Effectiveness of modified constraint induced movement therapy in restoring the fine motor function of upper limb among middle cerebral artery post stroke patients – a pilot study

Akash Ashok [ID], Ramana Kameswaran [ID], Vignesh Srinivasan [ID], Prathap Suganthirababu [ID], Saloni Ram Bachan [ID], Kumaresan Abathsagayam [ID]

Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Science, Chennai, Tamil Nadu, India

Abstract

Introduction. A cerebrovascular accident happens when brain cells suddenly die due to insufficient blood flow. One common result of a stroke affecting the middle cerebral artery (MCA) is the loss of upper limb function, which can have a significant impact on everyday activities. Mirror therapy (MT) and modified constraint induced movement therapy (mCIMT) are stroke rehabilitation methods for upper limb function. Mirror therapy stimulates brain areas such as the premotor and motor cortex using visual cues. In contrast, mCIMT restricts the unaffected arm, encourages repeated task practice, and utilises behavioural techniques to boost neuroplasticity, aiding in recovery.

Methods. Twenty stroke survivors were assigned randomly to the mCIMT group ($n = 10$) or the MT group ($n = 10$). The mCIMT group received mCIMT, while the MT group underwent mirror therapy over ten weeks with four weekly sessions. Outcome measures included the Fugl-Meyer Assessment Scale (FMAS) and the Wolf Motor Function Test (WMFT).

Results. The study highlights a significant enhancement in hand function in the mCIMT group compared to the MT group after 10 weeks of therapy. Post-treatment evaluations using the WMFT and FMAS yielded p-values less than 0.001, indicating a notable difference between the groups.

Conclusions. Analyses within and between groups showed significant impacts, supporting mCIMT's efficacy in enhancing fine motor skills among stroke patients with MCA involvement. These results stress the importance of personalised therapies such as mCIMT in post-stroke recovery, enhancing survivors' standard of living and improving functional outcomes.

Key words: fine motor skills, stroke, mirror therapy, motor assessment

Introduction

Stroke is a major global health concern, leading to widespread disability and high mortality rates. It is defined as a sudden neurological deficit caused by localised damage to the central nervous system resulting from vascular events, including cerebral infarction, intracerebral haemorrhage, and subarachnoid haemorrhage [1, 2]. According to the World Health Organization (WHO), stroke is the third leading cause of disability-adjusted life years globally and the second most common cause of mortality. An estimated 13.7 million occurrences of stroke occur worldwide each year, and the condition is thought to be the cause of 5.5 million stroke-related deaths [3–5]. The middle cerebral artery (MCA), whose segments M1 through M4 supply the brain's internal capsule, basal ganglia, and lateral surface, frequently contributes to strokes. The basal ganglia, which are crucial to emotions and motor control, are supplied by the M1 section. The insula, parietal lobe, inferolateral frontal lobe, and superior temporal lobe are all supplied by the M2 segment. The opercular segment (M3) includes the temporal, parietal, and frontal lobes. Finally, M4, or the cortical segment, is made up of smaller branches that enter the cerebral cortex and carry blood to specific regions of the brain [6]. Patients affected by MCA involvement experience more severe upper limb impairments. During the early stage of a stroke, around 60–80% of sufferers experience motor difficulties affecting either their upper or lower extremities. However, only 20% of those with severe paretic strokes regain normal upper limb function,

compared to 80% of those with milder strokes. This upper limb dysfunction not only affects the basic motor skills necessary for daily tasks such as walking, balance, and self-defence reflexes but also leads to deficits in fine motor abilities. Due to its impairment of fundamental tasks of daily living, including eating, washing, writing, walking, and manipulating items, this dysfunction severely reduces the quality of life, restricting stroke patients' ability to live independently within society. The hands and arms play a vital role in performing numerous tasks in the workplace. With a wide range of physical intervention techniques available, the aim of therapeutic training is to assist patients in using their affected side and performing motor skills voluntarily [7]. In recent years, advancements in acute stroke management – such as thrombolytic therapy, mechanical thrombectomy, and neurorehabilitation technologies – have led to improved recovery rates and reduced long-term disability. Moreover, innovations in robotic exoskeletons, assistive devices, and compensatory strategies have further enhanced the functional capabilities of stroke survivors [8].

