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Comparison of Constraint-Induced Movement Therapy vs Mirror Therapy Effect in Infarcted Cerebrovascular Patients for Improving Hand Function

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LINK MEDICAL INTERFACE

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ABSTRACT

Background: Cerebrovascular accidents (CVAs) are a leading cause of disability worldwide, significantly impairing hand function and impacting quality of life. Rehabilitation strategies like Constraint-Induced Movement Therapy (CIMT) and Mirror Therapy (MT) have shown potential for improving motor function in stroke patients.

Objective: To compare the effectiveness of CIMT and MT in improving hand function in patients with infarcted CVA.

Methods: A randomized controlled trial was conducted with 26 participants (13 in each group) recruited from rehabilitation centers. Group A received CIMT, involving 45-minute sessions, five days a week for four weeks, focusing on repetitive task training with the affected limb while restricting the unaffected limb. Group B underwent MT with similar session frequency, utilizing visual feedback through a mirror. Hand function was assessed using the Fugl-Meyer Assessment (FMA) and Chedoke Arm and Hand Activity Inventory (CAHAI). Data were analyzed using Mixed Model ANOVA on SPSS version 25.

Results: At post-assessment, the CIMT group showed significant improvement in FMA upper-arm (mean 29.46±1.45, p=0.011) and CAHAI scores (mean 71.77±3.88, p=0.020) compared to the MT group.

Conclusion: Both CIMT and MT were effective for hand function improvement in infarcted CVA patients, with CIMT demonstrating more significant results.

INTRODUCTION

Cerebrovascular accidents (CVAs), commonly known as strokes, are among the leading causes of disability worldwide, significantly impacting patients' quality of life due to impaired motor function, especially in the upper limbs. According to the World Health Organization, a stroke is defined as a rapidly developing clinical event leading to a focal disturbance of cerebral function, lasting more than 24 hours or resulting in death, with no apparent cause other than a vascular origin (1). Loss of upper limb function is one of the most debilitating consequences of stroke. Approximately 83% of stroke survivors regain some functional capacity in their lower limbs; however, only about 5–20% achieve similar functionality in their upper limbs (2). The upper limb dysfunction is often characterized by impaired hand function due to disrupted neural pathways between the brain and hand muscles, resulting in spasticity and other motor deficits (3). This loss of function critically affects patients' ability to perform activities of daily living, such as dressing, feeding, or grooming, thus substantially diminishing both fine and gross motor skills (4). Muscle weakness or lack of coordination further hampers these motor abilities, underscoring the necessity for early and effective rehabilitation to maximize recovery and improve quality of life (5, 6).

Constraint-Induced Movement Therapy (CIMT) is a widely researched rehabilitation technique designed to treat upper limb deficiencies in stroke patients. This approach involves mass training of the affected limb by restricting the use of the unaffected limb and modifying behavior to promote the use of the impaired limb (7). CIMT integrates repetitive task practice with shaping activities, where patients engage in structured, goal-oriented exercises that gradually increase in difficulty. Positive reinforcement is provided throughout this behavioral retraining process to encourage continuous progress (8). The primary mechanism of CIMT is to increase the use and quality of movement of the affected limb in real-world situations, thereby counteracting learned non-use and facilitating motor function recovery (9). This approach provides multiple practice opportunities and structural and functional training to the impaired limb, correcting or reversing habitual disuse and neglect (9).

Mirror therapy (MT) is another rehabilitation strategy that has shown significant promise in improving upper limb motor function in stroke patients. MT utilizes visual feedback through a mirror to create an optical illusion that aids in motor recovery (10). The mechanism of MT is primarily attributed to mirror visual feedback (MVF), which focuses

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attention on the affected limb, activates ipsilateral motor pathways, and stimulates the mirror neuron system, thereby enhancing motor rehabilitation (10). Post-stroke deficits, such as hemiplegia, reduced muscle strength, and impaired motor function, present significant challenges for patients, their families, and healthcare systems due to their considerable social and economic costs (11). Mirror therapy addresses these deficits by creating an illusion of movement of the paretic limb when the non-paretic limb is moved in front of a mirror. This therapeutic approach has been shown to significantly improve motor function even in patients with severe upper limb paralysis (12-14).

