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To compare effectiveness of constraint induced movement therapy versus mirror therapy along with conventional therapy to improve hand function in chronic stroke patients

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Abstract

Background: Stroke is a serious vascular disorder of the brain caused by an obstruction of blood and energy supply to brain due to blood clot moving from the heart to brain and/or by narrowing or bursting of blood vessels. Constraint Induced Movement Therapy (CIMT) has shown beneficial effects on motor system and on somatosensory recovery. Mirror Therapy (MT) is form of motor imagery in which a mirror is used to convey visual stimuli to brain through observation of movements performed on unaffected part. It improves motor system by training ipsilateral or contralesional primary sensorymotor cortex.

Method: Total of 40 patients were taken and then randomized to CIMT and MT groups. Conventional therapy was given to both the groups. Intervention groups received training for 45 min per day during 5 consecutive weekdays for 4 weeks. Outcome measure to assess hand function was the Wolf Motor Function Test (WMFT).

Result: The baseline characteristics between the groups were similar statistically. Along with conventional therapy; CIMT has shown significant improvement ($p < 0.0001$) in hand function in chronic stroke patients on individual tasks of WMFT as compared with MT.

Conclusion: When compared on WMFT, CIMT and MT both are individually helpful in improving hand function in chronic stroke patients along with conventional therapy. But CIMT showed more effect than MT on WMFT.

Keywords: chronic stoke, hand function, CIMT, MT, WMFT

Introduction

Stroke is a serious vascular disorder of the brain caused by an obstruction of blood and energy supply to the brain due to a blood clot moving from the heart to the brain and/or by narrowing or bursting of blood vessels [1]. The reduction of blood and energy supply caused by ischemic or hemorrhagic events commonly leads to serious damage or death of brain tissues that often-resulting significant impairments of motor, cognitive, and emotional functions or even in death. The most common consequences of stroke are hemiparesis and sensory impairments of the affected arm, hand, and leg, aphasia, dysphagia, vertigo and disorders of perception, consciousness, and a variety of other cognitive and emotional functions. Parallel to these impairments, more than half of patients additionally suffer from depression and anxiety disorders [2] from high blood pressure, diabetes, and other medical conditions. Stroke thus is one of the most devastating neurological and psychological conditions. It affects about 15 million people worldwide every year [3]. Up to 85% of the approximately 566000 stroke survivors experience hemiparesis, resulting in impairment of an upper extremity immediately after stroke, and between 55% and 75% of survivors continue to experience upper extremity functional limitations, which are associated with diminished health-related quality of life [4], even 3 to 6 months later that is chronic stroke [5]. Constraint-Induced Movement Therapy (CIMT), is a neuro rehabilitation approach developed by behavioral neuroscientist Dr Edward Taub and colleagues also called Taub training in Germany [6] has been shown to be a promising training method for enhancing the reuse of the more-affected hand in patients with chronic stroke [7-14]. Constraint-induced movement therapy (CIMT) is a commonly used rehabilitation intervention to improve upper limb function after stroke [15]. CIMT was originally developed for patients with a chronic upper limb paresis. CIMT has shown beneficial effects on motor system and in part also on somatosensory recovery [28]. The original CIMT treatment protocol is clearly described and includes three main elements: 1) Repetitive, task-oriented training of the more impaired upper limb for 6 hours a day, on 10 consecutive weekdays; 2) A transfer package of adherence-enhancing behavioral methods designed to transfer the gains made in the clinical setting to the patient’s real-world environment; and 3) Constraining the less impaired upper limb to promote the use of the more impaired upper limb [16]. Mirror therapy (MT) is a form of motor imagery in which a mirror is used to convey visual stimuli to the brain through observation of movements performed on the unaffected part. It was introduced by Ramachandran and Roger-Ramachandran to treat phantom pain after amputation [17-18]. MT is a patient-directed, noninvasive, economic, and relatively new intervention that uses the interaction of visuomotor-proprioception inputs to enhance movement performance of the impaired limb [19-21]. It provides maximal active participation of the patient and requires minimal interaction with the therapist [22]. In this approach, the patient performs movements of the unaffected limb while watching its mirror reflection superimposed on the affected limb. A visual illusion of the unseen affected limb is created, which generates awareness of the affected limb and provides positive feedback [20, 23]. MT improves the motor system by training the ipsilateral or contralesional primary sensorymotor cortex [24-26].

