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Original Article

Effect of mirror therapy on upper extremity motor function in stroke patients: a randomized controlled trial

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Abstract. [Purpose] This study aimed to evaluate the effectiveness of mirror therapy combined with a conventional rehabilitation program on upper extremity motor and functional recovery in stroke patients. [Subjects and Methods] Thirty-one hemiplegic patients were included. The patients were randomly assigned to a mirror (n=16) or conventional group (n=15). The patients in both groups underwent conventional therapy for 4 weeks (60–120 minutes/day, 5 days/week). The mirror group received mirror therapy, consisting of periodic flexion and extension movements of the wrist and fingers on the non-paralyzed side. The patients in the conventional group performed the same exercises against the non-reflecting face of the mirror. The patients were evaluated at the beginning and end of the treatment by a blinded assessor using the Brunnstrom stage, Fugl-Meyer Assessment (FMA) upper extremity score, and the Functional Independence Measure (FIM) self-care score. [Results] There was an improvement in Brunnstrom stage and the FIM self-care score in both groups, but the post-treatment FMA score was significantly higher in the mirror therapy group than in the conventional treatment group. [Conclusion] Mirror therapy in addition to a conventional rehabilitation program was found to provide additional benefit in motor recovery of the upper extremity in stroke patients.

Key words: Stroke rehabilitation, Mirror therapy, Upper extremity

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INTRODUCTION

Stroke is an important health problem with a high incidence and mortality that affects a large proportion of the population and causes disability in the survivors. Hemiplegia has been reported to develop in 85% of stroke survivors and 69% experience upper extremity functional limitations[1)]. Functional loss in the upper extremity causes difficulty in performing daily living activities, and causes to become dependent. The target in stroke rehabilitation is to enable the highest functional independence level possible for the individual and to increase the quality of life despite the current limitations. However, conventional treatment methods used for this purpose are insufficient in enabling upper extremity functional recovery.

Mirror therapy is a simple, inexpensive, and patient-oriented treatment. Functional brain imaging studies conducted on healthy individuals have shown that the ipsilateral primary cortex excitability increases when observing the mirror image of the hand during unilateral hand movements[2)]. Mirror therapy involves the superimposition of the reflections of healthy extremity movements on the affected extremity for the patient to observe them as if their extremity is moving[3)]. A mirror is placed at the midsagittal plane of the patient so that the healthy side image will be superimposed on the projection of the affected extremity[4)]. Thus, there is a visual illusion of increased movement ability of the paretic extremity[5)].

There are several studies on the effectiveness of mirror therapy in post-stroke upper extremity rehabilitation. While an

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improvement in the motor functions of patients who underwent mirror therapy was reported in some of these studies[6, 7], no difference was found between patients who had received mirror therapy and those receiving conventional rehabilitation in other studies[4]. The aim of the current study was to evaluate the effect of mirror therapy together with a standard rehabilitation program on upper extremity motor functions in a hemiplegic patient group and to investigate whether it provides additional benefit.

SUBJECTS AND METHODS

An assessor-blinded, randomized, controlled study design was used. The trial included 31 patients who developed hemiparesis after stroke and were hospitalized for rehabilitation at the Başkent University Physical Medicine and Rehabilitation Clinic between July 2013 and July 2014. Stroke was defined as an acute event of cerebrovascular origin that continued for more than 24 hours, lead to focal or global neurologic dysfunction, was diagnosed by a neurologist, and was verified by computed tomography or magnetic resonance imaging[8]. Study inclusion criteria were as follows: patients who were diagnosed with hemiplegia due to stroke that was unilateral and began within the past 6 months, a Brunnstrom stage for the upper extremity between I and IV, scores of ≥24 points on the Mini-Mental State, lack of excessive spasticity in the joints of the affected upper extremity (stage ≤2 according to the Modified Ashworth Scale), and no past history of stroke. Patients with joint movement limitations in the healthy upper extremity, a visual field defect or neglect syndrome, and those who had previously undergone a rehabilitation program were excluded from the study. All the potential participants were independently evaluated by a physician in terms considering the study inclusion criteria.

The study was approved by the Ethics Committee of the University with decision KA13/108 dated July 16, 2013. Written informed consent was obtained from all patients.

The study had 90% power with 5% type 1 error when a difference of 2.7 units between the Fugl-Meyer upper extremity scores of the groups was accepted as clinically significant.

The patients were evaluated before and after the treatment by a physician who had no information about the treatment groups or group assignments.

