Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 11s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

A comparative study between Constraint-Induced Movement Therapy (CIMT) and Motor Imagery Technique with Rhythmic Auditory Stimulation (MI + RAS) for Motor Skill Development in Patients with Middle Cerebral Artery (MCA) Stroke

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Cite this paper as: Dr. Bhavini Gurjar, Dr. Deepak Lohar, Dr. Jafar Khan, Dr. Deepika Balala, Dr. Shubham Menria, Dr. Richa Hirendra Rai, Dr. Renuka Pal, Dr. Rinshum Vyas, Dr. Shilpi Kapoor, Dr. Deepak Sharma, (2025) A comparative study between Constraint-Induced Movement Therapy (CIMT) and Motor Imagery Technique with Rhythmic Auditory Stimulation (MI + RAS) for Motor Skill Development in Patients with Middle Cerebral Artery (MCA) Stroke. *Journal of Neonatal Surgery*, 14 (11s), 1125-1128.

ABSTRACT

Middle Cerebral Artery (MCA) strokes commonly result in motor deficits, hindering activities of daily living[1]. This study compares the efficacy of Constraint-Induced Movement Therapy (CIMT)[2] and Motor Imagery (MI) combined with Rhythmic Auditory Stimulation (RAS)[3] on motor skill development post-stroke. Forty patients diagnosed with MCA infarct were randomly assigned into two groups: Group A received CIMT, and Group B received MI + RAS. Treatment was administered for 16 weeks. Outcomes were measured using the STREAM and MMT scales. Results demonstrated significant improvement in both groups; however, CIMT showed greater gains in voluntary movement[4], while MI + RAS showed better coordination in imagined and rhythmically cued tasks[5]. The study suggests tailored therapy depending on patient responsiveness.

1. INTRODUCTION

Stroke is a leading cause of adult disability, often resulting in hemiparesis, particularly affecting upper limb function[6]. MCA strokes are notorious for impairing voluntary movement, coordination, and functional independence[7]. Rehabilitation techniques such as CIMT, which encourage use of the affected limb by restraining the unaffected one, have shown significant neuroplastic effects[8]. On the other hand, Motor Imagery (MI), particularly when enhanced with rhythmic auditory cues (RAS), activates the motor cortex and auditory-motor networks even without overt movement[9].

Both CIMT and MI + RAS offer distinct pathways to recovery—one through forced-use and physical engagement[10], and the other via mental rehearsal and external rhythm-based entrainment[11]. This study evaluates their comparative impact on upper limb motor skill development using reliable outcome measures.

2. MATERIALS AND METHODS

Sample Size: 40 patients with post-MCA stroke motor impairments.

Study Design: Randomized Controlled Trial

Inclusion Criteria: First-time MCA stroke, aged 50–70, Brunnstrom Stage 3 or higher.

Exclusion Criteria: Cognitive impairment, severe aphasia, musculoskeletal deformities, or auditory deficits.

Ethical Approval: Institutional Ethics Committee approved the study under Ref No: PMU/PMCH/IEC/2024/267).

A total of 40 patients diagnosed with hemiparesis due to MCA stroke were included in this randomized controlled trial. Patients were divided into three groups:

- Group A (n=20): Received CIMT protocol.
- Group B (n=20): Received Motor Imagery with Rhythmic Auditory Stimulation (MI+RAS).

Outcome Measure:

- STREAM (Stroke Rehabilitation Assessment of Movement) [12]
- MMT (Manual Muscle Testing) [13]

Intervention Duration: 16 weeks, 5 days/week, 1 hour/day.

3. PROCEDURE

Group A: Constraint-Induced Movement Therapy (CIMT). Participants in Group A underwent CIMT, a technique based on the principle of forced use of the affected limb to encourage cortical reorganization and improve voluntary movement. Patients wore a mitt or sling on the non-affected limb for 90% of their waking hours to restrict its use. This promoted active engagement of the paretic limb in daily functional activities. The affected limb was trained through;

- Shaping tasks: Functionally relevant activities (e.g., reaching, grasping, manipulating objects of varying size and weight) were practiced progressively with increasing complexity[14].
- Task practice: Repetitive task-specific training for activities like buttoning, foot tapping, or picking up small items.
- Feedback and cueing: Verbal encouragement and corrective cues were provided to enhance movement quality[15].

