Mirror Illusion for Sensori-Motor Training in Stroke: A Randomized Controlled Trial

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Background: Poststroke, sensory deficits are not uncommon. In spite of the close association between the sensory and motor recovery, the deficits are usually underemphasized. Mirror therapy (MT), a neural-based approach for the motor deficit has not been explored for the sensory impairment. The objective of the present study was to develop and determine the effect of a MT program for sensori-motor impairment among poststroke subjects. *Methods Design:* Randomized controlled trial. *Setting:* Functional therapy laboratory of Rehabilitation Institute. *Participants:* Thirty-one chronic poststroke subjects (17 experimental and 14 controls), aged between 30 and 60 years, with ≤ diminished light touch in the hand. *Outcome Measure:* Semmes Weinstein Monofilament (cutaneous threshold), 2-Point discrimination test (touch discrimination) and Fugl-Meyer Assessment (hand motor recovery). *Intervention:* The experimental group received sensory stimulus such as tactile perception and motor tasks on the less-affected hand using mirror box. The control counterparts underwent only dose-matched conventional program. 30 sessions with a frequency of 5/week were imparted to the groups. *Results:* Post intervention, there was a significant ($P < .004$) increase up to 30% positive touch-response for the hand quadrants among the experimental group in comparison to only 13.5% rise for the same among the controls. The cutaneous threshold of the less-affected palm also improved significantly among the experimental subjects in comparison to the controls ($P = .04$). *Conclusion:* MT may be considered as a promising regime for enhancing cutaneous sensibility in stroke. The mirror illusion induced by MT may be utilized for sensory and motor deficits as well as for the more-affected and less-affected hands.

Key Words: Cerebrovascular accident—Cutaneous threshold—Hand—Monofilament—Rehabilitation—Tactile—2-point discrimination

Introduction

Sensory impairment is not uncommon after stroke; however usually not emphasized due to the apparent motor paresis.[1] The somatosensory deficits are not only presented on the contralateral body side to the brain lesion but also on the ipsilateral side.[2] The sensory recovery has been found to be strongly associated with the level of the motor recovery.[3] Further, the sensory deficit affects quality of life among stroke subjects.[4] Up to 85% of the subjects could experience sensory deficits. The individual may exhibit deficit in tactile, propriopception, vibration, steregnosis, and 2-point discrimination abilities.[5,6] The sensory deficits hamper the ability to utilize the available motor level in the functional tasks.[7] Thus, adequate motor recovery depends upon the intact sensation.[8-10] The impaired sensation along with the complex motor deficits increases the disability manifold.[6,11]

In a lesioned brain, the motor control is facilitated by alternative sensorimotor pathways recruited from secondary motor areas. Poststroke sensory deficits are the consequence of structural damage of cortical and subcortical structures. The primary somatosensory area situated in

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the postcentral gyrus is commonly affected regions.[6,12] Thalamus and basal ganglia are the most crucial areas which coordinate sensory information with motor cortex. Usually, thalamic stroke is supposed to be sensory stroke; whereas clinically a diversity of sensory loss presentation has been observed among other lesions also.[13,14]

The identification and assessment of sensory issues in poststroke subjects are still under explored. The apparent motor impairment in contrast to the subtle sensory deficits could be the reason for overlooking the issue. Additionally, stroke specific sensory outcome measures are sparsely available.[6,15]

In poststroke, sensory training of varied range has been investigated.[5,6,16] The techniques may range from passive techniques such as somatosensory electrical stimulation to active retraining of stereognosis, proprioception, discriminating, and localizing sensations.[16,17] The other investigated sensory interventions are sensory electrical stimulation, thermal stimulation, and pneumatic compression technique. However, none of them exhibited sufficient evidence for their effectiveness.[5,6] Further, sensory and motor techniques have also been combined to explore the response of upper limb function. It has been suggested to amalgamate the techniques to enhance the upper limb recovery.[18]

Techniques such as mirror Therapy (MT) have been developed for motor rehabilitation in stroke.[19] MT provides a form of visual illusion by watching the reflection of the unaffected limb on a mirror. The patient performs movement of the unaffected limb and creates an image of the affected limb in a mirror.[20,21] The illusion enhances the interhemispheric communication as well as activity of the certain brain areas associated with the motor performance of the affected limb. Various mechanisms have been proposed to be responsible for MT including mirror neuron system.[22]

MT using tasks has been proven to be an effective technique for the upper limb rehabilitation among stroke patients.[20-22] Although activity or task-based MT unquestionably utilize sensations to complete the task, the technique has not been explored for sensory rehabilitation.

It is evident that sensory and motor functions are interlinked in healthy and lesioned brain.[23,24] Integration of sensory abilities is crucial for the recovery of motor control and motor learning.[1,25,26] However, the sensory intervention has been underemphasized due to motor rehabilitation.[1] Poststroke, both the functions gets impaired and recovered together.[4,5,27-29] However, till today, all the stroke rehabilitation methods have developed exclusively for the motor aspect. A novel treatment training to treat sensory and motor impairments needs to be developed.

The objective of study was to develop a MT program using tasks for sensory and motor impairment and to determine the effect of the protocol on sensory and motor recovery among poststroke survivors.

Methods

The present study followed the CONSORT (Consolidated Standards of Reporting Trials) guidelines for the nonpharmacologic treatments.[30] The protocol of the study was approved by the Institutional Ethics Committee of Pandit Deendayal Upadhyaya National Institute for Persons with Physical Disabilities. The informed signed consent was obtained from all the enrolled participants.

The potential subjects were recruited from a national-level rehabilitation institute situated in an urban city. The investigation was conducted in a functional therapy laboratory of the institute. The participants were enrolled in the study if they met the following inclusion criteria: (i) unilateral stroke of >6 months, (ii) hemiparesis of right or left side, (iii) age between 30 and 60 years, and (iv) sensory deficit in the palamar aspect of the hand and fingers (assessed by the Semmes-Weinstein monofilaments as ≤ diminished light touch).[24,31] However, the subjects were excluded if they exhibited any of the following: (i) cognitive and perceptual deficits (determined clinically by trail making test, digit span, copying and drawing, line-bisection, and functional performance), (ii) receptive communicative disorder, (iii) contracture of hand muscles or any fixed wrist/hand/finger deformity, (iv) complex regional pain syndrome, (v) diabetic or any other type of neuropathy, and (vi) skin disorder affecting the upper limb.

The study was a randomized controlled, assessor blinded trial. Sample size was not calculated for the study as no MT study was found using sensory measure as a primary outcome. The subjects were not blinded due to nature of the intervention. The selected subjects were randomly divided into the experimental and control group using computer generated random numbers. The randomization procedure was performed by a research assistant who was not concerned with the present study. The allocation of intervention was divided in the ratio of 1:1 and that was serially arranged in sealed opaque paper envelopes.

After getting signed written informed consent, the subjects were enrolled for the study. The experimental group subjects received 30 sessions, 40 minutes each across the 6 weeks (5/week). Additionally, 50 minute conventional occupational therapy was also provided. The rationale for providing the conventional therapy to the experimental group was to avoid deprivation of the affected upper limb from the motor and sensory training. The control group subject received only standard motor and sensory rehabilitation; however, for 90 minutes duration to match the total dosage of therapy between the groups.

Specifically, the experimental participants received task-based mirror therapy using the mirror frames or mirror box (*dimensions and purpose are provided in the* Box 1). The mirrored wall of the frame/box was placed vertically along the midsternum level. The affected limb was hidden beside the nonreflective side of the wall. The subjects were provided sensory stimulus (various textures, size, and