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Original Article

The effects of very early mirror therapy on functional improvement of the upper extremity in acute stroke patients

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Abstract. [Purpose] The aim of the study was to evaluate the effects of a very early mirror therapy program on functional improvement of the upper extremity in acute stroke patients. [Subjects] Eight stroke patients who were treated in an acute neurology unit were included in the study. [Methods] The patients were assigned alternatively to either the mirror therapy group receiving mirror therapy and neurodevelopmental treatment or the neurodevelopmental treatment only group. The primary outcome measures were the upper extremity motor subscale of the Fugl-Meyer Assessment, Motricity Index upper extremity score, and the Stroke Upper Limb Capacity Scale. Somatosensory assessment with the Ayres Southern California Sensory Integration Test, and the Barthel Index were used as secondary outcome measures. [Results] No statistically significant improvements were found for any measures in either group after the treatment. In terms of minimally clinically important differences, there were improvements in Fugl-Meyer Assessment and Barthel Index in both mirror therapy and neurodevelopmental treatment groups. [Conclusion] The results of this pilot study revealed that very early mirror therapy has no additional effect on functional improvement of upper extremity function in acute stroke patients. Multicenter trials are needed to determine the results of early application of mirror therapy in stroke rehabilitation.
Key words: Acute stroke, Mirror therapy, Upper extremity

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INTRODUCTION

Stroke is the leading cause of disability among adults, and upper extremity hemiparesis restricts functional activities predominantly in the long term[1, 2)]. As upper-extremity function is critical for the performance of fine motor tasks, its therapeutic importance should be emphasized during rehabilitation programs[3, 4)]. Clinical trials have shown a better motor outcome with various sensorimotor programs, including repetitive task-oriented activities, constraint-induced movement therapy, biofeedback and functional electrical stimulation[5–7)].

Presentation of visual feedback is a form of sensory stimulation widely used to improve motor performance in stroke rehabilitation practice. Mirror therapy (MT) provides a form of visual feedback by having the subject watch his/her unaffected extremity's reflection in a mirror[8)]. The mechanism of MT relies on the mirror neuron system which is composed of a form of visuomotor neuron located in the premotor cortex, the primary somatosensory cortex and the inferior parietal cortex. The system is activated by passive observation or imagination or execution of an action[9)]. It is known that stimulation of the mirror-neuron system facilitates the primary motor cortex, which controls an action when performing a task[10–12)]. In many studies, it has been revealed that MT is an effective additional treatment option for the upper extremity of stroke patients[13–16)]. Also, some comparative studies have investigated the effectiveness of MT in conjunction with other neurophysiological approaches or physical modalities[17–19)]. However, more research is needed on optimal patient selection, application programs, duration, and intensity of MT[20)].

Although studies on the effects of MT on the upper extremity have demonstrated improvements in recovery of motor function and self-care ability in subacute and chronic stroke patients, the literature on MT with respect to improve-

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ment of upper extremity function is limited to information about patients during the two months post stroke[21]. On the other hand, it is well known that the length of time since stroke onset is important in rehabilitation interventions for motor learning in early stroke. Furthermore, multisensory stimulation in early rehabilitation interventions leads to improved brain plasticity[22]. Clinical trials on stroke rehabilitation have provided evidence concerning its effectiveness during poststroke recovery when the rehabilitation program is administered in the early stage[23]. In this regard, therapeutic interventions should focus on the upper extremity as soon as the patient's condition is stable.

To our knowledge, the effects of MT applied within a few days post stroke have been investigated only in an article that explored the effectiveness of MT in the treatment of unilateral neglect[24]. Although there is evidence concerning the beneficial effect of MT within 6 months on post stroke[25, 26], there is no knowledge about accurate time and adherence factors to initiate MT in acute phase of stroke.

This pilot study investigated the effect of a very early MT program on functional improvement of the upper extremity when applied to inpatients with acute stroke immediately after stroke.

SUBJECTS AND METHODS

In this pilot study, all patients were assigned to either the MT group receiving MT and neurodevelopmental treatment (NDT) or the NDT only group. Patients received their group allocation assignments before baseline measurements were performed.

The patients were from the Department of Neurology, Bakirkoy Research and Training Hospital for Neurologic and Psychiatric Diseases, and were included after a neurologic assessment. The inclusion criteria were (1) diagnosis of a stroke (within 1 month), (2) partial anterior circulation infarction (PACI), (3) upper extremity motor functional level according to Brunnstrom stages between 1 and 4, and (4) no musculoskeletal injury history in the affected upper extremity. The patients who had a residual upper extremity deficit from a previous stroke, intolerance to upright position, visual problem, cognitive deficit preventing them from following instructions, and unilateral neglect preventing them from being able to view the mirror were excluded.