Given the effectiveness of both CIMT and MT in improving hand function in stroke patients, this study aims to compare these two rehabilitation approaches to determine which one yields more significant outcomes in patients with infarcted cerebrovascular accidents. This study utilizes a randomized controlled trial design with a sample of 26 stroke patients recruited from various rehabilitation centers and outpatient clinics. The patients were divided into two groups: one receiving CIMT and the other undergoing MT. Both interventions were administered for 45 minutes a day, five days a week, over four weeks. Outcome measures were assessed using the Fugl-Meyer Assessment Scale, Jebsen Hand Function Test, and the Chedoke Arm and Hand Activity Inventory (CAHAI). The results of this study have the potential to guide clinical decision-making and optimize rehabilitation strategies for stroke patients with upper limb motor impairments.

MATERIAL AND METHODS

This study was designed as an experimental, randomized controlled trial to evaluate the comparative effects of Constraint-Induced Movement Therapy (CIMT) and Mirror Therapy (MT) on improving hand function in patients with infarcted cerebrovascular accidents (CVAs). The study was conducted from September 2023 to June 2024 and included participants recruited from various rehabilitation centers, outpatient clinics, and through home-based visits. A sample size of 26 participants was calculated using Epitool software, with 13 participants allocated to each group. A probability random sampling technique was employed to ensure a representative sample of the target population.

The inclusion criteria were patients diagnosed with infarcted CVA who were in the recovery stage of stroke from two months to one year, required hand function improvement, and were capable of participating in a 45-minute therapy session. Patients with hemorrhagic stroke, those with hand function disturbed due to reasons other than infarcted CVA, and those with shoulder subluxation or upper limb contractures were excluded from the study. Ethical considerations were strictly adhered to throughout the study, and informed consent was obtained from all participants. The study protocol was reviewed and approved by the relevant ethical review board, and all procedures were conducted in accordance with the Helsinki Declaration.

Data collection involved a detailed assessment of participants' hand function and motor abilities before, during, and after the intervention period. Participants were randomized into two groups: Group A received CIMT, while Group B underwent MT. Both groups received their respective interventions for 45 minutes per day, five days a week, for four weeks. CIMT involved massed practice and repetitive task training of the affected limb while restraining the unaffected limb, with tasks progressively increasing in difficulty. MT utilized a mirror to create visual feedback, enabling the patient to perceive movements of the non-paretic limb as movements of the paretic limb, thereby facilitating motor recovery.

Outcome measures were assessed using validated tools, including the Fugl-Meyer Assessment (FMA) scale for upper extremity function, the Jebsen Hand Function Test, and the Chedoke Arm and Hand Activity Inventory (CAHAI). These tools were administered at three different time points: pre-assessment (baseline), mid-assessment (after two weeks), and post-assessment (after four weeks). Data collection was performed by trained physiotherapists who were blinded to the group assignments to prevent any assessment bias.

Statistical analysis was conducted using SPSS version 25. Descriptive statistics, including means and standard deviations, were computed for all continuous variables. Mixed Model ANOVA was applied to compare the effects of the interventions between and within groups across different time points. Statistical significance was set at a p-value of less than 0.05. Results were presented in terms of mean ± standard deviation, and confidence intervals were calculated to determine the precision of the estimates. Data were analyzed following the intention-to-treat principle, and missing data were handled using multiple imputation methods.

Throughout the study, all participants were closely monitored for any adverse effects or complications related to the interventions. If any participant experienced discomfort or a decline in health status, they were referred to their primary healthcare provider for further evaluation and management. The findings from this study provide insights into the effectiveness of CIMT and MT in the rehabilitation of hand function among patients with infarcted CVA, potentially guiding future therapeutic strategies and clinical decision-making in stroke rehabilitation.