Mirror therapy (MT) is applicable to severely paretic stroke survivors who are fully paralysed, unlike many other therapies that necessitate some voluntary movement. This is possible because MT utilises visual cues instead of somatosensory inputs to elicit the desired response in the affected limb. Mirror therapy works by creating the illusion of movement in the affected limb through reflection or visual input from the unaffected limb. This is typically achieved by placing a mirror between the limbs. However, these methods have their limita-

tions and require personalised treatment strategies to achieve the best results. Newer therapies, such as transcranial magnetic stimulation (TMS) and virtual reality-based rehabilitation, have shown potential in further improving motor recovery [9, 10]. Functional brain imaging studies indicate that when a healthy participant observes a mirror reflection of their hand while performing unilateral hand movements, there is an increase in excitability within the primary motor cortex. Regions of the affected hemisphere may contribute to post-stroke motor recovery, particularly near the ipsilesional stroke site. The supplementary motor area, premotor cortex, and bilateral inferior parietal area are all activated during motor tasks. Post-stroke central modifications in networks governing paretic and nonparetic lower limbs were shown by. the premotor and parietal regions, basal ganglia, and the cerebellum are the main sites where motor imagery activates overlapping neuronal networks that mimic movement laws found in real motions Luft et al [11].

Modified constraint induced movement therapy (mCIMT) is a commonly used rehabilitation method aimed at enhancing upper limb motor recovery following a stroke. The typical CIMT protocol includes intensive daily practice of up to six hours with the affected limb, alongside restraining the unaffected limb to promote neuroplastic changes and functional recovery. However, its rigorous nature often poses challenges, including fatigue, poor compliance, and difficulty adapting to patients with moderate-to-severe impairments. These limitations necessitated the development of mCIMT, a protocol designed to enhance feasibility while maintaining therapeutic efficacy. The mCIMT protocol differs from the standard CIMT in several key aspects. First, it significantly reduces the therapy duration, often requiring 2–3 hours of practice per day over a shorter treatment period, e.g., 10 workdays [12, 13]. Second, mCIMT incorporates a 'transfer package', a structured program aimed at ensuring the integration of motor gains into daily functional tasks. Third, it emphasises task-specific functional activities tailored to individual needs and allows rest breaks to minimise fatigue. Importantly, mCIMT continues to employ the principle of limiting the unaffected limb to stimulate neuroplasticity but does so in a manner that is more manageable for patients. Evidence indicates that mCIMT is as effective as CIMT in promoting upper limb recovery, while also offering additional advantages in terms of patient adherence and practicality. For instance, studies have demonstrated that mCIMT enhances upper extremity (UE) function and daily activity usage, with patients finding it more tolerable due to its shorter and more flexible therapy sessions [14, 15]. In contrast to MT, which relies on visual feedback via mirrored illusions to stimulate motor recovery, mCIMT actively engages the affected limb through voluntary tasks while restricting the unaffected side. Both approaches effectively enhance motor function and participation in daily activities, but mCIMT provides a more direct mechanism for promoting voluntary motor control [16]. By overcoming the limitations of standard CIMT, mCIMT provides a practical and effective alternative for promoting motor recovery in stroke patients, especially those in the subacute phase of rehabilitation.

The FMAS is a widely regarded tool for assessing motor function in individuals with post-stroke hemiparesis. It is known for its strong psychometric properties, including high validity, responsiveness, and reliability. Each item in the FMAS indicates a motion, from proximal to distal joints, that is critical for motor function in hemiparesis after a stroke. Assessing the level of difficulty for each task on the FMAS is crucial for accurately diagnosing upper extremity paresis and effectively guiding rehabilitation strategies. Clinicians frequently use the FMA-UE to assess impairment both prior to intervention and during follow-up sessions. The FMA-UE scale ranges from 0 to 66 points, with higher scores reflecting better motor function [17, 18]. The interpretation of each item may vary depending on the clinician's assessment. In addition to evaluating the impairment itself, it is essential to have an accurate and sensitive evaluation of functional activities to assess the effectiveness of therapeutic interventions in improving upper extremity weakness. The Wolf Motor Function Test (WMFT) is a reliable and frequently used evaluation tool for assessing functional capability in the upper limbs. It includes two strength tests and a set of fifteen functional exercises that start with basic motions at closer joints and advance to more intricate actions at farther joints. Each of these 15 tasks needs to be finished within a time limit of 120 s. The evaluation also provides sub-scores indicating the movement quality during these tasks. Studies have validated the reliability and accuracy of the WMFT in gauging upper limb function, but challenges in its application, as well as the potential integration of novel technologies, should be considered to optimise rehabilitation outcomes [19].

