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Efficacy of mirror therapy in subacute stroke: A case-control study

Deo Rishi Tripathi[1], Mahesh Kumar Talele[2*], Surya Bhan Singh[1], Shipra Chaudhary[1] and Amod Kumar[1]

[1]Department of Physical Medicine and Rehabilitation, PGIMER & DR. Ram Manohar Lohia Hospital, New Delhi-110001, India and [2]Department of Neurological Rehabilitation, NIMHANS, Bengaluru-560029, Karnataka, India

Abstract: *Context:* The effect of mirror visual illusions on brain activity has been investigated in a number of studies. Motor imagery can be defined as the covert cognitive process of imagining a movement of your own body (-part) without actually moving that body (-part). *Aims:* Our aim was to investigate whether mirror therapy is effective at short-term (at 4wk) and long-term (at 6month) intervals on motor recovery, spasticity, and hand-related functioning of patients with subacute stroke. *Methods and Material:* The study recruited 40 patients suffering from sub-acute stroke with a male: female ratio of 27:8 of mean age 48.42years (age range 23-70 years). Mirror therapy was given in OPD setting over 5 weekly doses. Both the mirror group and control group participated in a conventional stroke rehabilitation program, 6 days a week, 2 to 3 hours a day with therapist in hospital and 1 hour at home for 4 weeks and follow-up at 6 months . The conventional program consists of neuro-developmental facilitation techniques, physiotherapy, occupational therapy, and speech therapy (if needed). For the same period, the mirror group received an additional 30 minutes of mirror therapy program per day. Statistical analysis used. *Results:* The mirror therapy treatment compared to the control group showed significant improvement at 4 weeks re-assessment from baseline assessment on hand functioning in Brunnstorm, Action Research Arm test and Functional Independence Measures. The mirror therapy treatment compared to the control group at 6-months of follow up reassessment from 4 weeks assessment showed moderate but insignificant improvement in the Brunnstorm and Action Research Arm test and significant improvement in Functional Independence Measures. *Conclusion:* In our group of subacute stroke patients, hand function improved more after mirror therapy in addition to a conventional rehabilitation program compared with a control treatment directly after 4 weeks of treatment and at the 6-month follow-up, whereas mirror therapy does not affect spasticity.

Keywords: Stroke, Mirror Therapy, Action Research Arm test.

Introduction

Cerebrovascular accident (CVA) is to be a national health problem in India. CVA is a complex dysfunction caused by a lesion in the brain. Majority of stroke survivors continue to live with disabilities, and the costs of on-going rehabilitation and long term-care are largely undertaken by family members, which impoverish their families [1-2].

According to the India stroke factsheet updated in 2012, the estimated age-adjusted prevalence rate for stroke ranges between 84/100,000 and 262/100,000 in rural and between 334/100,000 and 424/100,000 in urban areas [3]. A stroke study conducted in Kolkata [4] from 1998 to 1999 showed a crude prevalence rate of 147/100,000 and an annual incidence rate of 36/100,000. When adjusted to the 1996 US population, the age-adjusted prevalence rate was 334/100,000 and the age-adjusted annual incidence rate was 105/100,000. Compared to men, women had substantially higher age-adjusted prevalence rate (564/100,000 for women versus 196/100,000 for men) and incidence rate (204/100,000 for women versus 36/100,000 for men). For all age groups except for people aged 50-69 years, women had a higher prevalence rate than did men. Among stroke patients who underwent neuroimaging study (59.5% of all strokes), 68% proved to be infarct and the remaining 32% to be haemorrhage. It has been suggested that mirror therapy is a simple, inexpensive and, most importantly, patient-directed treatment that may improve upper-extremity function. Ramachandran and Rogers-

Ramachandran [5] were the first to introduce the use of these visual illusions created by a mirror for treatment of phantom limb pain. By superimposing the intact arm on the phantom limb using a mirror reflection, patients reported the sensation that they could move and relax the often-cramped phantom limb and experienced pain relief [6]. Since this initial report, successful use of mirror therapy has been reported in patients with other pain syndromes, such as complex regional pain syndrome [7-8], and in sensory re-education of severe hyperesthesia after hand injuries [9]. Previous studies in stroke, although undersized and not sufficiently controlled, suggested that mirror therapy may be beneficial for motor function recovery in the paretic hand [10-12].