Materials and Methods

Study design and setting: comparative study conducted in rehabilitation centers in and around Mumbai and Pune. Population was screened for the inclusion criteria. Patients who met the following criteria were included: 1) Chronic stroke patients with left middle cerebral artery involvement. 2) Upper limb voluntary control grade-5a i.e. Shoulder abduction with elbow extension. 3) Hand voluntary control grade-5b i.e. grasp with mass release. 4) Active wrist extension of 10 degrees, active extension of any two digits, active thumb abduction. 5) Both genders. 6) Mini mental status examination score more than 24. Patients who met inclusion criteria were randomly assigned to CIMT group (n = 20) and MT group (n = 20) using block randomization.

Procedure

All the participants were explained about the purpose of the study. The subjects were screened for inclusion and exclusion criteria by the primary investigator and then the baseline measurements were taken. An informed consent was taken from the patients who were willing to participate in the study. Patient was evaluated with brunnstrom's Upper limb and hand voluntary control grades. Eligible subjects were allocated into two groups. Group A – participants receiving CIMT along with conventional therapy. Group B - participants receiving Mirror Therapy along with conventional therapy. Wolf motor function test (WMFT) was used as an outcome measure for the study and was taken pretreatment session. Therapy was given 5 times per week for 1 treatment session of 45 minutes per day for 4 weeks. Outcome was taken 2 weekly at the end of the last session of the week to see the progression. Therapy for group A and group B along with the conventional therapy, included the following exercises:

1. The reaching Exercise

Patient Position

- The patient sits on a chair with a table with an anti-slip mat in front.
- Patient's shoulder is slightly flexed with elbow flexed to 90 degrees 2and forearm pronated.
- The patient puts the more affected elbow on the table and then places the hand flat on the anti-slip mat and moves the hand in sideways, forward and backward direction.
- This helps in improving motor control of the distal arm in different directions, emphasizing wrist and finger extension.

2. The Cylinder Grip Exercise

Patient Position

- The patient sits in a chair with a table in front.
- The patient slightly flexes, abducts and internally rotates the shoulder, extends the elbow and the wrist and then grasps the cylindrical object by flexing the fingers around the object, moves and releases cylinders using a cylinder grip by extending the wrist and fingers.
- This will help in improving the cylinder grip with the focus on extension of wrist and fingers.

3. The Grasp Exercise

Patient Position

- The patient sits in a chair with a table in front. A ball is placed on the table.
- The patient grasps the ball by flexing, abducting and internally rotating the shoulder and extending the elbow, wrist and fingers, then moves and releases the ball using wrist and five fingers extension.
- This will help in improving the five-finger grip, by motor control of the intrinsic muscles and extension and flexion of the fingers.
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4. The pinch Exercise

Patient Position

- The patient sits in a chair with a table in front. A large checkers game is placed on the table.
- The patient grasps and moves the stones using a pinch grip by shoulder flexion, adduction, internal rotation, elbow flexion, forearm pronation with wrist in flexion. Releases the ball by fingers and wrist extension.
- This will help in improving the pinch grip, with the focus on the extension of the fingers and wrist.

Exercises for in hand manipulations

5) The Marble Exercise

Patient Position

- The patient sits in a chair with a table in front. A tray with marbles is placed on the table.
- The patient slightly flexes the shoulder extends elbow with forearm in mid prone or supination wrist and fingers flexed picks up the marbles one by one and holds them in the hand while picking up the next one. The patient tries to pick up as many marbles as possible.
- This will help in improving the in-hand manipulation of objects and fine motor control of the hand.

6. The rice Exercise

Patient Position

- The patient sits in a chair with a table in front. Two trays are placed on the table. One tray is filled with water, the other one with rice.
- The patient places the more affected hand in the water and then in the tray with rice by flexing adducting and internally rotating the shoulder with elbow slightly flexed and forearm pronated.
- The patient then uses the finger tips and the thumb of the same hand to get the rice of the hand.
- This will help in improving selective movements of the fingers and the thumb.