Subjects and methods

Participant recruitment and assessment

A total of 20 patients, comprising both males and females, were enlisted from the neurology outpatient department of a tertiary care hospital, where screening for stroke history was conducted. Each participant was thoroughly briefed on the study protocols. This research focused on individuals who exhibit, at minimum, a 20-degree angle of active wrist extension and a 10-degree angle of active finger extension, including those in the subacute phase of their first MCA stroke. Inclusion criteria also involved participants with Brunnstrom stages of stroke recovery greater than 5 and aged 40 and above, of any gender, and who have a Mini-Mental status examination score exceeding 24. Their Modified Ashworth Scale (MAS) score should also fall between 1 and 3. Finally, the participants had to have stable medical conditions that allow their participation in the testing and intervention processes, and the ability to understand and follow instructions from the physical therapist [20]. Exclusion criteria included individuals with neurological or orthopaedic conditions that may interfere with the study, those diagnosed with complex regional pain syndrome or secondary adhesive capsulitis, and individuals with psychological disorders [21].

Demographic details

Procedures and interventions

Each participant was provided with detailed information regarding the nature, purpose, and potential benefits of the study, along with their right to refuse or withdraw from participation at any point, and the assurance of data confidentiality. The study was carried out at a tertiary hospital in Southern India, specifically targeting individuals in the subacute stage of recovery from strokes affecting the MCA as the study's focus group. The research involved 20 participants aged 40 and above who had suffered a MCA stroke, comprising 8 females and 12 males. Their ages varied as follows: 4 were near 40, 3 were close to 45, 4 were near 50, 5 were nearing 55, and 4 were nearing 60.

Based on the specific inclusion and exclusion criteria, individuals who met the eligibility criteria, including a minimum

A. Ashok, R. Kameswaran, V. Srinivasan, P. Suganthirababu, S.R. Bachan, K. Abathsagayam
mCIMT for fine motor recovery – MCA stroke

Physiother Quart 2026, 34(1)

of 20° of finger extension and 10° of wrist extension, were included in the study. Participants were then randomly assigned to either the mCIMT group or the MT group using the closed envelope method, with ten participants in each group. The mCIMT group, consisting of individuals with arm paresis following a first-time stroke in the MCA area, participated in treatment sessions at a tertiary care hospital. Before the procedure began, each participant gave written consent after being fully informed about the study. Using the closed envelope method, participants were randomly assigned to one of the two groups (mCIMT and MT), with each group comprising ten subjects. Remarkably, no participants withdrew from the study post-randomisation. Furthermore, to maintain participant blinding regarding group allocation, a tertiary care hospital, facilitated by an independent researcher, managed the allocation process.

The sessions, lasting 45 min, were conducted four times a week for 10 weeks, during which the unaffected arm was restricted. Participants were also encouraged to wear a restrictive mitten for at least three hours at home after each treatment session. During the sessions, participants performed nine upper limb function tasks specifically designed for the study, such as peg transferring, ball grasping and releasing, spoon feeding, block or cup stacking, clothing fastening, pouring and stirring, small object manipulation, book page turning, and scissor cutting. The number of repetitions for each task was meticulously documented during the sessions (Table 1).

The control group (MT) participated in mirror therapy sessions lasting 45 min, held four times a week over the same 10-week period. During these sessions, participants sat beside a table with a mirror placed vertically along the plane dividing it into left and right halves. The affected limb was positioned behind the mirror, while the unaffected limb was aligned with the mirror. Participants engaged in nine upper limb function tasks tailored for the study, such as peg transferring, ball grasping and releasing, spoon feeding, block or cup stacking, clothing fastening, pouring and stirring, small object manipulation, book page turning, and scissor cutting. Participants were instructed to observe the reflection of their unaffected limb in the mirror and to attempt to replicate the same movements with their affected limb. Before starting the treatment, pre-test evaluations using the FMA-UE and WMFT were conducted, and post-test assessments were carried out after the 10-week treatment period (Table 1).

Outcome measures

The FMAS comprises four distinct categories, each with a maximum score contributing to a total of 126:
– motor function (max score = 66)
– sensory function (max score = 12)
– range of motion in joints (max score = 24)
– joint pain (max score = 24)
These sections evaluate various aspects of upper limb abilities, and the combined scores provide an overall assessment of upper limb function.

Wolf Motor Function Test

The WMFT is split into 17 items, grouped into the Time, Functional Ability, and Strength categories (FAS). There are 15 tasks related to function and 2 related to strength. Performance time is designated as WMFT-time, while capability to perform tasks is denoted as WMFT-FAS. Tasks 1–6 are functional and timed, tasks 7–14 focus on strength, and the remaining 9 evaluate movement quality. The evaluator should start by assessing the less impacted upper extremities before progressing to the more affected side. Ratings are given on a 6-point scale, ranging from '0' (no effort made with the

