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[ORIGINAL ARTICLE]

Effect of Thermal Stimulation and Mirror Therapy on Hand Functions in Patients with Stroke: A Experimental Study

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ABSTRACT :

Background: Thermal stimulation can be used as an intervention to enhance sensory function. Activated areas by thermal stimulation are greater than those by tactile or mechanical stimulation. Mirror therapy creates the illusion of normal movement with the mirror image of the unaffected upper extremity. Thermal stimulation provides somatosensory stimulation that causes the forced use of the involved extremity as a protective response to heat which provokes volitional/reflexive motor activity. Somatosensory stimulation may induce brain plasticity.

Purpose: This study was carried out to determine the effect of thermal stimulation and mirror therapy in the sensorimotor and functional recovery of hand in stroke patients with hand impairment.Methods: 18 stroke survivors were randomly assigned to Thermal Stimulation rehabilitation treatment and Mirror Therapy rehabilitation group (30 minutes daily for 3 weeks). Three measures, including Brunnstormstage, Wolf motor Function Test, and Revised Nottingham Sensory Assessment scale was used as an outcome measure to assess the motor and sensory recovery.

Results: Thermal Stimulation group showed a potential trend for improved recovery stage as measured by Brunnstorm staging for motor recovery of hand as compared to the Mirror therapy group. The Thermal Stimulation group also showed a statistically significant and large improvement in tactile, proprioception and stereognosis score as measured by Revised Nottingham sensory assessment scale whereas Mirror Therapy group showed significant improvement in stereognosis score alone.

Conclusion: Thermal stimulation has more positive effect in the sensorimotor and functional recovery of hand in acute stroke patients with hand impairment within 3 weeks in comparison to Mirror Therapy. Thermal stimulation protocol should be added in the clinical setting of rehabilitation in stroke patients with hand impairment on the basis of the result of this study.

Key Words: Mirror Therapy, Brunnstorm staging, Stroke

Introduction:

Stroke is one of the most popular diseases occurring in our country that leads to motor or sensory impairment or loss of function.1Among the stroke survivors 85% suffer from some form of hand sensorimotor impairment.(2) Recovery of upper limb is slow and seen in less than 50% of population. About 30-66% of hemi-paretic patients fail to regain complete hand function 6 months post stroke. Poor functional recovery progresses and leads to learned non-use phenomenon of hand which causes further deterioration in the recovery period and prolonged rehabilitation. Hand impairment repairing is not possible without spontaneous motor actions as done in the lower limb rehabilitation where rehabilitation can be performed with the use of brace, spasticity and opposite leg in patients who have reduced strength in hemiplegic side.(3) Motor impairments involve problems of motor execution or motor planning/ learning.(4)

A wide range of rehabilitation techniques have been documented evaluating the effect of various techniques in causing improvement in the upper extremity muscle function and control. These

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include mirror therapy, functional electrical stimulation, Robot assisted training.[5] All these interventions of choice used in stroke patients primarily focus on the motor outcomes but no attention is given to the sensory outcome. Major role behind this discrepancy is of the clinical demands of motor improvement are given utmost importance than that to sensory recovery. In addition, clinically available assessments for sensory dysfunction are less reliable and reproducible than those for motor dysfunction.

The thermal stimulation is commonly used in orthopaedic rehabilitation but there are no reports that evaluate the effect of thermal stimulation intervention. Thermal stimulation can be used as an intervention to enhance sensory function. Activated areas by thermal stimulation are greater than those by tactile or mechanical stimulation. Thermal stimulation and Mirror Therapy are rehabilitation techniques which have been used and documented recently to promote the sensorimotor recovery in stroke patients.[6] Bothmodalities are economical and very easy in application. Most of the techniques that are used in stroke patients primarily focus on the improvement in the motor function and are complex and expensive. Thermal Stimulation and Mirror Therapy are easy to apply for patients as well as Therapist at home or the clinical setting. It has been documented in promotion of recovery both in upper extremity as well as lower extremity in patients with stroke.[7]

So this study was carried out to see the effect of sensory stimulation on the sensorimotor recovery, determine the effect of thermal stimulation and mirror therapy on the sensorimotor and functional recovery of hand in stroke patients with hand impairment.