7. The tissue exercise: (Refer fig. 1 and 2)

Patient Position

- The patient sits in a chair with a table in front. Tissues are placed on the table. The patient picks up a tissue with the more affected hand by slightly flexing and abducting the shoulder, flexing elbow to 90 degrees and pronating the forearm.

- Then tries to crumble the tissue by opening and closing the fingers and pressing the tissue in the hand.
- This will help in improving motor control of the intrinsic muscles of the fingers and the hand [27].

Fig 1: Tissue exercise. (MT)

Fig 2: Tissue exercise. (CIMT)

Outcome Measure
Wolf Motor Function Test

General Description of the WMFT

All tasks are performed as quickly as possible. Tasks are as follows:

1. Forearm to table (side): Subject attempts to place forearm on the table by abduction at the shoulder.
2. Forearm to box (side): Subject attempts to place a forearm on the box by abduction at the shoulder.
3. Extend elbow (side): Subject attempts to reach across the table by extending the elbow (to the side).
4. Extend elbow (to the side) with weight: Subject attempts to push the sandbag against outer wrist joint across the table by extending the elbow.
5. Hand to table (front): Subject attempts to place involved hand on the table.
6. Hand to box (front): Subject attempts to place hand on the box.
7. Weight to box (front): Subject attempts to place hand on the box with weight.
8. Reach and retrieve (front): Subject attempts to pull 1-lb weight across the table by using elbow flexion and cupped wrist.
9. Lift can (front): Subject attempts to lift can and bring it close to lips with a cylindrical grasp.
10. Lift pencil (front): Subject attempts to pick up pencil by using 3-jaw chuck grasp.
11. Pick up paper clip (front): Subject attempts to pick up paper clip by using a pincer grasp.
12. Stack checkers (front): Subject attempts to stack checkers onto the center checker.
13. Flip cards (front): Using the pincer grasp, patient attempts to flip each card over.
14. Grip Strength: Using hand held dynamometer; grip strength was measured.
15. Turning the key in lock (front): Using pincer grasp, while maintaining contact, patient turns key fully to the left and right.
16. Fold towel (front): Subject grasps towel, folds it lengthwise, and then uses the tested hand to fold the towel in half again.
17. Lift basket (standing): Subject picks up basket by grasping the handles and placing it on bedside table.

Data Analysis

The Hand Function was analyzed using Wolf Motor Function Test for upper extremity. The data was entered in an excel spread sheet, tabulated and subjected to statistical analysis. Data was analyzed with the help of figure Pad InStats©. Effect of CIMT and MT on hand function in chronic stroke analyzed using

1. Paired t-test – To see the difference between pre and post measurements within the group.
2. Unpaired t-test – To analyze the difference between pre and post measurements between the group.

The results were concluded to be statistically significant if $p<0.05$.

Result

After analysis of data, we can see that the subjects receiving CIMT and MT showed significant improvement on Wolf Motor Function Test as compared with pre-treatment data. (Table and figure 1 and 2). Table 1 shows, CIMT pre-treatment and post-treatment data analyzed by paired t-test and shows extremely significant result with the p-value <0.0001. Table 2 shows, MT pre-treatment and post-treatment data analyzed by paired t-test and shows extremely significant result with the p-value <0.0001. In that subjects receiving CIMT, on Comparison of Individual Tasks of Wolf Motor Function Test showed significant improvement than subjects receiving MT. (Table and figure 3). Table 3 represents, individual task analysis of CIMT and MT post-treatment data analyzed by unpaired t-test. It shows extremely significant results for tasks 1,3,4,9,12,13,14,15,16,17. Very significant results for tasks 2,5,11. Significant results for tasks 8,10. Not quite significant result for task 6 and 7.

Post- treatment (4 weeks), Constraint Induced Movement Therapy and Mirror therapy pre-treatment and post-treatment data difference by paired t-test.

Table 1: CIMT (GROUP A) pre-treatment and post-treatment data analyzed by paired t-test.