Table 1. Tasks performed and descriptions for both intervention groups

Task	Experimental group undergoing mCIMT	Control group undergoing MT
1. Peg transferring	Participants transferred pegs from one container to another using their affected hand.	Participants watched the reflection of their unaffected hand as it transferred pegs, while performing the same task with their affected hand.
2. Ball grasping and releasing	Participants grasped a ball with their affected hand and released it into a container.	Participants mirrored the grasping and releasing of a ball with their unaffected hand while using their affected hand.
3. Spoon feeding	Participants practiced scooping food with a spoon using their affected hand.	Participants used a spoon to scoop food, observing their unaffected hand's movements in the mirror.
4. Block/cup stacking	Participants stacked blocks or cups using their affected hand.	Participants observed stacking blocks or cups with their unaffected hand while attempting the same with their affected hand.
5. Clothing fastening	Participants practiced buttoning or fastening clothing with their affected hand.	Participants mirrored the movement of fastening clothing with their unaffected hand.
6. Pouring and stirring	Participants poured water from one cup into another and stirred it using their affected hand.	Participants observed pouring and stirring motions of their unaffected hand while attempting to replicate with the affected hand.
7. Small object manipulation	Participants manipulated small objects (e.g., coins, buttons) with their affected hand.	Participants manipulated small objects, observing their unaffected hand in the mirror.
8. Book page turning	Participants turned the pages of a book using their affected hand.	Participants practiced turning the pages of a book, mirroring the action with their unaffected hand.
9. Scissor cutting	Participants practiced cutting paper with scissors using their affected hand.	Participants observed scissor-cutting movements with their unaffected hand while using their affected hand.

mCIMT – modified constraint induced movement therapy, MT – mirror therapy

affected arm) to '5' (movement appears normal), with a total score of 75 indicating better function. Lower scores indicate lower levels of functioning. The WMFT-time protocol allocates 120 s per task, making clinical assessments more efficient.

Statistical analysis

1. Statistical analyses were performed using the SPSS software. Data were presented as mean values with corresponding standard deviations for each outcome measure. A prior power analysis ensured the adequacy of the sample size, providing 90% power with a 5% significance level for both the experimental (mCIMT) and control (MT) groups.

2. Descriptive statistics: Descriptive statistics, including mean and standard deviation, were calculated for baseline and post-treatment outcomes to summarise participant characteristics and outcome measures.

3. Within-group analysis: Changes within each group from baseline to post-treatment were evaluated using the Wilcoxon signed-rank test. This non-parametric test was selected due to the small sample size and non-normal distribution of the data, ensuring a reliable analysis of paired samples (Table 2).

4. Between-group analysis: The Mann–Whitney U test was used to compare outcomes between the mCIMT and MT groups. This test is appropriate for the independent groups in this study and the characteristics of the data (Table 3).

5. Effect sizes and confidence intervals: Effect sizes (2.67) and 95% confidence intervals were calculated to offer further context to the statistical significance, quantifying the magnitude of the changes observed in the outcome measures.

6. Significance level: All statistical tests were conducted at a significance level of $p < 0.05$.

The analyses of the statistics revealed significant improvements in fine motor function of the upper limb among MCA stroke patients following mCIMT compared to the MT group (Table 3).

Results

The effectiveness of the mCIMT and MT in restoring fine motor function among MCA stroke patients was evaluated using the FMA-UE and the WMFT. Both groups showed significant improvements in outcome measures post-treatment, with the mCIMT group demonstrating considerably greater gains than the MT group.

Fugl-Meyer Assessment (upper extremity)

For the FMA-UE, the mCIMT group showed an increase in mean scores from a pre-treatment value of 89.9 (*SD* 3.212) to a post-treatment value of 99.1 (*SD* 2.766). The Wilcoxon signed-rank test revealed a test statistic (*t*-value) of 55.00 and a statistically significant *p*-value of < 0.002. Similarly, the MT group demonstrated an improvement from a mean pre-treatment score of 89.3 (*SD* 2.983) to a post-treatment mean of 94.2 (*SD* 2.529), with a *t*-value of 55.00 and *p*-value of < 0.002. However, the mCIMT group exhibited larger post-treatment gains, suggesting a more pronounced effect on motor recovery for the upper extremity.

Wolf Motor Function Test

For the WMFT, the mCIMT group improved from a pre-treatment mean score of 28.4 (*SD* 2.065) to a post-treatment mean of 49.1 (*SD* 2.806). The Wilcoxon signed-rank test yielded a *t*-value of 55.00 and *p*-value of < 0.002. In the MT group, the mean score increased from 28.5 (*SD* 2.013) to 36.0 (*SD* 4.189), with a *t*-value of 53.50 and *p*-value of < 0.004. Although both groups exhibited significant within-group improvements, the mCIMT group showed a significantly greater improvement in WMFT scores compared to the MT group.