Methods: This is a single blinded experimental study comparing the Thermal stimulation therapy with Mirror Therapy on hand impairment in patients with stroke. The research study was approved by the institutional ethics committee. All patients were informed about the experiment and written consent was taken. Study was conducted in VikhePatil Hospital physiotherapy OPD from February 2019 to May 2020.

Inclusion Criteria: (1) Patients with first ever stroke. (2) Diagnosed cases of stroke with hand impairment. (3) Patients with motor deficit of upper limb under Brunnstorm stage [3]. (4) Patients who can follow verbal commands.

Exclusion Criteria: (1) Sensory impairment due to peripheral neuropathy or diabetes. (2)Persons with speech disorder. (3) Medical co-morbidity in hand. (pain or fracture of musculoskeletal system). (4)Patients with severe contracture of hand. (5)Patients with cognition impairment. (6) Patients contraindicated to heat and cold application.

Procedure Experimental: The EXP group received Thermal Stimulation intervention session of 20- to 30-minute duration 5 times weekly, which was given by the same physical therapist. Heating pack was wrapped in a towel and applied on the paretic hand for 15 seconds followed by ≥30 second's interval repeated 10 times. Patients were encouraged to move paretic hand away from heating agent if they felt uncomfortable or had accepted 15 second stimulation as noted on a stop watch. After10 time stimulation with the heating agent, same procedure was followed for the cooling agent. The Mirror Therapy group received 15 to 20 minutes of treatment 5 times weekly from the same physiotherapist. The participants were instructed to observe the non-paretic upper limb while performing movements. Participant performed wrist flexion, extension, radial and ulnar deviation, circumduction, fisting, releasing, abduction and adduction of all fingers in front of the mirror and attempting the same movements with the paretic upper limb. Patients were assessed with Brunnstorm recovery staging, wolf motor function test and Revised Nottingham sensory assessment before and after 21 days of treatment.

Fig 1: Hot pack and cold pack wrap

Fig. 2: Patient receiving Thermal (hot) stimulation intervention

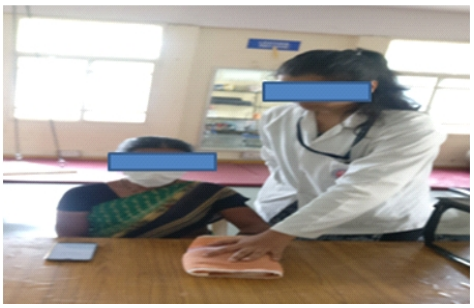

Fig. 3: Patient receiving Thermal (cold) stimulation intervention

Fig. 4: Patient performing movements of normal hand in front of mirror (Mirror Therapy)

Statistical Analysis:

Basic characteristics of the patients in the control and experimental groups of continuous data like age, duration of stroke onset were compared with Student t and Fisher exact test was used for nominal data like gender type of stroke side of paresis.

Student paired t-test was used to compare the results at the beginning and at the end of three weeks post thermal intervention between the Thermal Stimulation group and Mirror Therapy group. Mann Whitney U test was used to assess the change in the recovery staging pre and post treatment in both groups. Statistical significance was assumed for P< 0.05.

Results:

Eighteen patients who were diagnosed with stroke and met the inclusion criteria initially enrolled in the study. They were assigned randomly to Thermal stimulation group and Mirror therapy group. Seventeen subjects completed the treatment protocol (TS n= 9; MT n=9). One patient did not finish the experiment because of early discharge from hospital. No adverse effects due to thermal stimulation were reported after 3-week TS protocol.

Basic characteristics of patients showed no significant difference in demographic data and baseline values of all measures.

Table 1: Demographic and Baseline characteristics of the subjects of a sample of 17 stroke patients with hand impairment recruited to Thermal stimulation intervention or Mirror therapy.