The use of mirror therapy in post-stroke patients involves a re-assemblage of the body image in the sensorimotor cortex, which can generate movement limitations, classified as "learned paralysis". In fact, the fibers that extend from the brain to the spinal cord are deprived of oxygen and suffer an injury, causing a real paralysis. In addition to this, in the early stages of cerebral damage, the penumbra area presents a cellular swelling, temporarily leaving neurons with little or no conduction property. Moreover, during its inactive period, the brain receives only negative visual feedback; this will possibly promote a form of learned paralysis, due to residual mirror neuron functioning.

Several underlying mechanisms for the effect of mirror therapy on motor recovery after stroke have been proposed. For example, Altschuler et al suggested that the mirror illusion of a normal movement of the affected hand may substitute for decreased proprioceptive information, thereby helping to recruit the premotor cortex and assisting rehabilitation [10] through an intimate connection between visual input and premotor areas. Altschuler et al reported that range of motion (ROM), speed, and accuracy of arm movement were more [10] improved after mirror therapy. Stevens and Stoykov [12] suggested that mirror therapy related to motor imagery and that the mirror creates visual feedback of successful performance of the imagined action with the impaired limb. Stevens and Stoykov also reported that their 2 stroke patients trained with mirror therapy for 3 to 4 weeks and had an increase in Fugl-Meyer Assessment score, active ROM, movement speed, and hand dexterity [12] after mirror therapy. In a recent randomized controlled [13] trial, Sütbeyaz et al showed an improved lower-extremity motor recovery and motor functioning in subacute stroke patients after 4 weeks of mirror therapy. Therefore, mirror therapy has been used in many clinical instances, because it accelerates the functional recovery of a wide range of sensorimotor disorders, such as post-stroke hemiparesis [13]. Hamzei et al.[14] studied the neural plasticity in the primary sensory motor cortex using mirror therapy conducting an experiment in which subjects performed hand movement tasks for 20 minutes every day during 4 days. We hypothesized that congruent visual feedback from the moving nonparetic hand, as provided by a mirror, would restore function of the affected hand.

Aims & Objectives: Our aim was to investigate whether mirror therapy is effective at short-term (at 4wk) and long-term (at 6month) intervals on motor recovery, spasticity, Functional Independence Measures and hand-related functioning of patients with subacute stroke.

Material and Methods

This study was part of the routine therapeutic procedures followed in the department of physical medicine and rehabilitation of Dr Ram Manohar Lohia Hospital, New delhi. The patients were referred from Neurology and Medicine departments to our stroke clinic. Physiatrist along with an occupational therapist and physiotherapist assessed patients to determine eligibility and collect written informed consent.

The trial included 35 patients with hemiparesis after stroke {mean age, 48.42 years (age range 23-70 years); mean time since stroke, 4.48 months} from February 2012 to August 2014, all of whom met the study criteria. Stroke was defined as an acute event of cerebrovascular origin causing focal or global neurologic dysfunction lasting more than 24 hours, as diagnosed by a neurologist and Medicine specialist and confirmed by computed tomography or magnetic resonance imaging.

Inclusion Criteria:

1. Had a first episode of unilateral stroke with hemiparesis during the previous 12 months
2. Had a Brunnstrom score between stages I and IV for the upper extremity,
3. were able to understand and follow simple verbal instructions,
4. Had no severe cognitive disorders that would have interfered with the study's purpose (Mini-Mental State Examination score >24).