Table 2. Analysis of pre-test and post-test results of the WMFT and FMA for both groups

Outcome measure	Group	Test	Mean ± *SD*	*t*-value	*p*-value
FMA (upper extremity)	mCIMT	pre	89.9 ± 3.212	55.00	< 0.002
		post	99.1 ± 2.766		
	MT	pre	89.3 ± 2.983	55.00	< 0.002
		post	94.2 ± 2.529		
WMFT	mCIMT	pre	28.4 ± 2.065	55.00	< 0.002
		post	49.1 ± 2.806		
	MT	pre	28.5 ± 2.013	53.500	< 0.004
		post	36 ± 4.189		

WMFT – Wolf Motor Function Test, FMA – Fugl-Meyer Assessment
mCIMT – modified constraint induced movement therapy, MT – mirror therapy

Table 3. Results of analysis comparing the two groups

Outcome measure	Group	Test	Mean ± *SD*	*t*-value	*p*-value
FMA (upper extremity)	mCIMT	post	99.1 ± 2.766	145.500	< 0.002
	MT	post	94.2 ± 2.529		
WMFT	mCIMT	post	49.1 ± 2.806	155.00	< 0.001
	MT	post	36 ± 4.189		

WMFT – Wolf Motor Function Test, FMA – Fugl-Meyer Assessment
mCIMT – modified constraint induced movement therapy, MT – mirror therapy

A. Ashok, R. Kameswaran, V. Srinivasan, P. Suganthirababu, S.R. Bachan, K. Abathsagayam
mCIMT for fine motor recovery – MCA stroke

Physiother Quart 2026, 34(1)

Between-group comparison

A between-group comparison further confirmed the superiority of mCIMT over MT. Post-treatment FMA-UE scores revealed a mean value of 99.1 (*SD* 2.766) in the mCIMT group, significantly higher than the MT group's mean score of 94.2 (*SD* 2.529). The Wilcoxon signed-rank test produced a *t* value of 145.50, with a *p*-value of < 0.002. Similarly, post-treatment WMFT scores for the mCIMT group (mean = 49.1, *SD* 2.806) were significantly greater than those of the MT group (mean = 36.0, *SD* 4.189), with a *T* value of 155.00 and a highly significant *p*-value of < 0.001.

Interpretation

These findings highlight the superior effectiveness of mCIMT in enhancing motor recovery compared to MT. While both interventions positively contributed to motor function recovery, mCIMT consistently led to greater improvements in upper limb function, as demonstrated by the significant within- and between-group differences in FMA-UE and WMFT scores. The observed effect sizes and confidence intervals further emphasise the robustness of these findings, supporting the inclusion of mCIMT in neurorehabilitation programs for MCA stroke patients.

Discussion

Modified constraint induced movement therapy (mCIMT) has shown potential as an effective method for enhancing fine motor skills in individuals post-stroke, with a primary focus on the upper limb. This feasibility study aimed to assess the efficacy of mCIMT in restoring fine motor function, particularly in patients who experienced a stroke in the MCA region. Our findings suggest that mCIMT significantly improves fine motor function in the upper limb when compared to mirror therapy [22]. Modified CIMT shows promise as an effective strategy to improve fine motor skills in individuals who have had a stroke in the MCA area. By restricting the unaffected limb and promoting intensive training and task-specific activities for the affected limb, mCIMT leverages neuroplasticity mechanisms to improve motor recovery. This is particularly relevant in MCA stroke cases, where fine motor deficits are often significant due to the specific brain areas affected. In contrast, mirror therapy uses visual feedback to simulate movement in the affected limb by reflecting the actions of the unaffected limb. Its goal is to stimulate neural pathways and support motor recovery by involving the mirror neuron system. In contrast, mCIMT involves restricting the use of the unaffected limb to encourage intensive use of the affected limb through task-specific activities, thereby harnessing neuroplasticity mechanisms for facilitate motor relearning. While mCIMT shows promise, it is essential to consider several limitations that may impact its effectiveness. The therapy's intensive nature, requiring patient compliance and motivation, can lead to decreased adherence, particularly in real-world clinical settings. Additionally, emerging rehabilitation techniques, such as robotic-assisted therapy and virtual reality-based rehabilitation, present alternative approaches that could complement or, in some cases, surpass mCIMT. Robotic-assisted therapy offers adaptive and consistent support for motor recovery, particularly for patients with limited voluntary movement. Virtual reality rehabilitation has shown potential in engaging patients with immersive, task-oriented environments, which may reduce the reliance on high patient motivation and enhance accessibility.