Variable	Thermal Stimulation(n=8)	Mirror Therapy(n=9)	p value
Age(in years)	43±6.4	44±5.0	0.72 (t)
Stroke duration of onset (in months)	5(01)	6(02)	0.22(t)
Brunnstrom stage (score)	2.6±0.7	2.6±0.9	0.89(M)
Wolf Motor Function Test Score	23±14	22±11	0.16(t)
Revised Nottingham Sensory assessment Score	25±15	27±9	0.33(t)

Table 2: Recovery staging:-Brunnstorm recovery stage: The Thermal Stimulation group showed a potential trend for improved recovery stage and the results were statistically significant as measured by Brunnstorm staging for motor recovery of hand as compared to the Mirror therapy group.

Group	Pre Treatment	PostTreatment	Gain	PValue
TS	2.6±0.7	3.8±0.7	1.2	0.007(M)*
MT	2.6±0.9	3.3±1.1	0.7	0.13(M)

M indicates Mann–Whitney U test. *P<0.05

Table 3: Hand Function and strength outcome:- Wolf Motor Function Test:

No significant results were obtained in the strength domain of Wolf Motor Function test. Significant improvement in the Thermal stimulation group as well as mirror therapy group was seen in Functional domain Measured by Wolf Motor Function test. Thermalstimulation showed potentially higher improvement than Mirror therapy.

	Thermal Stimulation				**Mirror Therapy**			
	Pre treatment		**Post treatment**		**Pre treatment**		**Post treatment**	
Subscale	M(SD)	Range	M(SD)	Range	M(SD)	Range	M(SD)	Range
ftT(S)	2.33±1.15	0-5	2.9±1	0-5	2.22±0.83	0-5	2.9±0.6	0-5
FTB	2±1	0-5	3±1	0-5	2±1	0-5	3±0	0-5
EE	3±1	0-5	3±1	0-5	2±1	0-5	3±1	0-5
EE(W)	2.3±1.2	0-5	2.9±1.1	0-5	2.3±1	0-5	2.9±0.6	0-5
HTT(F)	2.4±1	0-5	2.78±1.23	0-5	2.1±1	0-5	3±0.71	0-5
HTB	2.7±1.3	0-5	3±1	0-5	2.2±0.8	0-5	3±1	0-5
RAR	2.7±1.3	0-5	3.1±1.5	0-5	2.6±1.1	0-5	3.1±0.9	0-5
LC	1±1	0-5	2±1	0-5	1±1	0-5	2±1	0-5
LP	1±1	0-5	2±1	0-5	1±1	0-5	2±1	0-5
LPC	1±1	0-5	2±1	0-5	1±1	0-5	2±1	0-5
SC	1±1	0-5	2±1	0-5	1±1	0-5	1±1	0-5
FC	1±1	0-5	2±1	0-5	1±1	0-5	1±1	0-5
TK	1±1	0-5	2±1	0-5	1±1	0-5	1±1	0-5
FT	1±1	0-5	2±1	0-5	1±1	0-5	1±1	0-5
LB	1±1	0-5	2±1	0-5	1±1	0-5	1±1	0-5

Table 4: Comparison of pre- treatment and post- treatment scores with WMFT (grip strength, weight) scale in 17 stroke patients with hand impairment recruited to Thermal Stimulation and Mirror Therapy group

	Pre treatment				Post treatment			
	TS		MT		TS		MT	
	Wt (kg)	Grip (kg)	Wt (kg)	Grip (kg)	Wt (kg)	Grip (kg)	Wt (kg)	Grip (kg)
Mean	1.1	3.75	1.77	2	1.37	5	1.88	2
SD	1.04	6.49	1.03	1.63	0.99	7.07	0.87	1.63

Table 5: Sensory Function:- Revised Nottingham Sensory assessment:

The Thermal Stimulation group also showed a statistically significant and large improvement in tactile, proprioception and stereognosis score as measured by Revised Nottingham sensory assessment scale whereas Mirror Therapy group showed significant improvement in stereognosis score alone.