Study Design: The protocol was approved by Ethics Committee. The required sample size was determined by using the pooled estimate of within-group standard deviations obtained from pilot data. Power calculations indicated that detecting a 20% difference in improvement in FIM self-care score between groups (with β=.20 and α=.05) would require a sample of 15 subjects for each group. Patients were Divided into two group Control group and Mirror group by simple random selection. All assessments were performed by Physiatrist, Physiotherapist and Occupational therapist who was blinded to the treatment assignment. After signing informed consent and baseline measurements, patients were randomly assigned to either the mirror group (n=18) or the control group (n=17).

Interventions: Both the mirror group and control group participated in a conventional stroke rehabilitation program, 6 days a week, 2 to 3 hours a day with therapist in hospital and 1 hour at home for 4 weeks and follow-up at 6 months. The conventional program consists of neuro-developmental facilitation techniques, physiotherapy, occupational therapy, and speech therapy (if needed). For the same period, the mirror group received an additional 30 minutes of mirror therapy program per day. Two Box were made (20x12x12inch) and mirror is (12(ht)x12(L) inches) one box is for Right side hemiplegia and another one is for left sided hemiplegia.

Mirror is placed in mid of the box. During the mirror practices, patients were seated close to a table on which a mirror box was placed. The involved hand was placed behind the mirror and the noninvolved hand in front of the mirror. The practice consisted of nonparetic-side wrist and finger flexion and extension movements while patients looked into the mirror, watching the image of their noninvolved hand, thus seeing the reflection of the hand movement projected over the involved hand. Patients could see only the noninvolved hand in the mirror; otherwise, the noninvolved hand was hidden from sight. During the session patients were asked to try to do the same movements with the paretic hand while they were moving the nonparetic hand. The control group performed the same exercises for the same duration but used the nonreflecting side of the mirror in such a way that the paretic hand was hidden from sight. The same therapist delivered the mirror or sham treatment to the patients.

Outcome Measures Outcome was measured in terms of motor recovery (Brunnstrom stages), spasticity (Modified Ashworth Scale [MAS]), the self-care items of the FIM instrument and Action Research Arm Test (ARAT). Outcome measures were performed at 0 months (pretreatment), 4 weeks (post treatment), and 6 months (follow-up). Pretreatment and post treatment assessments were performed while patients were in the rehabilitation ward, whereas follow-up assessments were performed in the outpatient clinic. We called every participant by phone after discharge and invited them to our outpatient clinic to minimize loss to follow-up.

Motor Recovery: Brunnstrom defined 6 sequential stages of motor recovery and described how the hemiplegic arm and hand progress through these stages as a method for assessing recovery.

The 6 stages of Brunnstrom for the hand are;1st flaccidity; 2nd little or no active finger flexion; 3rd mass grasp, use of hook grasp but no release, no voluntary finger extension, and possibly reflex extension of digits; 4th lateral prehension, release by thumb movement, semivoluntary finger extension, with small range; 5th palmar prehension, possibly cylindric and spheric grasp, awkwardly performed and with limited functional use, voluntary mass extension of digits, with variable range; and 6th all prehensile types under control, skills improving, full-range voluntary extension of digits, individual finger movements present but less accurate than on the opposite side. Despite some reports about its low responsiveness to change, we preferred

the Brunnstrom staging system because it reflects underlying motor control based on clinical assessment of movement quality. Higher Brunnstrom scores indicate better motor recovery.

Spasticity: The MAS was used to grade the spasticity of the wrist flexor muscles. The MAS is a 5-point ordinal rating scale with good interrater reliability designed to measure muscle tone. MAS scores range from 0 to 4: a MAS score of 0 represents "no increase in muscle tone," and a score of 4 is "limb rigid in flexion or extension".