Our study findings are consistent with previous research, supporting the effectiveness of mCIMT in improving upper limb motor function post-stroke, as highlighted by Yadav et al. [13]. We noted substantial enhancements in FMA and WMFT scores among participants undergoing mCIMT, indicating that the intensive, task-focused training regimen of mCIMT could facilitate neuroplasticity and motor relearning, resulting in improved motor capabilities [23]. Additionally, the contrast with mirror therapy offers valuable perspectives on the comparative efficacy of various rehabilitation approaches. Mirror therapy, which leverages visual feedback to enhance motor imagery and aid in motor recovery, has demonstrated potential in stroke rehabilitation [24]. However, our results imply that mCIMT could lead to more substantial enhancements in fine motor function, as seen in the superior outcomes of the mCIMT group According to Fleet et al., a 10-week intervention conducted three times per week, known as modified CIMT (mCIMT), proved to be a successful approach for enhancing upper extremity recovery following a stroke [25]. In that research, a 10-week course of modified CIMT was implemented for individuals who had experienced strokes in the MCA region. Hijikata et al. [26] assert that the FMA-UE is a reliable measure for assessing upper extremity fine motor abilities in individuals who have had long-term strokes, particularly those with notable impairments. In their study, the FMA is used to evaluate hand function in patients who have experienced strokes in the MCA region. Hodics et al. affirm that the average speed of completing tasks in the WMFT is a reliable and responsive metric for characterising the functional abilities of stroke survivors with substantial to severe upper limb deficits [27]. In that research, the Wolf Motor Function Test is employed as a metric to assess outcomes.

The enhancements seen in fine motor function after mCIMT are especially important for stroke survivors who struggle with hand dexterity and coordination, as these challenges greatly affect their daily activities. By focusing on particular motor skills and encouraging rigorous practice, mCIMT seems to meet the specific requirements of individuals post-stroke in the MCA region, providing a customised and efficient method for rehabilitation.

In summary, the study provides valuable insights into the potential effectiveness of mCIMT in restoring fine motor function in individuals who have experienced strokes in the MCA region. While mirror therapy may offer certain benefits in motor rehabilitation, the evidence supporting the effectiveness of mCIMT in restoring fine motor function in MCA stroke survivors is more robust. With its focused approach, intensive training protocol, and neuroplasticity-enhancing mechanisms, mCIMT stands out as a more effective intervention for promoting significant improvements in upper limb motor function and enhancing independence in daily activities among this population. The use of validated assessment tools such as the FMA-UE and WMFT further bolsters the credibility of the findings, reinforcing mCIMT as a viable treatment option for individuals with MCA stroke. In conclusion, while mCIMT remains a promising intervention for motor recovery in stroke survivors, a more comprehensive approach to stroke rehabilitation should include comparisons with emerging technologies like robotic-assisted therapy and virtual reality rehabilitation. Addressing the intensive demands of mCIMT, alongside considerations of patient motivation, accessibility, and individual needs, will provide a more holistic understanding of its role in stroke recovery.

Physiother Quart 2026, 34(1)

A. Ashok, R. Kameswaran, V. Srinivasan, P. Suganthirababu, S.R. Bachan, K. Abathsagayam
mCIMT for fine motor recovery – MCA stroke

Limitations

It is important to acknowledge the limitations of this study. The small sample size and the short duration of the feasibility study may limit the broader applicability and long-term effectiveness of the observed outcomes. Furthermore, the lack of blinding and the potential for bias in group allocation could have influenced the results. Future research should aim to address these limitations and explore the optimal parameters and long-term benefits of mCIMT in stroke rehabilitation.

Conclusions

This study assessed the effectiveness of modified constraint induced movement therapy in improving fine motor function of the upper limb in middle cerebral artery stroke survivors. The results indicate that mCIMT is a promising and effective intervention for restoring fine motor skills, enhancing hand function, and improving dexterity in individuals with upper limb impairment following a stroke. The results indicate that mCIMT should be considered a valuable component in rehabilitation programs aimed at improving fine motor function in stroke survivors.

However, this study also underscores the need for further research with larger sample sizes and randomised controlled trials to fully elucidate the potential long-term benefits of mCIMT. Future investigations should explore the optimal duration and intensity of mCIMT therapy, assess its effectiveness across a broader spectrum of patient populations, and evaluate its impact across various stages of stroke recovery. Also, qualitative studies investigating patient experiences and satisfaction with mCIMT could provide essential insights to refine therapeutic protocols and improve clinical outcomes.

Clinical implications

Clinicians and therapists may consider integrating mCIMT into rehabilitation programs for MCA stroke patients with upper limb impairments. This therapy could be particularly effective when customised to meet individual patient needs, with an emphasis on task-specific training to optimise functional recovery. Combining mCIMT with other rehabilitation strategies, such as mirror therapy or physical therapy, could offer a more comprehensive approach to upper limb motor recovery.