Upper extremity motor recovery was evaluated using Brunnstrom stages. Brunnstrom stage evaluates the motor development of hemiplegic patients. In this test, the recovery process is divided into 6 stages. The upper extremity, lower extremity, and the hand are evaluated separately. The lowest stage is identified as stage I (flaccid, no voluntary movement) and the highest stage as stage VI (isolated joint movement)[9].

The Fugl-Meyer Assessment (FMA) upper extremity score was used to evaluate the various dimensions of motor weakness[10]. FMA is a quantitative assessment tool that measures motor recovery after stroke in the shoulder, elbow, forearm, wrist, and hand. Points from 0 to 2 are given to each item according to the performance on the motor function evaluation (0: Unable to perform, 1: Performs partially, 2: Performs completely). The maximum motor performance score for the upper extremity is 66 points[11]. The scale has high intra-rater reliability (r=0.99), inter-rater reliability (r=0.94), and construct validity[12, 13].

The functional disability level was evaluated with the Functional Independence Measure (FIM) self-care subscale. FIM measures physical and cognitive dysfunction and the need for help, and consists of 18 items. These items are grouped in 6 subscales measuring self-care, sphincter control, transfers, locomotion, communication, and social cognition[14]. Changes in performance of activities are measured objectively through observation of the performance. Each item is evaluated with a 7-point Likert scale that specifies the amount of help needed (1=complete dependence, 7=complete independence). The maximum total score is 126 and the maximum self-care score is 42[15]. The validity and reliability of the Turkish version have been established[16].

After their basal evaluations were performed, the patients were randomly assigned to the mirror group (n=16) or the conventional group (n=15) by using a random number table. The randomization of the patients was conducted by a physician who was blinded to the study protocol and was not involved in the actual study.

The patients in both groups underwent 60–120 minutes of a conventional upper extremity rehabilitation program 5 times a week for 4 weeks. This program consists of neurodevelopmental facilitation techniques organized specifically for each patient, range of motion exercises, strengthening exercises, and occupational therapy. During the same period, in addition to the conventional treatment, the mirror group underwent 20 minutes of a mirror therapy program 5 times a week under the supervision of a therapist. Mirror therapy included flexion and extension movements of the non-paretic upper extremity wrists and fingers. The patients were seated on a chair with a table in front of them. The mirror was placed between the extremities and vertical to the table in front of them so that the non-paretic hand was reflected. The patients were asked to perform periodic flexion and extension movements of the wrist and fingers on the non-paretic side and to observe the reflection of these movements in the mirror under supervision. Patients could see only the non-paretic hand in the mirror. These movements were performed at the speed the patients desired. The patients in the conventional group performed the same exercises against the non-reflecting face of the mirror for an equal length of time. The same therapist delivered the mirror or sham therapy to the patients.

Statistical analysis was conducted with SPSS 22.0 software. The Kolmogorov-Smirnov test was used to evaluate whether the numerical variables had a normal distribution. Descriptive statistics were expressed as mean ± standard deviation for

Table 1. Demographic characteristics of the mirror and conventional groups

	Mirror group (N=16)	Conventional group (N=15)
Age (years) (mean ± SD)	60.9 ± 10.9	60.8 ± 20.0
Time since stroke (days) (mean ± SD)	46.1 ± 43.3	42.4 ± 37.8
Gender, n (%)		
Female	6 (37.5%)	8 (53.3%)
Male	10 (62.5%)	7 (46.7%)
Dominant side, n (%)		
Right	15 (93.8%)	15 (100.0%)
Left	1 (6.3%)	0 (0.0%)
Paretic side, n (%)		
Right	8 (50.0%)	9 (60.0%)
Left	8 (50.0%)	6 (40.0%)
Lesion type, n (%)		
Ischemic	15 (93.8%)	10 (66.7%)
Hemorrhagic	1 (6.3%)	5 (33.3%)

Table 2. Between-group differences of Brunnstrom stage change scores

	*Mirror Group (N=16)	Conventional Group (N=15)
Brunnstrom-arm		
*Pre-treatment, median (range)	1 (1–3)	1 (1–3)
Post-treatment, median (range)	2.5 (1–5)	2 (1–5)
Brunnstrom-hand		
Pre-treatment, median (range)	1 (1–3)	1 (1–3)
*Post-treatment, median (range)	3 (1–6)	2 (1–5)

*Statistically significant

numerical variables with a normal distribution, as median and interquartile range for numerical variables without a normal distribution, and as numbers and percentages for categorical variables. χ^2 and Fisher's tests were used to determine differences between the groups regarding frequencies. For the comparisons between the independent groups, the independent samples t-test (Student's t-test) was used when parametric test assumptions were met and the Mann-Whitney U test was used when they were not met. We used the Wilcoxon test for within-group comparisons because the parametric test assumptions were not met. A p-value less than 0.05 was considered statistically significant.