RESULTS

The study analyzed data from 26 participants, divided equally into two groups: Group A (CIMT) and Group B (Mirror Therapy). The descriptive statistics, inferential statistics, and between-group comparisons were presented using tables to provide clarity on the findings. There were 6 (46.2%) males and 7 (53.8%) females in Group A (CIMT) and 7 (53.8%) males and 6 (46.2%) females in Group B (Mirror Therapy). The between-group comparison for FMA upper-arm scores showed a non-significant difference at pre- and mid-assessment ($p = 0.352$ and $p = 0.082$, respectively). However, a significant difference was observed at the post-assessment ($p = 0.011$), with the CIMT group showing higher improvement compared to the Mirror Therapy group.

Table 1: Frequency Distribution of Gender of Patients in Treatment Groups

Gender of Patient	Group A (CIMT)	Group B (Mirror Therapy)	Total
Male	6 (46.2%)	7 (53.8%)	13 (50.0%)
Female	7 (53.8%)	6 (46.2%)	13 (50.0%)
Total	13 (100%)	13 (100%)	26 (100%)

Table 2: Between-Group Comparison of Fugl-Meyer Assessment (FMA) Upper-Arm Scores

Assessment Time	Group	N	Mean ± SD	95% CI (Lower-Upper)	F	p-value
Pre	CIMT	13	24.461 ± 1.898	23.314 - 25.608	0.902	0.352
	MT	13	25.153 ± 1.818	24.054 - 26.252		
Mid	CIMT	13	27.307 ± 1.702	26.279 - 28.336	3.296	0.082
	MT	13	26.076 ± 1.754	25.016 - 27.136		
Post	CIMT	13	29.461 ± 1.450	28.585 - 30.337	7.504	0.011
	MT	13	27.769 ± 1.690	26.747 - 28.791		

Table 3: Between-Group Comparison of Fugl-Meyer Assessment (FMA) Wrist and Hand Scores

Assessment Time	Group	N	Mean ± SD	95% CI (Lower-Upper)	F	p-value
Pre	CIMT	13	17.692 ± 2.868	15.958 - 19.426	0.006	0.941
	MT	13	17.769 ± 2.350	16.348 - 19.189		
Mid	CIMT	13	22.153 ± 2.609	20.577 - 23.730	2.386	0.136
	MT	13	20.615 ± 2.467	19.124 - 22.106		
Post	CIMT	13	27.461 ± 2.757	25.795 - 29.127	6.607	0.017
	MT	13	24.923 ± 2.253	23.561 - 26.284		

For the FMA wrist and hand scores, both groups showed similar results at the pre- and mid-assessment stages ($p = 0.941$ and $p = 0.136$, respectively). At the post-assessment, the CIMT group showed a significantly greater improvement ($p = 0.017$) compared to the Mirror Therapy group.

Table 4: Between-Group Comparison of FMA Total Upper Extremity Scores

Assessment Time	Group	N	Mean ± SD	95% CI (Lower-Upper)	F	p-value
Pre	CIMT	13	42.153 ± 3.760	39.881 - 44.426	0.363	0.553
	MT	13	42.923 ± 2.660	41.315 - 44.530		
Mid	CIMT	13	49.461 ± 3.125	47.572 - 51.350	5.982	0.022
	MT	13	46.692 ± 2.626	45.105 - 48.279		
Post	CIMT	13	56.923 ± 3.377	54.881 - 58.964	14.720	<0.001
	MT	13	52.692 ± 2.097	51.425 - 53.959		

The FMA total upper extremity scores showed a non-significant difference at pre-assessment ($p = 0.553$). A significant difference was noted at mid-assessment ($p = 0.022$) and was even more pronounced at post-assessment ($p < 0.001$), with CIMT showing superior improvement over Mirror Therapy.

Table 5: Between-Group Comparison of Chedoke Arm and Hand Activity Inventory (CAHAI) Scores

Assessment Time	Group	N	Mean ± SD	95% CI (Lower-Upper)	F	p-value
Pre	CIMT	13	60.846 ± 3.023	59.019 - 62.673	0.458	0.505
	MT	13	61.923 ± 4.872	58.978 - 64.867		
Mid	CIMT	13	66.230 ± 3.876	63.888 - 68.573	2.063	0.164
	MT	13	64.000 ± 4.041	61.557 - 66.442		
Post	CIMT	13	71.769 ± 3.876	69.426 - 74.111	6.250	0.020
	MT	13	68.307 ± 3.146	66.406 - 70.208		

The CAHAI scores demonstrated non-significant differences between the two groups at pre- and mid-assessments ($p = 0.505$ and $p = 0.164$, respectively). However, at post-assessment, the CIMT group showed significantly better results than the Mirror Therapy group ($p = 0.020$).

