Original Article

Evaluation of Mirror Therapy for Upper Limb Rehabilitation in Stroke

Muzaffar Tufail[1], Wadhwa RK[2], Borah Diganta[3], Laisram Nonica[4], Kothari SY[5]

Abstract

Trials have shown modest clinical improvement in disabilities after stroke with the use of different techniques; however most of the treatment protocols for the paretic upper extremity are either expensive or labour intensive, which makes the provision of intensive treatment for many patients difficult. It has been suggested that mirror therapy is a simple, inexpensive and, most importantly patient-directed treatment that may improve upper extremity function.

A prospective randomised case control study was done on 60 patients of both the sexes in the age group of 19 to 82 years having stroke for the first time. This study was conducted in the Department of Physical Medicine and Rehabilitation of a tertiary care hospital. All the patients who fulfilled the criteria were enrolled for study; patients were randomly allotted to the study or control group. Study group was given mirror therapy in addition to the conventional stroke rehabilitation programme. Patients were assessed in terms of motor recovery (Brunnstrom stages), spasticity (modified Ashworth Scale), and the self-care items of the Barthel index. These indices were measured at 0 month (pretreatment), 1 month (post-treatment), and 6 months (follow-up).

There was a statistically significant difference in spasticity improvement between the study and control groups; however no significant difference was seen in motor recovery and self care items between the groups. The patients had significant improvements within the groups after the therapy for one month.

Mirror therapy can be a useful intervention supplement in rehabilitation of patients; it provides a simple and cost effective therapy for recovery of hand function.

Key words: **Mirror therapy, stroke, rehabilitation, functional improvement, spasticity.**

Introduction:

Stroke is a global epidemic and an important cause of morbidity and mortality. As defined by WHO stroke is "rapidly developing clinical signs of focal (or global) disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than of vascular origin"[1]. It is well known in the world of health care, especially among physiatry, neurology and neurosurgery professionals that stroke patients today have more treatment options than ever before. However, in spite of this, stroke remains the leading cause of disability and the third leading cause of death among adults in the United States of America[2]. In India, stroke is perhaps the second commonest cause of death and probably the most common cause of disability[3]. More than 50% stroke patients remain vocationally impaired and about 30% need full support for activities of daily living[3]. Understanding of stroke evolved from apoplexy of Hippocrates to present definition of stroke that explains all the mechanisms of the event, so does its rehabilitation from complete hopelessness to advanced present day stroke rehabilitation centres.

Small trials have shown modest clinical improvement in disabilities after stroke with the use of different techniques: electrical stimulation over the surface of

Author's affiliations:
[1] *MBBS PGT DNB (PMR)*
[2] *DPMR, DNB (PMR), SAG Officer*
[3] *MD, DNB (PMR), Associate Professor*
[4] *MBBS, DCH, DPMR, DNB (PMR), Professor and Sr. Specialist*
Department of PMR VMMC and Safdarjang Hospital, New Delhi 29
[5] *MBBS, MS (Orthopedics), DNB (PMR), Special DGHS*
Ministry of Health, Government of India, Nirman Bhavan, New Delhi 11

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Correspondence:
Dr. Tufail Muzaffar MBBS PGT DNB (PMR)
Dept. of PMR VMMC and Safdarjang Hospital, New Delhi 29.
tufailmuzaffar@gmail.com

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muscles to contract them for simple movements[4], intense practice with electromechanical devices that assist in reaching or stepping[5], non-invasive stimulation of the peripheral nerve or direct stimulation of the motor cortex to augment cortical plasticity and learning during arm therapies[6,7], pharmacotherapy with agonists of dopamine, acetylcholine, and serotonin, which may modulate neurotransmission and learning[8] and the use of mental imagery of an action[9].

However most of the treatment protocols for the paretic upper extremity are either expensive or labour intensive and require manual interaction by the therapists for several weeks, which makes the provision of intensive treatment for many patients difficult. It has been suggested that mirror therapy is a simple, inexpensive and, most importantly, patient-directed treatment that may improve upper extremity function. Since 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 programme at the early stages of treatment and applying it for a long period might be even more beneficial for improving hand function.