	Cimt pre-time	**Cimt post time**			
	Mean ± SD	Mean ± SD	p value (<0.05)	t value	Result
WMFT (SEC)	55.871 ± 40.378	34.680 ± 30.347	<0.0001	6.771	Extremely Significant
WMFT Task 7 (kgs)	0.7375 ± 0.2625	1.2875 ± 0.4389	<0.0001	11.000	Extremely Significant
WMFT Task 14 (kgs)	2.545 ± 0.6111	3.989 ± 0.8398	<0.0001	20.108	Extremely Significant

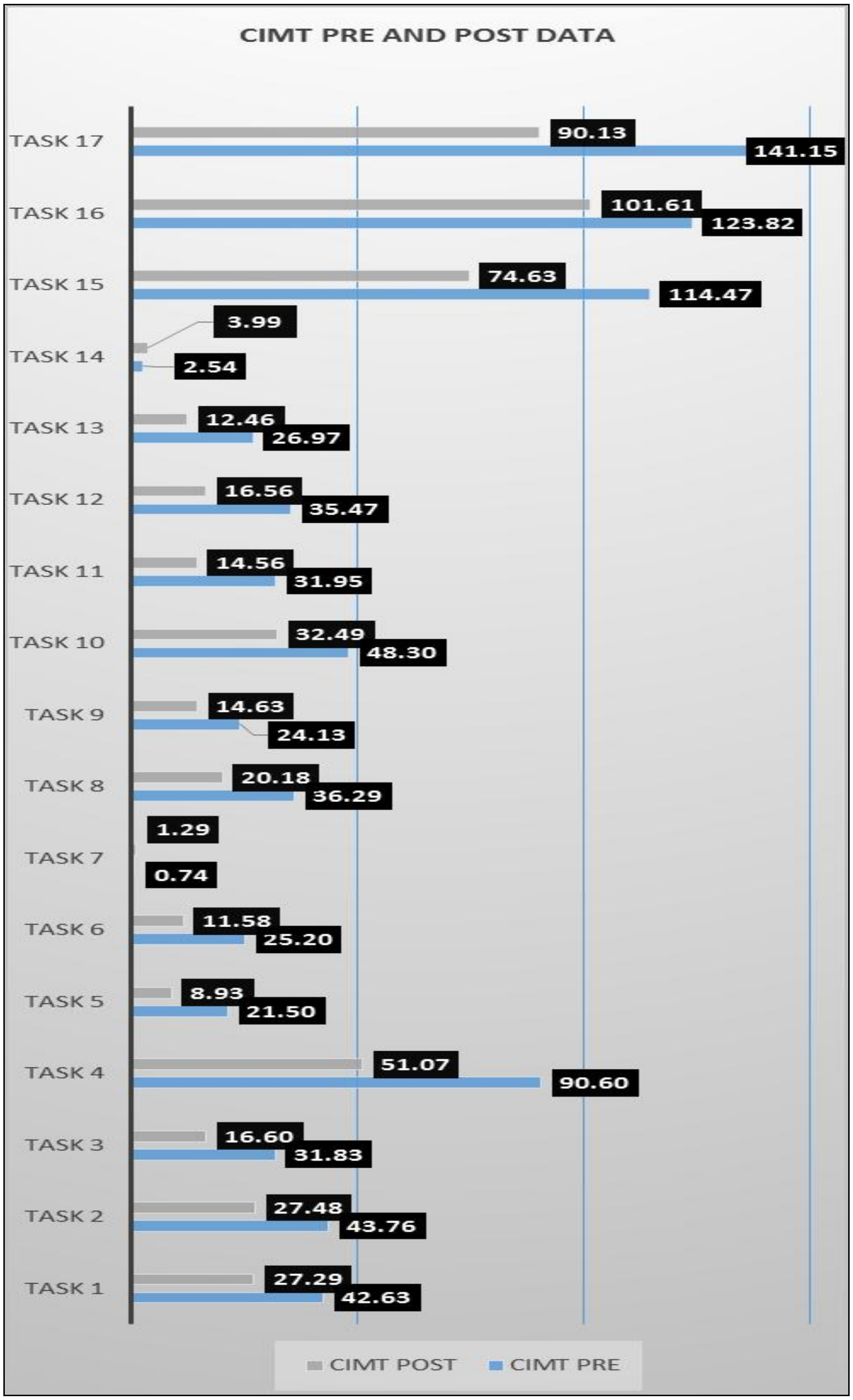

Fig 1: CIMT pre & post treatment data showing significant difference. p is< 0.0001.

Table 2: MT (GROUP B) pre-treatment and post-treatment data analyzed by paired t-test.