Further studies will be instrumental in optimising mCIMT protocols for clinical use, ensuring that this promising intervention can be integrated effectively into routine stroke rehabilitation.

Acknowledgement

Ethical approval
The research related to human use complied with all the relevant national regulations and institutional policies, followed the tenets of the Declaration of Helsinki, and was approved by the Institutional Scientific Research Board (ISRB) of Saveetha College of Physiotherapy, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (approval No: 01/023/2023/ISRB/PGSR/SCPT).

Informed consent
Informed consent was obtained from all individuals included in this study.

Disclosure statement
No author has any financial interest or received any financial benefit from this research.

Conflict of interest
The authors state no conflict of interest.

Funding

References
[1] Sacco RL, Kasner SE, Broderick JP, Caplan LR, Connors JJ, Culebras A, Elkind MSV, George MG, Hamdan AD, Higashida RT, Hoh BL, Janis LS, Kase CS, Kleindorfer DO, Lee J-M, Moseley ME, Peterson ED, Turan TN, Valderrama AL, Vinters HV; American Heart Association Stroke Council, Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular Radiology and Intervention; Council on Cardiovascular and Stroke Nursing; Council on Epidemiology and Prevention; Council on Peripheral Vascular Disease; Council on Nutrition, Physical Activity and Metabolism. An updated definition of stroke for the 21st century: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2013;44(7):2064–89; doi: 10.1161/STR.0b013e318296aeca.

[2] Adams Jr HP, Bendixen BH, Kappelle LJ, Biller J, Love BB, Gordon DL, Marsh 3rd EE. Classification of subtype of acute ischemic stroke. Definitions for use in a multicenter clinical trial. TOAST. Trial of org 10172 in acute stroke treatment. Stroke. 1993;24(1):35–41; doi: 10.1161/01.str.24.1.35.

[3] Saini V, Guada L, Yavagal DR. Global epidemiology of stroke and access to acuteischemic stroke interventions. Neurology. 2021;97(20 Suppl 2):6–16; doi: 10.1212/WNL.0000000000012781.

[4] Murphy SJ, Werring DJ. Stroke: causes and clinical features. Medicine. 2020;48(9):561–6; doi: 10.1016/j.mpmed.2020.06.002.

[5] Kamalakannan S, Gudlavalleti AS, Gudlavalleti VS, Goenka S, Kuper H. Incidence and prevalence of stroke in India: a systematic review. Ind J Med Res. 2017;146(2):175–85; doi: 10.4103/ijmr.IJMR_516_15.

[6] Navarro-Orozco D, Sánchez-Manso JC. Neuroanatomy, middle cerebral artery. InStatPearls [Internet] 2023. StatPearls Publishing.

[7] Park J, Lee N, Cho Y, Yang Y. Modified constraint-induced movement therapy for clients with chronic stroke: interrupted time series (ITS) design. J Phys Ther Sci. 2015;27(3):963–6; doi: 10.1589/jpts.27.963.

[8] Malik AN, Tariq H, Afridi A, Rathore FA. Technological advancements in stroke rehabilitation. J Pak Med Assoc. 2022;72(8):1672–4; doi: 10.47391/JPMA.22-90.

[9] Gandhi DB, Sterba A, Khatter H, Pandian JD. Mirror therapy in stroke rehabilitation: current perspectives. Ther Clin Risk Manag. 2020;16:75–85; doi: 10.2147/TCRM.S206883.

[10] Yang Y, Zhao Q, Zhang Y, Wu Q, Jiang X, Cheng G. Effect of mirror therapy on recovery of stroke survivors: a systematic review and network meta-analysis. Neuroscience. 2018;390:318–36; doi: 10.1016/j.neuroscience.2018.06.044.

A. Ashok, R. Kameswaran, V. Srinivasan, P. Suganthirababu, S.R. Bachan, K. Abathsagayam
mCIMT for fine motor recovery – MCA stroke

Physiother Quart 2026, 34(1)

[11] Lee MM, Cho HY, Song CH. The mirror therapy program enhances upper-limb motor recovery and motor function in acute stroke patients. Am J Phys Med Rehabil. 2012;91(8):689–700; doi: 10.1097/PHM.0b013e31824fa86d.

[12] Sirtori V, Corbetta D, Moja L, Gatti R. Constraint-induced movement therapy for upper extremities in stroke patients. Cochrane Database Syst Rev. 2009(4); doi: 10.1002/14651858.CD004433.pub2.