Hand-Related Motor Functioning: The FIM is the functional status component of the Uniform Data System for Medical Rehabilitation. It contains 18 items that measure independent performance in self-care, sphincter control, transfers, locomotion, communication, and social cognition. The FIM scores range from 1 to 7: a score of 7 represents "complete independence," and a score of 1 is "complete dependence" (performs less than 25% of task). The FIM self-care subscale was used in the present study; the total score ranges from 6 (lowest) to 42 (highest). The reliability and validity of the Turkish version of the FIM has been documented.

Action Research Arm Test: There are four subtests (items) each has 3 marks: Grasp (6), Grip (4), Pinch (6), Gross Movement (3). Items in each are ordered so that, if the subject passes the first, no more need to be administered and he scores top (18, 12, 18, 9) marks for that subtest; if the subject fails the first *and* fails the second, he scores zero (0), and again no more tests need to be performed in that subtest; otherwise he needs to complete all tasks within the subtest.

Statistical Analysis: We analyzed data using SPSS for Windows. All statistical analysis was performed on the final 35 patients, and there were no missing data. Groups were compared at baseline using the *t*-test for independent samples for the continuous variables and the chi-square test or Fisher exact test for categoric data. To investigate whether the mirror group changed by more than the control group at post treatment and at follow-up, we calculated change scores for each group and compared them by using an independent samples *t*-test.

Results

Baseline comparisons showed that age, sex, injury characteristics, time since stroke, Brunnstrom stages, MAS of wrist flexor muscles, and FIM self-care scores did not differ between the groups(control group and mirror group) (P>.05).

Table-1: Demographic Characteristics of the Mirror and Control Groups and Baseline Measurements

Characteristic	Mirror Group Mean+- SD	Control Group Mean+- SD	*P*
No. of patients (N)	18	17	
Age (y)	51.89±(13.89)	44.76±(18.4)	0.203
Time since stroke (mo)	3.44±(1.37)	5.59±(5.28)	0.122
Female/male	3/ 15	5/ 12	
Paretic side (right/left)	Right	right	
Dominant (right/left)	Right	right	
Lesion type (ischemic/hemorrhagic)	15 / 3	9 / 8	
Brunnstrom stage (hand)	2.22±0.428	1.94±0.243	0.785
Action Research Arm Hand test	7.67±9.555	6.71±6.752	0.735
FIM self-care score	35.22±3.75	34.59±2.623	0.568

Fig-1: Comparison of Brunnstorm staging between groups

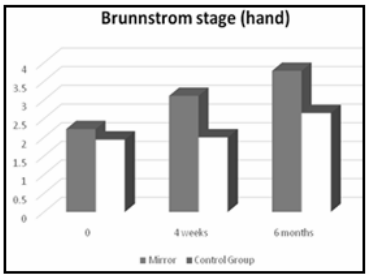

Fig-2: Comparison of Action Research Arm test between groups

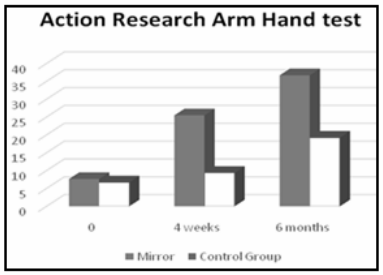

Fig-3: Comparison of FIM scores between groups

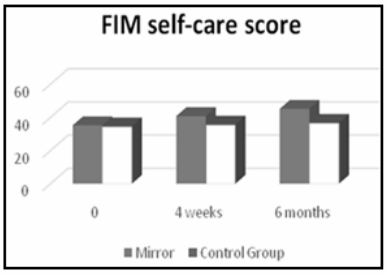

Table-2: Presents the between-group comparisons of the change score for motor recovery, spasticity and hand-related functioning both from baseline to posttreatment and posttreatment to follow-up