	Mt pre-time	Mt post time			
	Mean ± SD	Mean ± SD	p value (<0.05)	t value	Result
WMFT (SEC)	57.403 ± 40.612	47.344 ± 39.628	<0.0001	13.275	Extremely Significant
WMFT TASK 7 (kgs)	0.7500 ± 0.2690	1.0375 ± 0.3371	<0.0001	14.038	Extremely Significant
WMFT TASK 14 (kgs)	2.518 ± 0.5246	3.072 ± 0.6214	<0.0001	12.278	Extremely Significant

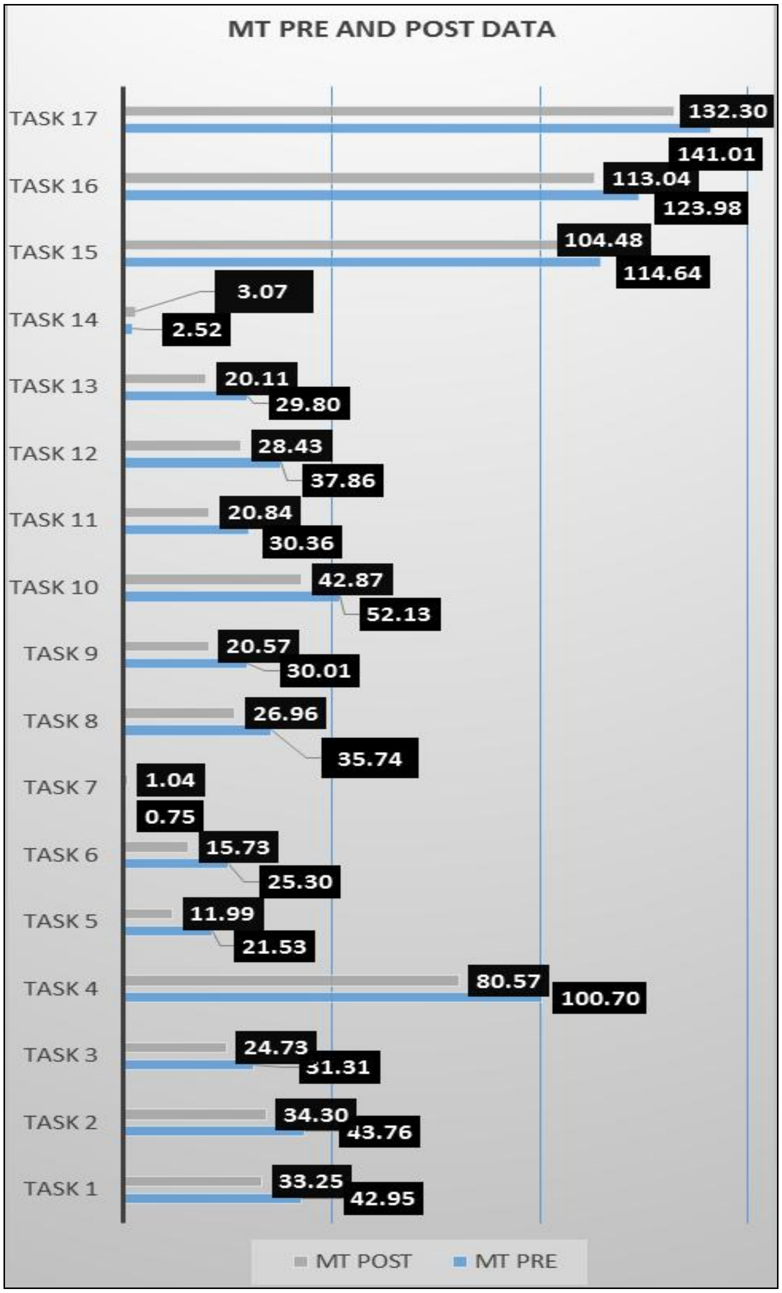

Fig 2: MT pre & post treatment data showing significant difference. p is< 0.0001.

Individual Task Analysis

Table 3: CIMT (Group A) and MT (Group B) post treatment data analyzed by unpaired t-test.