RESULTS

Demographic data of the groups are presented in Table 1. Baseline comparisons showed that age, gender, dominant hand, paretic hand, stroke etiology, time since stroke, upper extremity and hand Brunnstrom stages, FMA scores of the upper extremity, and FIM self-care scores did not differ between the groups at baseline (p>0.05).

After treatment, there was a statistically significant increase in the upper extremity Brunnstrom stages (p=0.001 for mirror group, p=0.008 for conventional group) and hand Brunnstrom stages (p=0.001 for mirror group, p=0.006 for conventional group) . However, we did not find a statistically significant difference between the pre- and post-treatment upper extremity and hand Brunnstrom stages of the groups (p>0.05).

The pre- and post-treatment Brunnstrom stages of the patients are presented in Table 2.

There was a statistically significant improvement in both groups in FMA after the treatment compared to the pre-treatment value (p=0.001 for both groups). The post-treatment FMA upper extremity score was statistically significantly higher in the mirror group than in the conventional group (p=0.047). The pre- and post-treatment FMA upper extremity score changes of the groups are shown in Table 3.

There was no statistically significant difference between the groups for the FIM self-care score after treatment (p>0.05), but there was a significant improvement compared to pre-treatment scores in both groups (p<0.001 and p=0.001, respectively). The pre- and post-treatment FIM self-care scores of the groups are presented in Table 3.

DISCUSSION

This study showed that mirror therapy combined with conventional rehabilitation in stroke patients provides additional benefit in terms of upper extremity motor improvement. However, we did not see any superiority over conventional treatments in the FIM self-care score that evaluates the daily living activities of a person.

Stroke can cause many disabilities in the life of a person despite the new advances in acute stroke treatment that have increased life expectancy[17)]. The aim of stroke rehabilitation should be to improve the patient's physical, cognitive, emotional, and social quality of life. Upper extremity paralysis, a common occurrence following stroke, is one of the most limiting problems for the patient[18)]. The aim in new approaches and treatment methods is to reactivate the plasticity characteristics of

Table 3. Between-group differences in FMA and FIM self-care change scores

	*Mirror Group (N=16)	*Conventional Group (N=15)
FMA upper extremity score		
Pre-treatment, mean (range)	12.8 ± 7.8 (5–25)	12.4 ± 8.9 (3–29)
*Post-treatment, mean (range)	27.1 ± 14.5 (5–59)	17.3 ± 11.7 (5–38)
FIM self-care score		
*Pre-treatment, mean (range)	11.6 ± 6.1 (6–28)	13.1 ± 5.1 (6–23)
Post-treatment, mean (range)	19.8 ± 8.1 (12–39)	16.9 ± 6.4 (7–29)

FIM: Functional Independence Measure; FMA: Fugl-Meyer Assessment.
*Statistically significant

the brain to regain the lost brain functions or maintain what is left. The motor cortex can be modified with repeated muscle activity, supporting the neural plasticity concept. Mirror therapy is one of the new approaches. The movements in front of a mirror are thought to trigger neuronal connections in the relevant motor cortex and functional magnetic resonance images (fMRI) have supported this hypothesis[19].

Ramachandran was the first to suggest that mirror therapy could increase movements of the paretic extremity after stroke[20]. Altschuler et al. suggested that mirror therapy provides a visual input regarding the normal movement of the affected arm and this may compensate for decreased or lost proprioceptive input[6]. Stevens and Stoykov have defined mirror therapy as some type of visually managed motor illusion where the movement is performed mentally without a clear application[5].

Dohle et al. conducted a randomized controlled study on 36 patients who had experienced acute ischemic stroke due to middle cerebral artery involvement. Mirror therapy (5 days a week, 30 minutes a day) was added to the standard treatment for 6 weeks. Mirror therapy was reported to result in a significant improvement only in the finger motor score of FMA with no difference between the groups in daily living activities. They also found a significant improvement in superficial touch sensation in the mirror group compared to the control group. They suggested that mirror therapy not only activated the motor cortex but also changed cortical somatosensorial representation[4]. In another study, a total of 60 acute stroke patients with severe upper extremity paralysis were divided into 3 groups: individual mirror therapy, group mirror therapy, and controls. The patients received mirror therapy or sham therapy for 30 minutes/day for a total of 20 sessions. While a moderate improvement in FMA scores was seen in all patients after the treatment, no difference was found among the groups[21]. Yavuzer et al. studied the effect of mirror therapy (5 days a week, 2–5 hours/day) in 36 patients with subacute stroke. The post-treatment evaluation of the patients revealed significant improvement in the hand and upper extremity Brunnstrom stages and the FIM self-care scores compared to the control group. This significant difference was still evident at the 6-month follow-up[7]. Similarly, Song et al. reported that mirror therapy improved upper extremity functions and daily living activities of patients with chronic stroke[1].