	Thermal Stimulation				Mirror Therapy			
	Pre treatment		Post treatment		Pre treatment		Post treatment	
Subscale	M±SD	Range	M±SD	Range	M±SD	Range	M±SD	Range
Tactile Sensation								
Light touch	1±1	0-2	2±0	0-2	1±1	0-2	1±1	0-2
Temperature	1±1	0-2	1.9±0.3	0-2	1±1	0-2	1.6±0.5	0-2
Pin prick	2±1	0-2	2±0	0-2	1±1	0-2	2±0	0-2
Pressure	2±1	0-2	2±0	0-2	1±1	0-2	1±0	0-2
Tactile Localization	2±1	0-2	2±0	0-2	1±1	0-2	2±0	0-2
Bilateral Simultaneous touch	2±1	0-2	1.9±0.3	0-2	1±1	0-2	1.4±0.6	0-2
Proprioception	1.3±1.2	0-3	2.6±0.7	0-3	1.9±1.1	0-3	2.8±0.4	0-3
Stereognosis	5.5±7.8	0-22	21±4	0-22	11±7.3	0-22	21±3	0-22

Table 6: Comparison of post- treatment scores in 17 stroke patients with hand impairment recruited to Thermal Stimulation and Mirror Therapy group

Outcome Measures	Post Treatment Scores		
	TS	MT	P value
Brunnstorm Stage of Recovery	3.80±0.7	3.3±1.1	0.288
Wolf Motor Function Test	39±12	33±8.9	0.255
Grip strength	5±7.07	2±1.63	0.233
Weight	1.37±0.99	1.88±2	0.524
Revised Nottingham Sensory assessment(Tactile score)	11.25±2.12	7.33±2.95	0.007*
Proprioception score	2.9±0.3	2.3±0.8	0.064
Stereognosis score	21±4.0	21±3	1.000

Table 7: Comparison of pre- treatment and post- treatment outcome scores in 17 stroke patients with hand impairment recruited to Thermal Stimulation and Mirror Therapy group

	Thermal Stimulation			Mirror Therapy		
	Pre	Post	P value	Pre	Post	P value
Brunnstorm Stage of Recovery	2.6±0.7	3.8±0.7	0.007*	2.6±0.9	3.3±1.1	0.13
Wolf Motor Function Test	23±14	39±12	0.027*	22±11	33±8.9	0.033*
Grip strength	3.75±6.49	5±7.07	0.718	2±1.63	2±1.63	1.0
Weight	1.1±1.04	1.37±0.99	0.603	1.77±1.03	1.88±0.87	0.8
Revised Nottingham Sensory assessment (Tactile score)	5.14±4.14	11.25±2.14	0.002*	4±4.24	7.33±2.45	0.075
Proprioception score	1.3±1.2	2.9±0.3	0.002*	1.9±1.1±	2.3±0.8	0.390
Stereognosis score	5.5±7.8	21±4.0	0.000*	11±7.3	21±3	0.006*

Discussion:

This study highlights the importance of sensory stimulation in cases of stroke to induce sensorimotor recovery in hand specifically. The findings of this study support the proposed hypothesis mentioned in the study of more sensorimotor improvement by thermal stimulation than the mirror therapy.

The results of our study showed that thermal stimulation is effective in improving the sensorimotor function of the hand. The main fundamental behind the hand function improvement is somatosensory stimulation leads to the enhanced corticomotor excitation which in turn influences the neuroplasticity in brain. The results of our study also put light on the fact that thermal stimulation given in addition to traditional rehabilitation for hand impairment increases the volume of sensorimotor recovery in stroke patients. There is literature available that confirms the neuronal plasticity in succession to brain damage in stroke patients.

Noxious TS is similar to the heat pain sensation or it is similar to the cold pain on the impaired UE that can cause the volitional or reflex movements that provoke the active movements to move the subjects affected hand. In a study done by Roxane et. al it was proposed that continuous reflexive movements of the affected UE may lead to the formation of sensory and motor connections to enhance the cortical reorganization in brain and thus enhance the motor and functional recovery of the limb in stroke patients. TS activates the primary somatosensory cortex, secondary somatosensory cortex, thalamus, and insula.[7] This could be the mechanism behind the improvement in the wolf motor function test score in our study in the thermal stimulation group. In our study there was more improvement in the Thermal

stimulation group than the Mirror Therapy group. Although we did not use innocuous thermal stimulation but the results of the noxious thermal stimulation on hand were similar to the study done by Roxane et. al showing positive effects in the motor recovery in the Upper extremity by noxious heat.