Task	Cimt Post Data Mean ± Sd	Mt Post Data Mean ± Sd	P value (<0.05)	T value	Result
1	27.286 ± 3.467	33.248 ± 5.151	<0.0001	4.294	Extremely Significant
2	27.486 ± 3.816	34.297 ± 9.464	0.0049	2.986	Very ignificant
3	16.599 ± 4.880	24.726 ± 7.655	0.0003	4.002	Extremely Significant
4	51.072 ± 3.954	80.569 ± 11.654	<0.0001	10.719	Extremely Significant

5	8.933 ± 3.084	11.986 ± 2.998	0.0030	3.175	Very Significant
6	11.583 ± 3.473	15.729 ± 9.452	0.0734	1.841	Not Quite Significant
7	1.2875(kg) ± 0.4389	1.0375(kg) ± 0.3371	0.0504	2.020	Not Quite Significant
8	20.178 ± 4.887	26.962 ± 10.950	0.0157	2.530	Significant
9	14.632 ± 3.998	20.567 ± 5.512	0.0004	3.898	Extremely Significant
10	32.489 ± 6.038	42.866 ± 17.532	0.0167	2.503	Significant
11	14.563 ± 2.617	20.844 ± 9.052	0.0050	4.013	Very Significant
12	16.558 ± 2.529	28.431 ± 12.898	0.0003	4.155	Extremely Significant
13	12.462 ± 1.663	20.113 ± 8.066	0.0002	10.899	Extremely Significant
14	3.989(kg) ± 0.8398	3.072(kg) ± 0.6214	0.0004	3.925	Extremely Significant
15	74.634 ± 6.688	104.476 ± 10.256	<0.0001	2.981	Extremely Significant
16	101.614 ± 4.929	113.041 ± 9.912	<0.0001	4.617	Extremely Significant
17	90.134 ± 7.003	132.298 ± 15.432	<0.0001	11.127	Extremely Significant

