therapy group achieved a statistically significantly higher improvement in gait ability than the control group.

A study by Ji and Kim [24] found that walking functional factors were significantly increased in the MT group when MT was conducted on stroke patients 5 times each week for 8 weeks. Hung *et al.* [25] reviewed the effect of mirror therapy on motor function, walking velocity, step length, passive range of motion (PROM) for ankle dorsiflexion.

It is generally agreed that early implementation of intensive stroke rehabilitation is associated with faster improvement in the performance of motor recovery after stroke occurance. There was more statistically significant improvement at the 12th week of treatment, and each patient group gained the higher scores of motor recovery after training. The Brunnstrom stage of motor recovery, FMA, and BBA scores have higher values, as shown in Table 2. After training, Brunnstrom stage and BBA showed that there was no statistically significant difference between both patient groups. However, the mirror group FMA was significantly higher than the control group in Table 3.

Feltham *et al.* [26] demonstrated that the treatment for visual feedback using a mirror positively affects coordination and neuromuscular activity of hemiplegic patients.

A study by Fadiga and Craighero [27] revealed that passive observation of action could help help facilitate motor cortex excitability of the muscles used in a specific action. The mirror neurons are now playing an essential role in learning of motor tasks and being required for social skills. Most of the studies on mirror therapy mainly focus on its effect on motor learning [28]. It is assumed that these motor learning systems can be applied to the motor recovery of motor function in patients with stroke [29], [30].

Mirror therapy is an intervention that applies visual information via mirror visual feedback (MVF) to stimulate the mirror neuron system and reduce motor impairment in the lower limbs following a stroke. Imaging studies have shown that mirror therapy facilitates neuroplasticity by stabilizing cortical activity within the primary motor cortex (M1), which is a key area for the development of paresis, and consequently restores motor command execution and function [31]–[33].

The effectiveness of mirror therapy depends on the motivation to practice of the patients. If the patients have a regular practice, the results are usually satisfying. Therefore, the tricks that help patients to continue regular practicing are essential for mirror therapy.

This study had a small sample size and was unable to control the patient's environment and training motivation at all times.

5 Conclusions

The study proposes that mirror therapy can improve lower limb motor recovery, functioning, and balance in acute stroke patients. Mirror therapy is cost-effective, simple to apply, and self-performing. However, further well-designed studies with a large sample size are needed to confirm its benefit. Using functional imaging techniques to detect brain reorganization may help to prove its neuroplasticity effects.

Acknowledgments

The authors are pleased to acknowledge the Faculty of Engineering, Faculty of Medicine, and Stroke Rehabilitation Unit of Thammasat University for supporting this research work. This work is supported by the Excellence Center in Stroke, Thammasat University.

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