A potential limitation of previous studies was generalisability of the results. Inclusion criteria were based only on the population of subacute stroke inpatients (all within 12 months post stroke) after first stroke without severe cognitive function. In our study patients were taken three months post stroke including subacute stroke (3 to 12 months post stroke) and chronic stroke (>12 months post stroke).

The mirror provides patients with visual input. The mirror reflection of the moving good arm looks like the affected arm moving correctly and perhaps substitutes for the often decreased or absent proprioceptive input. Use of the mirror may also help recruit the premotor cortex to help with motor rehabilitation[10]. The premotor cortex has a number of features suggesting it might possibly be a link from the visual image in the mirror to motor rehabilitation following stroke. Premotor cortex has significant contributions to the descending corticospinal tracts, more bilateral control of movement than the motor cortex itself and intimate connections with visual input. On a number of neurological and psychological levels, mirror therapy may help to reverse elements of learned disuse of the affected limb[11].

Mirror therapy has been seen to provide encouraging results in treatment of hemiparesis[11-14]. It seems likely that this illusion enhances activation of the premotor and motor cortex in a similar way to action observation or motor imagery. This effect can be explained by the activation of so-called mirror-neuron system. Mirror neurons are neurons that fire when the subject performs a movement, but also during observation of the same movement by someone else, and they seem to play a central role in the process of motor (re-)learning by action observation[12].

Materials and Methods:

This study was a prospective randomised case control study. This study was conducted in Department of Physical Medicine and Rehabilitation, VMMC and Safdarjang Hospital, New Delhi. All the patients of stroke with hemiparesis were examined and screened according to the inclusion and exclusion criteria. Seventy patients who fulfilled the criteria were enrolled in the study after taking an informed consent. Patients were randomly allotted to study or control group using numbers generated from research randomiser. Study group was given mirror therapy (Figs 1 & 2) in addition to the conventional stroke rehabilitation programme. The conventional programme was patient-specific and consisted of neuro developmental facilitation techniques, stretching and strengthening exercises, ADL training in occupational therapy and speech therapy (if needed). During the mirror practices (Figs 3-6), patients were seated close to a table on which a mirror (30.5 × 30.5cm) was placed vertically. The involved hand was placed

Fig 1- *Hand at the Beginning of Mirror Therapy*
Fig 2- *Hand One Month after Mirror Therapy*

Fig 3- *Researcher Showing the Mirror Box,* **Fig 4-** *Researcher Showing the Hand Positioning,* **Fig 5-** *Researcher Explaining the Therapy,* **Fig 6-** *Patient Is Doing Mirror Theropy*

behind the mirror and the non-involved hand in front of the mirror. The practice consisted of non-paretic side wrist and finger flexion and extension movements and some purposeful movements. Patient looked into the mirror, watching the mirror image of non-involved hand. Patient's involved hand was hidden from sight. During the session patients were instructed to imagine the reflected image as the involved hand. Patients were also instructed to try to do the same movements with the paretic hand while they watched only the mirror image of the non-paretic hand. The control group only performed the conventional stroke rehabilitation programme and not the mirror therapy. Each patient was evaluated in terms of tools of measurement.

Inclusion criteria: Patient with first episode of unilateral stroke with hemiparesis, after at least 3 months post stroke, proven by computed tomography or magnetic resonance imaging and Brunnstrom score between stages I and IV for the upper extremity. Patient was able to understand and follow simple verbal instructions and has a normal hand function before the stroke. Patient was willing to participate in the study.

The exclusion criteria: Patients with second episode of unilateral stroke with hemiparesis, duration of less than 3 months post stroke, Brunnstrom score >IV or inability to understand and follow simple verbal instructions.

Patients with low vision or had difficulty in attending therapy sessions on daily basis.

Tools of measurement: Patients of both the groups were assessed in terms of motor recovery (Brunnstrom stages), spasticity (modified Ashworth Scale), and the self-care items of the Barthel index. These indices were measured at 0 month (pre-treatment), 1 month (post-treatment), and 6 months (follow-up). All patients were evaluated under same circumstances (time of the day, ambient temperature, testing position).

Results:

Seventy patients qualified for the study and were randomly allocated into either study or control group. Of the total of 70 patients enrolled in the study, 60 patients completed one month of therapy and all of those who completed one month came for the third evaluation at 6 months. Study group (patients with mirror therapy) had more dropout rate during the first month compared to the control group.