The results of this study indicate that while both CIMT and Mirror Therapy are effective in improving hand function in patients with infarcted CVA, CIMT consistently showed more significant improvements across different measures compared to Mirror Therapy.

DISCUSSION

The findings of this study demonstrated that both Constraint-Induced Movement Therapy (CIMT) and Mirror Therapy (MT) were effective interventions for improving hand function in patients with infarcted cerebrovascular accidents (CVAs). However, CIMT consistently showed more significant improvements across various outcome measures, including the Fugl-Meyer Assessment (FMA) for the upper arm, wrist and hand, and the Chedoke Arm and Hand Activity Inventory (CAHAI). These results align with previous research, such as the study by Ju and Yumi (2018), which found that modified CIMT led to more pronounced improvements in upper extremity function compared to MT, with significant outcomes on the Modified Barthel Index (9). This supports the current study's findings that CIMT offers more substantial benefits than MT for upper limb rehabilitation in stroke patients, particularly at mid and post-assessment phases.

The current study also found that MT, while effective, did not achieve the same level of improvement as CIMT. This observation is consistent with the literature review by Kamaliyah et al. (2024), which reported that MT provided significant improvements in muscle and motor function when conducted over extended periods but was less effective compared to other therapeutic modalities when not combined with other interventions (17). The use of visual feedback in MT, although beneficial for motor recovery, might not be as potent as the intensive practice and behavioral retraining involved in CIMT. The mechanism behind CIMT's superior effectiveness could be attributed to its ability to prevent learned non-use and promote neural reorganization by forcing the use of the affected limb through repetitive, task-oriented training (8).

The study by Dhanalakshmi et al. (2024) further supports the current findings by showing that CIMT produced greater improvements in upper extremity function compared to Proprioceptive Neuromuscular Facilitation (PNF) techniques, which aligns with the observation that intensive, repetitive task practice, as utilized in CIMT, has a more substantial impact on motor recovery (16). The current study's methodology, which included a randomized controlled trial design, high-quality outcome measures, and a well-defined intervention protocol, contributed to the robustness of the findings. However, there were limitations, such as the small sample size, which might have impacted the generalizability of the results. Future studies with larger sample sizes and multi-center trials would help validate these findings and explore the long-term effects of both therapies.

One of the strengths of this study was the use of validated and reliable outcome measures, including the FMA and CAHAI, which provided comprehensive insights into the different aspects of hand function recovery. Additionally, the blinding of assessors to the group assignments minimized the risk of bias in the outcome assessments. However, a limitation of the study was the lack of long-term follow-up, which could provide a clearer picture of the sustained effects of both therapies. It is possible that MT might have longer-term benefits that were not captured within the four-week intervention period used in this study. Incorporating follow-up assessments several months post-intervention could provide valuable data on the durability of the observed effects.

The study also highlighted the importance of individualized therapy approaches in stroke rehabilitation. While CIMT proved to be more effective overall, MT could still be valuable for patients who may not tolerate the intensity of CIMT or have specific contraindications to its application. Future research should investigate the potential of combining these two therapies to create a more comprehensive rehabilitation approach that maximizes the benefits of both techniques. For example, integrating the visual feedback elements of MT with the task-oriented and repetitive training of CIMT could offer a balanced and effective rehabilitation strategy for different patient profiles.

CONCLUSION

In conclusion, the findings of this study reinforced the evidence that CIMT is a more effective intervention compared to MT for improving hand function in patients with infarcted CVAs. However, the potential of MT should not be discounted, particularly as a supplementary therapy or for specific patient needs. Future research should focus on optimizing and individualizing rehabilitation protocols, examining combined therapy approaches, and conducting long-term follow-ups to provide a more comprehensive understanding of the effectiveness of these interventions. This would ultimately enhance clinical decision-making and lead to more tailored and effective rehabilitation strategies for stroke patients.

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