[13] Yadav RK, Sharma R, Borah D, Kothari SY. Efficacy of modified constraint induced movement therapy in the treatment of hemiparetic upper limb in stroke patients: a randomized controlled trial. J Clin Diagn Res. 2016; 10(11):YC01; doi: 10.7860/JCDR/2016/23468.8899.

[14] Ju Y, Yoon IJ. The effects of modified constraint-induced movement therapy and mirror therapy on upper extremity function and its influence on activities of daily living. J Phys Ther Sci. 2018;30(1):77–81; doi: 10.1589/jpts.30.77.

[15] Hsieh H-C, Liao R-D, Yang T-H, Leong C-P, Tso H-H, Wu J-Y, Huang Y-C. The clinical effect of Kinesio taping and modified constraint-induced movement therapy on upper extremity function and spasticity in patients with stroke: a randomized controlled pilot study. Eur J Phys Rehabil Med. 2021;57(4):511–9; doi: 10.23736/S1973-9087.21.06542-4.

[16] Thieme H, Morkisch N, Mehrholz J, Pohl M, Behrens J, Borgetto B, Dohle C. Mirror therapy for improving motor function after stroke. Cochrane Database Syst Rev. 2018; 7(7):CD008449; doi: 10.1002/14651858.CD008449.pub3.

[17] Woodbury ML, Velozo CA, Richards LG, Duncan PW, Studenski S, Lai SM. Dimensionality and construct validity of the Fugl-Meyer Assessment of the upper extremity. Arch Phys Medicine Rehabil. 2007;88(6):715–23; doi: 10.1016/japmr. 2007.02.036.

[18] Hiragami S, Inoue Y, Harada K. Minimal clinically important difference for the Fugl-Meyer assessment of the upper extremity in convalescent stroke patients with moderate to severe hemiparesis. J Phys Ther Sci. 2019;31(11): 917–21; doi: 10.1589/jpts.31.917.

[19] Morris DM, Uswatte G, Crago JE, Cook III EW, Taub E. The reliability of the wolf motor function test for assessing upper extremity function after stroke. Arch Phys Med Rehabil. 2001;82(6):750–5; doi: 10.1053/apmr.2001.23183.

[20] Pandyan AD, Johnson GR, Price CI, Curless RH, Barnes MP, Rodgers H. A review of the properties and limitations of the Ashworth and modified Ashworth Scales as measures of spasticity. Clin Rehabil. 1999;13(5):373–83; doi: 10.1191/026921599677595404.

[21] Birklein F, O'Neill D, Schlereth T. Complex regional pain syndrome: an optimistic perspective. Neurology. 2015; 84(1):89–96; doi: 10.1016/j.neulet.2018.04.031.

[22] Nogueira NG, Parma JO, de Assis Leão SE, de Souza Sales I, Macedo LC, Galvão AC, de Oliveira DC, Murça TM, Fernandes LA, Junqueira C, Lage GM, de Paula Ferreira B4. Mirror therapy in upper limb motor recovery and activities of daily living, and its neural correlates in stroke individuals: a systematic review and meta-analysis. Brain Res Bull. 2021;177:217–38; doi: 10.1016/j.brainresbull.2021.10.003.

[23] Cao M, Li X. Effectiveness of modified constraint-induced movement therapy for upper limb function intervention following stroke: a brief review. Sports Med Health Sci. 2021;3(3):134–7; doi: 10.1016/j.smhs.2021.08.001.

[24] Lim KB, Lee HJ, Yoo J, Yun HJ, Hwang HJ. Efficacy of mirror therapy containing functional tasks in poststroke patients. Ann Rehabil Med. 2016;40(4):629–36; doi: 10.5535/arm.2016.40.4.629.

[25] Fleet A, Page SJ, MacKay-Lyons M, Boe SG. Modified constraint-induced movement therapy for upper extremity recovery post stroke: what is the evidence?. Top Stroke Rehabil. 2014;21(4):319–31; doi: 10.1310/tsr2104-319.

[26] Hijikata N, Kawakami M, Ishii R, Tsuzuki K, Nakamura T, Okuyama K, Liu M. Item difficulty of Fugl-Meyer assessment for upper extremity in persons with chronic stroke with moderate-to-severe upper limb impairment. Front Neurol. 2020;11:577855; doi: 10.3389/fneur.2020.577855

[27] Hodics TM, Nakatsuka K, Upreti B, Alex A, Smith PS, Pezzullo JC. Wolf Motor Function Test for characterizing moderate to severe hemiparesis in stroke patients. Arch Phys Med Rehabil. 2012;93(11):1963–7; doi: 10.1016/j.apmr.2012.05.002.