Characteristic	Group	0-4 week	Unpaired P-value	4week-6month	Unpaired P-value
Brunnstrom stage (hand)	Mirror Group	0.89±(0.323)	0.000	0.67±(0.485)	0.906
	Control Group	0.06±(0.243)		0.65±(0.493)	
Action Research Arm Hand test	Mirror Group	17.83±(5.864)	0.000	11.22±(3.405)	0.279
	Control Group	2.65±(2.783)		9.88±(3.789)	
FIM self-care score	Mirror Group	5.56±(4.853)	0.004	4.39±(4.474)	0.01
	Control Group	1.141±(2.623)		1.06±(2.358)	

Initial and final evaluations were made 1 to 3 days before and 1 to 3 days after the treatment period. All of the patients reported to more than 1 scheduled session during the study and finished the treatment period. However, 3 patients from the mirror group and 2 patient from the control group could not come to the follow-up clinic for final evaluation because 3 of were out of station and 2 was suffering from illness. We did not observe any adverse events. The mirror therapy treatment compared to the control group showed significant improvement at 4 weeks re-assessment from baseline assessment on hand functioning in Brunnstorm, Action Research Arm test and Functional Independence Measures. The mirror therapy treatment compared to the control group at 6-months of followup reassessment from 4 weeks assessment showed moderate but insignificant improvement in the Brunnstorm and Action Research Arm test and significant improvement in Functional Independence Measures.

Discussion

This study shows that mirror therapy in addition to a conventional rehabilitation program was more beneficial in terms of motor recovery and hand-related functioning than a similar treatment without mirror therapy. We found no effect on spasticity.

The beneficial effect of mirror therapy on hand functioning was recorded in parameters of Brunnstorm, Action Research Arm test and Functional Independence Measures at 4 weeks showed significant improvement as has been previously reported by *Gunes Yavuzer* [15] *MD, PhD who did* a Randomized, controlled, assessor-blinded, 4-week trial, with follow-up at 6 months to evaluate the effects of mirror therapy on upper-extremity motor recovery, spasticity, and hand-related functioning of 40 inpatients (mean age, 63.2yr), all within 12 months poststroke. Thirty minutes of mirror therapy program a day consisting of wrist and finger flexion and extension movements or sham therapy in addition to conventional stroke rehabilitation program, 5 days a week, 2 to 5 hours a day, for 4 weeks. He found the scores of the Brunnstrom stages for the hand and upper extremity and the FIM self-care score improved more in the mirror group than

in the control group after 4 weeks of treatment (by 0.83, 0.89, and 4.10, respectively; all *P*_.01) and at the 6-month follow-up (by 0.16, 0.43, and 2.34, respectively; all *P*_.05). No significant differences were found between the groups for the MAS.

Study Limitations: A potential limitation of this study is the generalizability of the results. According to our inclusion criteria, our findings and conclusions are based on the population of subacute stroke inpatients (all within 12 months poststroke) who survived from first stroke without severe cognitive deficits but with severe motor impairment of the hand and upper extremity. Because of our exclusion criteria none of our patients had apraxia or neglect. Future studies may investigate the effectiveness of mirror therapy on stroke patients with apraxia or neglect. Because few studies have investigated mirror therapy for patients with stroke, there is no agreement on aspects such as optimal patient selection or duration and intensity of training of this new therapeutic approach. Incorporating mirror therapy into the conventional program at the early stages of treatment and applying it for a long period might be even more beneficial to improving hand function. Future studies may investigate the effectiveness of mirror therapy as a home treatment or perform functional brain imaging studies on the underlying mechanism of motor recovery after mirror therapy in patients with stroke.

Conclusions

In our group of subacute stroke patients, hand function improved more after mirror therapy in addition to a conventional rehabilitation program compared with a control treatment directly after 4 weeks of treatment and at the 6-month follow-up, whereas mirror therapy has no affect on spasticity.

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*All correspondences to: Dr. Mahesh Kumar Talele, Postdoctoral Fellow, Room No-231, Kabini Hostel Complex, NIMHANS, Bengaluru-560029, Karnataka, India. E-mail: drmkt99@gmail.com