Michielsen et al. used a rehabilitation program 60 minutes a day, 5 days a week at home and 1 day a week at the hospital for 6 weeks in both groups in a randomized controlled study on patients with chronic stroke. The patients were evaluated before and after the treatment, and at the 6-month follow-up. FMA upper extremity scores of the patients were found to be significantly high in the mirror group, but this difference was not maintained at the 6-month follow-up. There was no significant difference in any other outcome measure. However, changes in the primary motor cortex in the affected hemisphere were detected on fMRI in the mirror group[22].

A Cochrane review that included 14 randomized controlled studies of 567 patients reported that mirror therapy is markedly useful in the development of motor functions, with the available evidence indicating a beneficial effect on daily living activity performance and pain, with the development of motor functions continuing through 6 months post-treatment[23]. However, the effects on the motor functions were also found to change according to the type of treatment used in the control group. The small sample size, different rehabilitation programs used in the control groups, and certain methodological limitations in most of these studies were recognized as limitations of the reviewed articles. Motor function was used as the primary outcome in the included studies. The most commonly used measures for the evaluation of motor function were the FMA scale[22–25] and Brunnstrom stage[7]. The FMA upper extremity score and Brunnstrom stage were used in the current study. Similar to other studies, a significant improvement was found in FMA following mirror therapy when compared to the control group. However, there was no significant improvement in the Brunnstrom stage compared to the control group. Improvement following a stroke is most striking in the first 12 months[26]. Patients enrolled in this study were in the first 6 month period following their strokes. Therefore, motor improvement was found in both groups.

The FIM self-care subscore was used to evaluate daily living activities. The FIM self-care subscore showed a significant improvement in both groups, but there was no difference between groups. This may be due to the relative inadequacy of the sample size, the short treatment duration, or the fact that the vast majority of the patients were Brunnstrom stage I or II. Dohle et al. found no difference between the groups regarding FIM motor subscores, similar to this study, but there was a significant improvement in the mirror group regarding FMA upper extremity scores[4]. The lack of long-term follow-up may also lead to misinterpretation of treatment results. Plasticity dependent on repeated muscle activity may take days, months, or years to appear and may contribute to improved function through cortico-motor reorganization[27].

Although a borderline significant improvement was found in the FMA upper extremity scores of the patients in the mirror group compared to the conventional group, the lack of a difference between the groups for Brunnstrom stages may be because the patients did not perform an exercise program for the proximal part of the arm in front of a mirror. The patients were instructed to perform only joint range of motion movements with the wrist and fingers. This may explain why we did not see a significant improvement in Brunnstrom stage, where synergy patterns are evaluated. All isolated muscle movements are evaluated with the FMA, so motor improvement may be reflected more rapidly in the scale results.

Mirror therapy is a simple, easy to use, and low-cost rehabilitation method for patients and staff, and it can be integrated into the home environment. Studies on the effectiveness of mirror therapy have mostly focused on upper extremity function. However, the number and content of published studies is inadequate to support any robust conclusions.

The limitations of this study are the low number of subjects, the lack of an imaging technique that shows post-treatment brain reorganization, and a short follow-up. Larger and well-designed randomized controlled studies are required to investigate the effectiveness of post-stroke mirror therapy. Future studies should compare mirror therapy with conventional rehabilitation and newly developed treatment methods, and should try to determine the optimum frequency and duration of mirror therapy while also focusing on daily living activities. Studies evaluating the effectiveness of mirror therapy at different periods after stroke will also be useful in the identification of the period when the most benefit will be observed.

In conclusion, mirror therapy used in addition to conventional rehabilitation methods was found to be effective in the development of upper extremity motor functions in stroke patients. Mirror therapy was not superior to the conventional treatment group in increases in the FIM self-care scores that we used for the evaluation of daily living activities but longer follow-up of the patients may change these results. Larger randomized controlled trials are needed to evaluate mirror therapy. The new treatment methods that are already used or will be developed with a better understanding of neural plasticity and use of functional brain imaging methods will enable us to reach the next level in stroke rehabilitation.

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