In this pilot study, one hundred and twenty patients were assessed in terms of eligibility criteria, and 30 patients were included in the study; only eight patients (approximately 7%) completed the study. Usual care services were provided throughout the early period.

The patients were informed about the study, and written informed consent was provided by each patient. The study was approved by the Local Ethics Committee (No. 41340010/18954-290) and conducted according to the Helsinki Declaration.

Primary outcome measures were the upper extremity motor subscale of the Fugl-Meyer Assessment (FMA), the Motricity Index (MI) upper extremity score, and the Stroke Upper Limb Capacity Scale (SULCS). Secondary outcome measures were somatosensory assessment with the Ayres Southern California Sensory Integration Test, and the Barthel Index (BI). Measurements of upper extremity function were performed before the intervention (baseline) and after the intervention (post treatment). All assessments were made by the same investigator, who was blinded to group allocation.

Upper-extremity motor recovery was measured using the FMA, which consists of 18 items dealing with the shoulder/elbow/forearm, five items dealing with the wrist, seven items dealing with the hand, and three items dealing with coordination. The maximum score of the FMA is 66, and each item is scored an ordinal scale from 0 to 2, with 2 representing no deficit. The test-retest and interrater reliability of the upper extremity scale of the FMA were excellent[27]. Arya et al.[28] defined clinically important difference in FMA in stroke patients as an improvement of 10 or more points.

The MI measures both upper and lower extremity motor abilities. In this study, only upper extremity abilities including hand-grasp, elbow flexion, and shoulder abduction were assessed on the affected side. The reliability and validity of this scale have been confirmed[29].

The SULCS is a new unidimensional, hierarchical scale that assesses upper extremity capacity and consists of 10 items. The total score is calculated as a sum score for all items, which are rated between (0, unable to perform task) and (1, able to perform task), with a higher score indicating better upper extremity capacity[30].

The Ayres Southern California Sensory Integration Tests were used to assess sensory integration. These tests evaluate visual perception, somatosensory perception, and motor performance with the body crossing the midline and right-left discrimination[31]. In this pilot study; finger identification and the right-left discrimination tests for somatosensory perception were applied.

The BI was used to determine the level of independence in functional activities and included ten items. The score ranges from 0–100, and a higher BI score indicates better functioning[32]. Minimal clinically important difference for BI is 18.5 points[33].

The NDT group received individualized therapy sessions that were based on the Bobath Concept and lasted 40 minutes. In the MT group, each subject participated in a very early MT program that lasted 20 minutes, in addition to individualized NDT. All treatments were applied once a day, five times a week for 3 weeks. The therapy program was conducted as inpatient rehabilitation, after a patient was discharged from the acute stroke service, the program was continued as outpatient rehabilitation in the physiotherapy unit of the division of physiotherapy and rehabilitation by the same physical therapists.

The physical therapist (B.E.H.) analyzed the movement and task performance related to the rehabilitation goal to identify activity limitations and problems relating to movement dysfunction. Therapy sessions were planned based on the Bobath concept to obtain the identified goals for each patient. The emphasis was on control of muscle tone, quality of movement, external support, weight-bearing, and stability of the trunk during arm activity in functional situations with various positions (lying, sitting, and standing both with and without objects and during unilateral or bilateral tasks).

In the MT program, with the patient in a sitting posi-

Table 1. Demographic and clinical features of the subjects

	MTG	NDTG
	Mean ±SD/n	Mean ±SD/n
Number of patients	4	4
Age (years)	57.2±6.5	66±5.4
Time since stroke (days)	8.5±4.4	10±12.5
Gender (female/male)	2/2	1/3
Previous stroke history	1	1
Comorbidities		
Hypertension	3	4
Hyperlipidemia	1	-
Diabetes mellitus	2	1
Coronary artery disease	3	1
Type of stroke		
Ischemic	4	4
Affected side (dom/ndom)	3/1	2/2

MTG: mirror therapy group; NDTG: neurodevelopmental therapy group; dom: dominant; ndom: nondominant

