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Effect of mirror therapy on upper extremity function in chronic stroke patients: An experimental study

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Abstract
Stroke is defined by the World Health Organization as a condition characterized by rapidly developing symptoms and signs of a focal brain lesion, with symptoms lasting for more than 24 hours or leading to death, with no apparent cause other than that of vascular origin. Several treatment approaches in stroke rehabilitation are delivered in the form of – Bobath approach, Brunstorm approach, Motor Relearning Program, Task Oriented Approach, Functional Electrical Stimulation, EMG biofeedback etc. It is a Neuro-rehabilitation technique designed to remodulate cortical mechanisms of pain and has proved successful in phantom pain, stroke, and CRPS. In Mirror therapy, patients perform movements of the unaffected limb while watching its mirror reflection superimposed over the (unseen) affected limb, thus creating a visual illusion (and therefore positive feedback for the motor cortex) of the affected limb movement. Thus, the aim of the study was to find out the effect of mirror therapy on paretic upper limb in chronic stroke patients.

Keywords: chronic stroke, upper limb recovery, mirror therapy

Introduction
In Mirror therapy, patients perform movements of the unaffected limb while watching its mirror reflection superimposed over the (unseen) affected limb, thus creating a visual illusion (and therefore positive feedback for the motor cortex) of the affected limb movement [1-2]. The Middle Cerebral artery (MCA) which supplies the entire lateral aspect of cerebral hemisphere and sub cortical structures is the commonest site of infarction with face and upper limb more involved than lower limb [3]. The accepted ways for treatment of stroke includes Medications, Surgery, Hospital care and Rehabilitation. Rehabilitation efforts to restore upper limb function have been substantially less successful than interventions to improve lower limb function and ambulation, with most survivors unable to use their affected arm post-stroke. (Feys HM *et al* in 1998). Neuroscience-based rehabilitation is gaining support as a way to improve outcome in numerous pathologies, even in those in which the deficit appears to be due to cortical abnormalities [4-5].
Mirror therapy is a simple, inexpensive and most importantly patient directed treatment that may improve upper-extremity function. Ramachandran and Rogers-Ramachandran (1986) [6] were the first to introduce the use of these visual illusions created by a mirror for treatment of phantom limb pain. Visual Stimuli enhances neuroplastic changes within the brain. Evidence of cortical reorganization of primary somatosensory cortex by visual feedback. (Mai Hofner *et al.* 2003-04). Thus, the aim of the study is to evaluate the effect of mirror therapy on upper extremity function in chronic stroke patients.

Materials and Method
Ethical approval was obtained for the study by Institutional Review Board (IRB) with proposal No. 28. PTC/IEC/59/2013-14. The study design was experimental study done at Neuro-rehabilitation centers of various general hospitals at Ahmedabad. Total study duration was 1 year and each subject was treated for Period of 4 Weeks, 5 days/week for 30 mins/session. Total 16 subjects were included in the study according to conclusion criteria. Purposive sampling method was used and subjects were allocated to Mirror therapy (MT) group and control group (CT) randomly.

Inclusion criteria were
- Age between 30-60 years
- Post-stroke duration > 6 month
- Both male and female
- Patients with ability to follow 3 step verbal command
- Patients who is willing to participate in the study
- MMSE > 24

Exclusion criteria were
- Cognitive impairments (MMSE <24)
- Patients with Unilateral neglect
- Presence of any other condition like fracture, Rotator cuff tears on paretic side
- Severe pain associated with glenohumeral subluxation
- Visual impairments

Materials used for the study were
- Mirror box
- 10, 5, 2.5 cm cube
- Glass of water
- Marbles (1.5 cm)
- Ball bearing (6 mm)
- Calculator

Outcome measures were
1. Wolf Motor Function Test (WMFT): This test was designed to assess the motor ability of patients with moderate to severe upper extremity motor deficits in the laboratory and clinic.
2. Action Research Arm Test (ARAT): ARAT is one performance test designed for the assessment of upper limb function [7]. This test has 19 items grouped into 4 subtests. Grasp, grip, pinch and gross movement.
3. Fugl-Meyer Assessment Scale (FMA): This is an impairment based test with items organized by sequential recovery stages.
4. Modified Ashworth Scale (MAS): MAS is a 5 point ordinal scale used to measure the spasticity. MAS scores ranges from 0 to 4, where 0 represents 'no increase in muscle tone' and 4 represents 'affected parts rigid in flexion or extension'(Bohannon and Smith, 1987).

After getting approval from Institutional Ethics Committee (IEC), all stroke patients coming to Neuro-Rehabilitation center of S.B.B. College of physiotherapy were screened for study purpose. Patients with confirmed diagnosis of chronic stroke who were following selection criteria were recruited for the study. Nature and purpose of the study was explained very well to the patients. Informed written consent was taken prior to the study.
Subjects were randomly divided into 2 groups:
1. Mirror therapy group (MT)
2. Control Therapy group (CT)

Baseline assessments of outcome measures were taken before commencing the intervention in either of the group. Patients were treated in either of group for 4 weeks, 5 days/week i.e. 20 sessions total. The individualized based treatment session of 30 minutes was conducted by a therapist for 5 days per week.