Mean age of study group was 47.97±13.99 years and mean age of control group was 49.13±10.69 years, p-value 0.73. Males were more common in both the study (83.3%) and control (76.7%) groups. Educational status of the patients varied from no education to post-graduation level in both study and control groups. Majority of patients were of poor socio-economic status, 53% and 60% in study and control groups respectively. Right and left hemiplegia were almost equally prevalent in both study and control groups. Ischaemic stroke was more common cause of stroke in both study as well as control groups. Ischaemic to haemorrhagic stroke ratio was 6:1 in both the groups.

Patients in both the groups were divided into subacute (3-12 months) or chronic stroke (>12 months). Among the patients seen, subacute duration was more prevalent in both the groups; however in chronic groups some extremes of duration were seen resulting in wide variation. In study group 3 months was the earliest and 156 months was the longest duration of stroke, while in control group duration ranged from 3 to 120 months.

The mean stroke duration was 18.37± 30.88 months among the study group and 22.80 ± 35.96 months among the control group. There was no significant difference between the two groups as the p-value was 0.610.

Brunnstrom score (Table 1 & Fig 7)

At the beginning of the study, Brunnstrom scores of study group and control group were 2.8 ± 0.805 and 2.8 ± 0.847 respectively, p-value 1 on independent t test. After one month of mirror therapy and exercise programme, mean of study group increased to 3.30 ± 1.088 while that of control group increased to 3.23 ± 0.679; however there was no significant difference within 95% confidence interval, p-value 0.777. Mean change increased further in study group as well as in control group, however the p-value 0.281 was still insignificant.

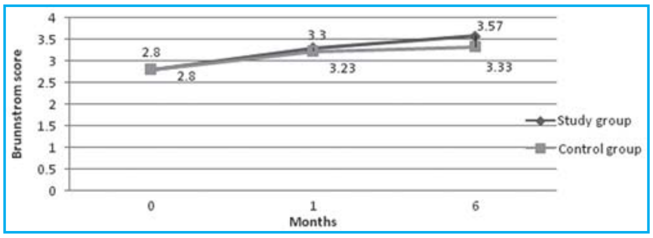

Fig 7- *Time Trend of Brunnstrom Score (n=60)*

Modified Ashworth score (Table 2 & Fig 8)

Mean MAS at the beginning of the study of study group was 2.07 ± 0.983 and control group was 2.00 ± 0.868, with no significant difference, p-value 0.782. One month after the exercise and mirror therapy there was an obvious improvement in spasticity in study group (mean MAS 1.33 ± 0.711) compared to the control group (mean MAS 2.33 ± 0.802). The difference between cases and controls was significant, p-value 0.000. Improvement persisted in six months follow-up in the study group, with only slight improvement of spasticity in control group.

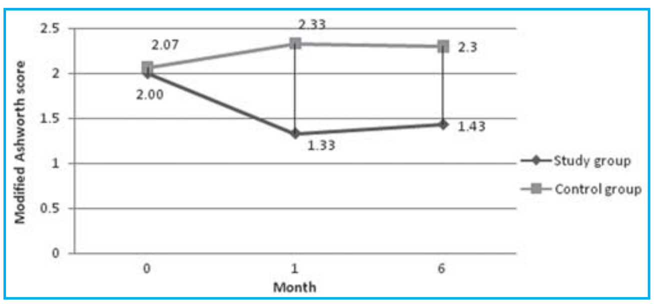

Fig 8- *Time Trend Modified Ashworth Score (n=60)*

Barthel index (Table 2 & Fig 9)

At the beginning of the study mean BI of study group was 27.83 and that of control group was 28.33; there was no significant difference between two groups, p-value of 0.830. At one month post-treatment the mean BI of both study group and control group increased; however there was no significant difference between the two groups, p-value of 0.146. At third assessment the BI had improved further; study group had a mean of 35.67 while the control group had a mean of 32.67 but no significant difference was found between the two groups.