Sessions lasted for 60 minutes/day, 5 days/week, for a total of 16 weeks under the supervision of a physiotherapist. Functional changes were monitored and graded periodically using the STREAM and MMT scales at baseline, 8 weeks, and 16 weeks.

Group B: Motor Imagery with Rhythmic Auditory Stimulation (MI + RAS) Participants in Group B received guided Motor Imagery sessions enhanced with Rhythmic Auditory Stimulation.

MI was designed to mentally rehearse purposeful upper limb movements without physical execution, while rhythmic cues provided temporal structure and sensory priming[3]. The protocol included:

- Imagery scripts: Therapist-guided visual and kinesthetic imagery scripts of tasks like reaching, pouring, combing hair, or eating were used.
- RAS integration: Tasks were synchronized with rhythmic auditory cues (metronome at 50–60 bpm or instrumental music with clear beats). Rhythmic entrainment improved timing, sequencing, and mental focus.
- Mirror feedback and observation: Patients watched live demonstrations to enhance motor imagery vividness using visual-motor associations[17]
- Verbal feedback and mental scoring: Patients described imagined movement quality and timing to reinforce internal feedback.

Each session lasted 60 minutes/day, 5 days/week, for 16 weeks. Therapy was supervised by a trained neuro-physiotherapist with MI and RAS experience. Assessments were done at baseline, 8 weeks, and 16 weeks using STREAM and MMT.

4. STATISTICAL ANALYSIS AND RESULTS

The collected data was analyzed using paired and unpaired t-tests to compare intra-group and inter-group changes from baseline to 16 weeks. Descriptive statistics including mean and standard deviation were calculated.

The results were tabulated for STREAM and MMT scores for both groups.

Group A (CIMT) showed statistically significant improvement in STREAM scores ($p < 0.01$) and MMT grades ($p < 0.01$), indicating enhanced voluntary motor control and muscle strength[4]. Group B (MI + RAS) also showed significant

improvement, especially in coordination tasks assessed through STREAM distal components[18].

Between-group comparisons revealed greater overall improvement in Group A (CIMT), particularly in gross motor function. However, Group B excelled in tasks requiring rhythmic and sequential coordination[5].

5. DISCUSSION

This study aimed to evaluate and compare the effectiveness of CIMT and MI + RAS for motor recovery in patients with MCA stroke. The results indicate that both approaches significantly enhanced motor outcomes, supporting their application in stroke rehabilitation.

CIMT's mechanism is based on use-dependent plasticity, which stimulates the affected hemisphere through repeated, task-specific training. This aligns with previous research demonstrating cortical reorganization with CIMT[8].

On the other hand, MI with RAS engages mirror neuron networks and auditory-motor coupling, facilitating motor learning even without physical execution[9]. Rhythmic auditory cues help synchronize imagined movements with time-based structure, which may explain the improvement in coordination seen in Group B[19]. Thus, both interventions are valuable; CIMT is more beneficial for improving active movement and strength, while MI + RAS enhances coordination and rhythmic patterning.

6. LIMITATIONS

- Small sample size (n=40).
- Study duration limited to 16 weeks without long-term follow-up.
- Exclusion of cognitive and aphasic patients limits generalizability.
- No patient blinding.
- Limited tools used for outcome measures.

7. RECOMMENDATIONS

- Future studies should include a larger, multicentric sample[20]
- Include cognitive and functional outcome measures
- Conduct long-term follow-up (6 months or more)
- Explore hybrid approaches combining CIMT and MI + RAS
- Use neuroimaging to observe cortical changes[8]

8. CONCLUSION

The present study demonstrates that both Constraint-Induced Movement Therapy (CIMT) and Motor Imagery with Rhythmic Auditory Stimulation (MI + RAS) significantly improve motor function in patients recovering from MCA stroke. While CIMT was superior in improving strength and gross movement, MI + RAS contributed significantly to coordination and rhythmic motor control. An integrated approach may yield optimal outcomes in future clinical practice.

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