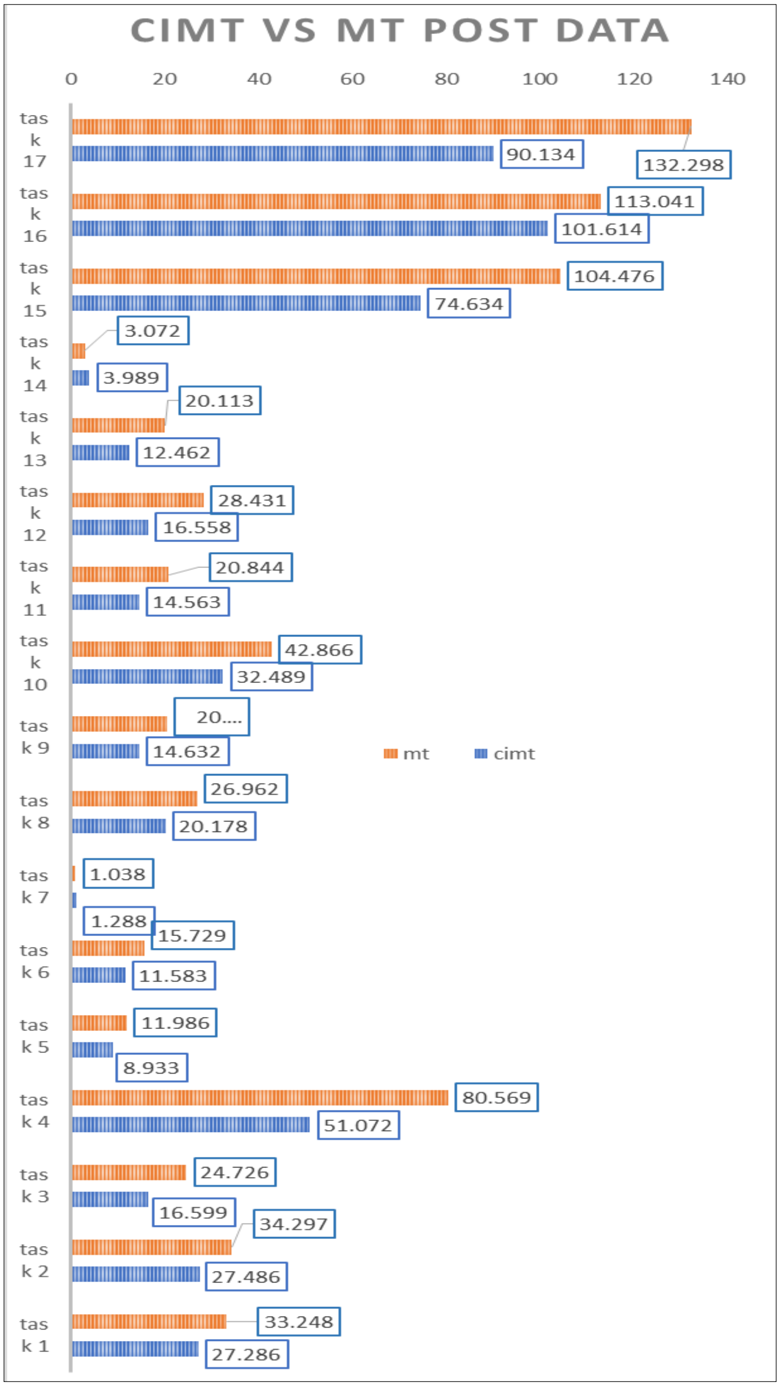

Fig 3: CIMT and MT post-treatment data.

Discussion

The present study was done to see the effectiveness of CIMT and MT on upper extremity hand function assessed by using Wolf Motor Function Test in patients with Chronic stroke. In this study total 40 patients both males and females were included with 20 participants in each group (CIMT and MT along with Conventional Treatment) with mean age 52 + 10 years. In this study we found that CIMT and MT are effective in improving hand function in chronic stroke patients. Further on, comparing CIMT and MT along with conventional training we found that CIMT is more effective in improving hand function in chronic stroke patients. Our results are in account with EQ van Delden *et al*.; they reported that CIMT has beneficial effects on the paretic hand in chronic stroke patients, possibly as a result of changes in contra lesional cortical networks [29]. Keh-Chung Lin *et al*. has reported that a 4 weeks CIMT program improves motor function assessed using Fugl- Meyer assessment UE and functional performance assessed using Motor Activity Log but there was not significant improvement in functional performance when assessed using Functional Independence Measure in chronic stroke patients. The possible reason that they did not found significant difference in improving functional performance assessed using Functional Independence Measure could be their study had small sample size, small intervention period, the population i.e. chronic stroke and very less bilateral symmetrical activities whereas in our study we found that 4 weeks of CIMT improves motor function assessed using Wolf Motor Function Test [30]. They reported that unilateral movements may generates an in terhemispheric inhibition in the ipsilateral hemisphere that prevents mirror movements in opposite upper limb. In contrast, Bilateral movement activates similar neural distributed networks in both the hemisphere, allowing mirror movements [31, 32]. In contrast with our study results, Morris *et al*. [33] did not showed significant difference between the benefits of CIMT and MT and unilateral arm training when compared in chronic stroke patients; possibly because these studies were based on a small trial with heterogeneous characteristics of study subjects (eg, time after onset of stroke). Our findings concur to those of Cunningham *et al*. Functional recovery of the upper extremity is promoted by plastic changes in the functioning of the brain, which, in general, also occur in learning [34]. These experiences induced changes are brought about by a combination of neural repair and neuro-anatomic reorganization and include greater excitability and recruitment of the neurons in both hemispheres, sprouting of dendrites, and strengthening of synaptic connections [34-37]. A variety of functional symmetric tasks were incorporated into the exercise program in our study that allowed repetitive practice on skilled movements. Repetitive exercises/ practice helps to activate weak paralyzed muscles as well as Task related training to improve strength and co-ordination [38]. As well as practice of meaningful / functional tasks and specific exercises also gives the damaged system the opportunity to regain the ability to select and use those sensory inputs which are relevant to the action being practiced. Thus, the overall findings of this study suggest that 4 weeks of CIMT is a better approach along with conventional rehabilitation to improve upper extremity hand function in patients with Chronic stroke.

Conclusion

In this study both the groups i.e. Group A (CIMT) and Group B (MT) along with Conventional Treatment program showed improvement of affected upper extremity hand function in chronic stroke. But on comparing both the training groups statistically, CIMT proved to be more effective than MT to improve affected upper extremity hand function assessed by using Wolf Motor Function Test in patients with chronic stroke.

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