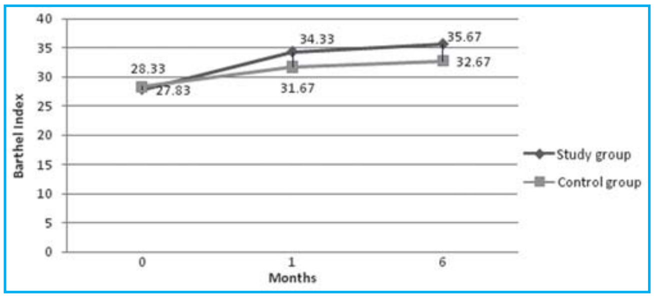

Fig 9- *Time Trend Barthel Index (n=60)*

Discussion:

In our study we found that patients both in study group as well as control group had significant improvement in motor recovery of hand as measured by Brunnstrom stage (BS) one month after treatment, however no significant difference was found between the groups in 95% confidence interval (CI). The difference between the means as seen at the beginning of treatment and after one month of treatment was 0.5; 95% CI, 0.286 to 0.714 (study group) versus 0.433; 95% CI, 0.221 to 0.646 (control group) p-value 0.777. This is in contrast to Yavuzar *et al*[12] where the mean change scores and 95% CI of the Brunnstrom stages for the hand were mean change, 1.5; 95% CI, 1.1 to 1.9 (study group) versus mean change, 0.4; 95% CI, 0.1 to 0.8 (control group); p-value 0.001. This difference could be explained by the fact that in our cohort we had both subacute as well as chronic stroke patients, since there was not much improvement in motor recovery as measured by BS in the chronic stroke patients. Yavuzer *et al*[12] had a smaller group than our study and they had included only the subacute cases.

Modified Ashworth score (MAS) showed marked improvement in the study group compared to the control group. To start with both the groups had almost equal MAS (statistically insignificant difference p-value of 0.728); however after one month of treatment the group difference between the means was -0.667; 95% CI, -0.932 to -0.401(study group) versus 0.267; 95% CI, 0.099 to 0.435 (control group); p-value 0.000. The

Table 1: *Independent T Test Results (n=60)*

	Group	No. of Cases	Mean	Std. deviation	Std. error mean	P-value Independent t-test
Brubbstrom's score 0	Study	30	2.80	0.805	0.147	1.000
	Control	30	2.80	0.847	0.155	
Brubbstrom's score 1	Study	30	3.30	1.088	0.199	0.777
	Control	30	3.23	0.679	0.124	
Brubbstrom's score 6	Study	30	3.57	0.971	0.177	0.281
	Control	30	3.33	0.661	0.121	
MAS 0	Study	30	2.00	0.983	0.179	0.782
	Control	30	2.07	0.868	0.159	
MAS 1	Study	30	1.33	0.711	0.130	0.000
	Control	30	2.33	0.802	0.146	
MAS 6	Study	30	1.43	0.728	0.133	0.000
	Control	30	2.30	0.837	0.153	
BI 0	Study	30	27.83	9.798	1.789	0.830
	Control	30	28.33	8.130	1.484	
BI 1	Study	30	34.33	6.915	1.262	0.146
	Control	30	31.67	7.112	1.298	
BI 6	Study	30	35.67	5.979	1.092	0.087
	Control	30	32.67	7.279	1.329	

difference decreased at follow-up; however there was still a statistically significant difference p=0.000. This is in contrast to Yavuzer *et al*[12] who had (mean change, 0.3; 95% CI, 0.0 to 0.6 versus mean change, 0.3; 95% CI, 0.1 to 0.6; p=0.904). Spasticity is defined as velocity dependent resistance to stretch. In upper motor neuron lesions such as stroke, the stretch reflex is exaggerated due to loss of supraspinal control; however, mirror provides feedback that excites an alternative pathway that suppresses the excessive contraction of the muscles, ultimately leading to reduction of spasticity[11].