Table 2. Comparison of inter- and intragroup changes

	BT median min–max	AT median min–max	Δ	BT median min–max	AT median min–max	Δ
ASIT						
FI	13 (0–16)	14.5 (0–16)	1.5	14 (0–16)	14.5 (0–16)	0.5
RLD	17 (10–20)	20 (20–20)	3	15 (3–20)	20 (5–20)	5
FMA	6 (5–21)	34 (9–63)	28	11 (0–50)	29 (7–66)	18
MI	7.5 (0–29)	45 (19–76)	37.5	24 (0–56)	48 (10–77)	24
SULCS	1.5 (1–3)	5.5 (2–10)	4	1.5 (0–5)	5 (1–10)	3.5
BI	40 (30–50)	62.5 (35–90)	22.5	35 (20–80)	62.5 (30–90)	27.5

MTG: mirror therapy group; NDTG: neurodevelopmental therapy group; BT: before treatment; AT: after treatment; ASIT: Ayres Sensory Integration Test; FI: finger identification; RLD: right-left discrimination; FMA: Fugl-Meyer Assessment; MI: Motricity Index; SULCS: Stroke Upper Limb Capacity Scale; BI: Barthel Index

tion on a bed, a mirror was positioned perpendicular to the patient's midline. The affected hand was put into a mirror box, whereas the unaffected hand was placed in front of the reflective surface. The unaffected extremity of the subject was put in front of the mirror so that it would create a visual image via its reflection in the mirror. By doing this, the patient sees the illusion of an unaffected extremity instead of actual extremity. The therapist (I.Y.) told the patient to focus only on what could be seen in the mirror. The mirror box was composed an acrylic mirror (22 cm×35 cm×22 cm) and blackboards. The box was designed to allow it to be folded and easily carried.

The very early MT program was designed to improve upper extremity motor function including specific hand activities used in activities of daily living. In the MT program, task-oriented activities were designed individually according to each patient's orientation, attention, and movement accuracy, beginning from gross motor activities to fine motor activities, during sessions. The complexity of the tasks was increased gradually depending on the patient's attention. The intervention was performed by the subjects themselves under the supervision of a physical therapist; some instructions were given to the patients, and some modifications were allowed to increase performance.

Statistical analysis was performed using the IBM SPSS Statistics for Windows software package (version 22.0; IBM Corp., Armonk, NY, USA). Data are presented as the mean ± standard deviation. At baseline and after the treatment, the outcomes in the two groups were summarized and recorded as means and standard deviations (SDs). Within-group and between-group differences were compared with Wilcoxon and Mann-Whitney U tests. A p-value <0.05 was considered statistically significant for all analyses.

RESULTS

A total of 30 eligible patients were included in this pilot study. Twenty two patients dropped out of the study. Six patients were excluded during the study period because of insufficient cooperation, and 16 patients dropped out because of difficulty regarding transportation to the outpatient rehabilitation unit. Demographic and clinical features of the two groups are presented in Table 1. Both the primary and secondary outcome measurement scores demonstrated no statistically significant difference at baseline (p>0.05). No statistically significant improvement were found for any measures in either group after treatment (p>0.05) (Table 2).

Primary and secondary outcome results of each subject in both groups are shown in Table 3. In terms of minimally clinically important differences (MCIDs), there were some improvements in FMA and BI in both the MT group and NDT groups (two patients from both groups).

No adverse event occurred during the training period in the current study. There were no deleterious effects of the very early MT or NDT on measurement parameters.

DISCUSSION

This pilot study indicated that very early MT has no additional effect on functional improvement of the upper extremity function in acute stroke patients. Also, we did not observe any adverse effects of the very early MT in the acute phase of stroke.

In the literature, it has been reported that, application of MT may result in beneficial effects on upper extremity motor control in chronic stroke patients, excluding those with severe arm paresis[34]. However, there is limited scientific evidence regarding the effect of MT in acute stroke patients. Invernizzi et al.[35] demonstrated that patients treated with MT showed better results than their control groups in the