Yavuzeret. al in a study has explained that the mirror visual neurons are visuomotor neurons that are active during the act of observation. The author explains that when you observe a movement there is a process that is taking place internally. This process causes a reaction of the activation of the muscles. The muscles that get activated are the ones that are required for the activity to occur. Mirror neurons are group of receptors that invoke the learning of a skill or task by the visual illusion of the task. We gave mirror intervention similar to that given in this study wherein the patient placed the impaired hand within the mirror box and normal non-paralyzed hand in plane of the mirror. The patient was then asked to perform the conventional rehabilitation movements like finger flexion and extension movements along with the wrist flexion and extension and the patient viewed the reflection in the mirror. The author had put forth that in this study the visual image of a normal hand movement compensates for the compromised proprioception stimulus. This will further build the premotor cortex connections and assist in the rehabilitation by forming a strong connection. This strong connection is formed through the visual cortex to the premotor areas. So it can be stated that the proprioceptive input is reduced in stroke patients and according to our results the proprioception score did not improve post mirror therapy intervention but it showed a significant improvement in thermal stimulation group.[9] Therefore we can conclude that thermal stimulation improves the sensory aspect of hand in stroke patients.

A study done by Shama Praveen et. al conducted a study by using of mirror therapy in combination with thermal stimulation in stroke patients with upper extremity motor function impairment. One of the group received mirror therapy in combination with thermal stimulation. Subjects in later group received conventional rehabilitation for upper extremity for flexors and extensors for 4 weeks. Rehabilitation including active exercises and functional training was given. The upper extremity motor functions were significantly improved after using mirror therapy and thermal stimulation for 4 weeks as compared with the control group that received conventional therapy. Our study differed from this study as we compared the effect of thermal stimulation and mirror therapy separately. In our study we acknowledged that thermal stimulation together with conventional therapy gave better results than the Mirror therapy.[10]

Both the interventions have their respective positive effects in causing the sensorimotor recovery in hand in stroke patients. The essential advantage of mirror therapy is that it creates the illusion of normal movement with the mirror image of the unaffected upper extremity which can substitute for decreased proprioceptive information, successively may help to recruit the premotor cortex. Rehabilitation strategy enhanced through the mechanism of inducing neuronal connection between visual cortical area and premotor cortical area. Thermal stimulation on the opposite hand promotes upper extremity recovery in stroke patients by inducing cortical reorganization within the cerebral cortex by thermal tactile stimulation. Another major advantage of TS is that it provides somatosensory stimulation. This somatosensory stimulation induces voluntary reflex movement that causes the forced use of the involved extremity. It has been proposed that somatosensory stimulation is responsible to form strong connections causing neuro-plastic changes.

This is a preliminary study done to compare the effect of thermal stimulation and mirror therapy on hand impairment in patients with strokeand has several limitations that warrant consideration. First, this study was based on a small sample size. Further research based on a larger sample is needed to validate and extend the findings. Second we did not involve the entire upper limb for thermal stimulation. Another drawback of the study was that the thermal stimulation group received conventional therapy for 30 minutes in addition to 20-30 minutes of thermal stimulation. The integrity of blinding and the results of our study might have been threatened. Also the duration of study was short and maintenance of constant temperature was difficult.

Conclusion:

Thermal stimulation has more positive effect in the sensorimotor and functional recovery of hand in acute stroke patients with hand impairment within 3 weeks in comparison to Mirror Therapy. Thermal stimulation protocol should be added in the clinical setting of rehabilitation in stroke patients with hand impairment on the basis of the result of this study. It is suggested that future studies investigate the effect of Thermal stimulation on sensory recovery in patients with stroke having lower limb impairment.

Conflict of Interest Statement: None

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