For MT group
Mirror was kept in mid-sagital plane. The mirror's reflective surface faces the individual's unaffected upper extremity, while the paretic upper extremity is "hidden" on the other side of the mirror. Patients watched the mirror image of the unaffected arm as if it were the affected one. Patients were reminded to move their affected limb "as well as possible" throughout the session.
Under the supervision of the therapist the patient observes the reflection of their non-paretic upper limb:
Elbow flexion, elbow extension, radio-ulnar pronation-supination, wrist flexion-extension, MCP flexion-extension. It was given with the conventional therapy. This therapy includes exercises in the form of ROM exercises for upper limb, Stretching exercises, Strengthening exercises, Dexterity exercises, Balance and Gait Training.

For CT group
Same protocol was followed with the same movements but without mirror, so eliminating the effect of visual illusion. Same conventional therapy was given. Same verbal instructions were given to both the groups. After 4 weeks outcome measures were taken.

Results
Statistical analysis was done using SPSS version 16 and Microsoft Excel 2007. Prior to the statistical tests data was screened for Normal Distribution. Outcome measures were taken at baseline, after 2 weeks (Intermediate) and after 4 weeks (post intervention). Level of significance was kept at 5% with confidence interval (CI) at 95%.
Data was not normally distributed for all the outcome measures. So Non-Parametric tests were applied for within group and between group analysis. Wilcoxon Signed Rank Test was used for within group analysis and Mann-Whitney U test was used for between group analysis.

Table 1: Results of all the outcome measures at 2 and 4 weeks

Weeks	Analysis	Outcome measures	Groups with p value	
			MT	CT
0-2 weeks	Within group	ARAT	>0.05	>0.05
		MAS	>0.05	>0.05
		WMFT	<0.05	<0.05
		FMA	<0.05	>0.05
	Between group	ARAT	>0.05	>0.05
		MAS	<0.05	>0.05
		WMFT	>0.05	>0.05
		FMA	>0.05	>0.05
0-4 weeks	Within group	ARAT	<0.05	<0.05
		MAS	<0.05	>0.05
		WMFT	<0.05	<0.05
		FMA	<0.05	<0.05
	Between group	ARAT	<0.05	<0.05

		MAS	<0.05	>0.05
		WMFT	<0.05	<0.05
		FMA	<0.05	<0.05

This results shown significant improvement in all the outcome measures measured after 4 weeks in both within group and between group analysis, but shows insignificant results in ARAT and FMA after 2 weeks.

Discussion

The present study was to evaluate the effect of Mirror Therapy on upper extremity function in patients with chronic stroke. The mean age of all the participants in MT (n=8) and CT (n=8) groups is 60.4±7.65 and 57.3±5.01 respectively. Subjects were matched for gender and side of affection in both the groups in order to minimize the difference in the heterogeneous population.

Paretic arm is the most devastating impairment in chronic stroke patients. That motor impairment regularly prevents active use of the arm for functionally relevant activities leading to reduction of its cortical representation. Mirror Therapy has been proposed to improve upper extremity function. The present study shows improvement in that impairment. It has been demonstrated that observation of mirrored distal movements enhances corticospinal excitability, similar to actual movement execution.

Apparently this modulation of excitability contributes to motor recovery even in the proximal limb [8-9]. In present study the effect of mirror therapy was present more in distal joints. This is also proved by previous studies which demonstrate different contribution of both hemispheres for proximal and distal motor function. There is evidence that the distal component is organized strictly unilaterally. Whereas proximal movements rely more on bihemispheric representation [10-12]. Thus, we propose that movement mirroring mainly stimulates lateralized motor representations for the distal limb.

Results showed statistically significant difference in FMA of upper extremity sub-scores between group after 4 weeks of intervention with p value 0.044 (<0.05). Effect of Mirror Therapy is attributed to "Mirror Neurons" i.e. neurons in the pre-motor area of humans that are active during observation of meaningful movements.

In this present study patients were asked 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'.

Summers *et al.* (2007) [13] investigated the effectiveness of bilateral arm training and reported that compared with unilateral training, bilateral training intervention was more effective in facilitating upper-limb motor function in chronic stroke patients.

Possible mechanism for reducing spasticity was explained by Moseley G *et al.* in 2008 [14] in his review that visual input indicating that one's hand is being stimulated is sufficient to evoke the sensation of that hand being touched, raises the speculative possibility that this process might be sufficient to, Evoke descending inhibitory mechanisms which reduces the excitation of alpha and beta motor neurons and induces relaxation.

Participants in CT group were also moving their upper extremity similar to MT group without use of mirror. The CT group patients were having direct visual image of paralyzed limb whereas in MT optic visual stimulation was pronounced. Optical illusion has a significantly greater stimulating effect on the brain and that the improvement in motor function of the paralyzed body half is significantly better, than with direct stimulation of the paralyzed limbs. This finding is supported by a study done by Prof. Amimoto in 2008.

The simultaneous changes in excitability of M1 in mirror therapy might result in neural re-organizations appropriate for-functional recovery. Garry *et al*. [15] found that looking at the moving hand facilitates excitability of ipsilateral M1 compared to looking at the inactive hand or a dummy position.

Conclusion

The present study concludes that Mirror Therapy is beneficial in improving upper extremity function in chronic stroke patients and it reduces the spasticity. So, it can be used for upper extremity rehabilitation. Limitations of my study was Lack of generalization of study effects due to small sample size and Long term follow up after cessation of intervention was not done. So future study can be done with larger sample size.

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Ethical clearance: Ethical approval was obtained for the study by Institutional Review Board (IRB) with proposal No. 28. PTC/IEC/59/2013-14.

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