Table 3. Primary and secondary outcome results of patients

		MTG				NDTG			
Parameters		Subject 1	Subject 2	Subject 3	Subject 4	Subject 1	Subject 2	Subject 3	Subject 4
ASIT									
FI	BT	16	0	16	10	0	12	16	16
(0–16)	AT	16	0	16	13	0	16	16	16
	Δ	0	0	0	3	0	4	0	0
RLD	BT	10	14	20	20	3	20	20	10
(0–20)	AT	20	20	20	20	5	20	20	20
	Δ	10	6	0	20	2	0	0	10
FMA	BT	21	5	7	5	0	50	4	18
(0–66)	AT	63	9	59	9	7	66	13	45
	Δ	42	4	52	4	7	16	9	27
MI	BT	29	0	15	0	0	56	0	48
(0–100)	AT	76	19	71	19	19	77	10	77
	Δ	47	19	56	19	19	21	10	29
SULCS	BT	3	1	2	1	0	3	0	5
(0–10)	AT	10	2	9	2	1	10	1	9
	Δ	7	1	7	1	1	7	1	4
BI	BT	50	30	50	30	20	80	35	35
(0–100)	AT	90	35	90	35	30	90	60	65
	Δ	40	5	40	5	10	10	25	30

MTG: mirror therapy group; NDTG: neurodevelopmental therapy group; BT: before treatment; AT: after treatment; ASIT: Ayres Sensory Integration Test; FI: finger identification; RLD: right-left discrimination; FMA: Fugl-Meyer Assessment; MI: Motricity Index; SULCS: Stroke Upper Limb Capacity Scale; BI: Barthel Index

Action Reach Arm Test, Functional Independence Measure and MI 23 days after stroke. In another study, Radajewska et al.[21] indicated that MT improves the ability to independently perform activities of daily living in patients with right arm paresis after stroke. They included 60 right-handed poststroke patients at 8–10 weeks (average 9.25) after onset who had already completed stationary neurorehabilitation in a rehabilitation center. In patients with a mean duration post stroke of a little as 7 days only Mohan et al.[36] has reported that MT early after stroke is not superior to conventional treatment for improvement of lower extremity motor recovery and balance, with the exception of improvement of mobility in first time stroke patients. Similarly, the patients included in the present pilot study in the very early period post stroke days (6 days), and the observed improvements in motor function reached up to 50% in the patients in terms of MCIDs in both groups. To our knowledge, no findings for MCIDs of ASIT, MI and SULCS measures have been reported. The results of this study show that there is no additional effect of application of very early MT on upper extremity function in acute stroke patients.

In terms of somatosensory recovery, there is limited information about the contribution of MT in stroke patients. Pandian et al.[24] reported that MT improves unilateral neglect in acute stroke patients. In another study, Wu et al.[37] evaluated patients with the Revised Nottingham Sensory Assessment and found that there was statistically significant improvement in their MT group in temperature sense. In this pilot study, we did not observe any improvement in finger identification or in the right-left discrimination tests in Ayres Southern California Sensory Integration Tests. Our very early MT protocol focused on motor training, and we did not apply specific sensory training. We included sensory assessment to evaluate the contribution of the visual illusion in MT, which provides proper sensory inputs.

In the literature, there is no agreement on aspects such as optimal patient selection or duration and intensity of training of the MT. Due to only 25% of assessed patients being suitable candidates for MT, we suggest that clinical factors, such as loss of attention, and insufficiency in trunk control, which restricts initiation of MT, should be assessed carefully to make a decision when to begin MT. Because cognition, vision, neglect, and fatigue can affect treatment compliance and response, all stroke patients may not be proper candidates for participation in MT. None of the reported dropouts were because of adverse treatment effect.

Since a 20-minute session of MT application is a long time for patients to focus on a treatment, some modifications in relation to time of application of MT may be required, and interval training may be a proper option in acute neurology units. Because they were training their unaffected upper extremity, some patients had difficulty realizing the rationale for the therapy.

The study design includes some important features that should be considered in interpretation of the results. Firstly, the importance of applying an adequate dose of MT is crucial to achieve a therapeutic effect. For this reason, MT sessions were applied in a manner similar to the other studies in the literature. Secondly, a concomitant intervention (the individualized motor training programme) was imple-

mented. Thirdly, in determination of improvements in upper extremity function, ICF domains including body structures and activity level were used. We did not assess participation level because of the stage of the disease.

The study has some limitations regarding interpretation of its results. One of them is the very small sample size. The second limitation is, the use of medication that may have contributed to outcomes, as our study was conducted in the acute phase of stroke. The final limitation of the study is that its results cannot be generalized because of the small sample size.

This pilot study indicated that very early MT has no additional effect on functional improvement of upper extremity function in acute stroke patients. It also indicated that MT can be applied safely if clinical characteristics are assessed carefully to determine when or if very early MT should be initiated. Further research is required to determine the effectiveness of application very early MT with interval training. Incorporating MT into an NDT program at the early stages of treatment and applying it frequently with short periods might be even more beneficial for improving upper extremity function.

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