Functional status as measured by BI in both the study group and the control group had significant recovery one month post-treatment and continued to have recovery at six months follow-up. However, the two groups did not show statistically significant difference in gains of functional outcome on hand function outcomes of Barthel index. Study group had a mean difference one month post-treatment of 6.500; 95% CI, 4.791 to 8.209 versus control group 3.333; 95% CI, 2.006 to 4.661; p-value 0.146. Yavuzer *et al*[12] had a significant improvement in FIM scores in the study group compared with the control group. FIM self-care score (mean change, 8.3; 95% CI, 6.5 to 10.1 versus mean change, 1.8; 95% CI, 0.3 to 3.2; p-value 0.001) showed significantly more improvement at follow-up in the mirror group compared with the control group. In our study, though patients felt significant improvements subjectively in many subtle activities of daily living while using the affected side (like opening door knob, applying soap, applying oil on hair, decreased time for clothing and unclothing, locking unlocking, better arm swing and transfers), due to lack of these measurements in BI and most other scales, these changes cannot be quantified objectively.

The neural mechanisms underlying the efficacy of mirror therapy are not clear, but the resulting improvement in motor function is an instantiation of use-dependent neural plasticity, which has been demonstrated in the form of expansion of topographic maps in a variety of situations.

It is well known that patients with sensory loss are among the most difficult to rehabilitate. Rehabilitative interventions focus largely on the motor system. Patients with impaired somatic sensation may constitute the most appropriate group for mirror therapy because of their dependence on visual input. Sathian *et al*[14] found patients with predominantly motor deficits did not benefit during testing with the mirror at their initial visit.

Table 2: *Advantages and Disadvantages of Mirror Theropy*

Mirror therapy advantages	Mirror therapy disadvantages
Mirror therapy is cheap and it is easy to make the mirror box.	It is difficult to explain the patients how the mirror therapy is going to work and its mechanism of action.
We can treat many patients at a time.	Optimal dose and set of exercises is not yet established.
It is convenient to do even at home and does not need rehabilitation set up.	Patient needs repeated motivation for compliance and cueing during the sessions to concentrate on the mirror.
During treatment patients get a better feeling to see the mirror image, something like an Avatar hand.	It is sometimes boring for the patient to sit in front of the mirror with limited choice of activities.
Three patients had relief of CRPS symptoms while on mirror therapy.	Mirror therapy gives good visual feedback, however in patients with good hand sensation they do not get as much correction of mismatch as do patients with poor sensory feedback.
All the patients in the mirror group had a drastic change in the hand spasticity after one month of mirror therapy; the tone reduction was maintained at six months follow-up.	It causes cyber sickness like illness in few patients with headache and rise in blood pressure.
It is easily administered even to patients with limited mobility, not able to participate in other exercise programmes and even in patients with no hand function unlike CIMT that requires some preserved hand and wrist movement.	Mirror therapy needs good higher mental function for appreciation and understanding of the method.
When patient is asked to see the mirror image, the patient is exploring the contralateral side of the lesion which is the problem seen in hemispatial neglect, theoretically it should help in hemineglect.	Mirror therapy may theoretically increase learned non-use by seeing the mirror image of hand that is working well.
Mirror therapy does not pose any major risk to the patient and therapy can be terminated as soon as the patient gets fatigued.	Mirror therapy cannot provide increasingly challenging tasks to improve a skill and task performance.

This could be the possible explanation of our findings because only a few patients in our study had somatosensory loss, resulting in lower difference in gains of the functional outcome between the study group and control group.

Mirror neurons are bimodal visuomotor neurons that are active during action observation, mental stimulation (imagery), and action execution. For example, it has been shown that passive observation of an action facilitates M1 excitability of the muscles used in that specific action. Mirror neurons are now generally understood to be the system underlying the learning of new skills by visual inspection of the skill[12].

In addition to previously reported "observation with intent to initiate" or "stimulation through simulation" mechanisms based on increased visual or mental imagery feedback, another possible mechanism for the effectiveness of the mirror therapy might be bilateral arm training. In the study by Yavuzer *et al*[12] they directed the patients to move the paretic hand as much as they could while moving the non-paretic hand and watching the image in the mirror in a bilateral training approach. However in our study when patient tried to do bimanual movement with mirror they had a curiosity to see the paretic arm hidden behind the mirror and needed repeated cueing to direct their attention on the reflected image rather than on the paretic arm.

Conclusion:

In Indian scenario where affording the latest technological aid like robots, computer based virtual realities or functional electrical stimulation is not possible by most of the patients, mirror therapy provides a simple and cost effective addition towards the rehabilitation. Mirror therapy can be a useful intervention supplement in rehabilitation of patients if not a substitute for more advanced equipment and tools.

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