Introduction

Stroke is one of the leading causes of disability in adults. Nearly 800,000 individuals in the United States suffer from a stroke every year. [1] Despite improvements in acute stroke care, survivors may suffer from long-lasting neurological impairments, particularly in the motor function of the upper limbs (UL). Approximately 85% of survivors of stroke present with hemiparesis, or unilateral weakness immediately following stroke. Approximately 55-75% have some degree of UL dysfunction six months following stroke. [2] Deficits including spasticity, weakness, abnormal synergy, and sensory loss, can affect activities of daily living (ADLs) and decrease quality of life. [3]

Rehabilitative treatments attempt to restore function by creating neuroplastic change, reshaping nervous system connections in response to training.[4] Mirror therapy (MT) is hypothesized to activate motor and visual networks without requiring extensive voluntary movement of the affected arm.[5] In MT, patients look at a reflection of their healthy limb moving in a mirror, creating a visual illusion that the affected limb is also moving. This mirror visual feedback is thought to cause the activation of mirror neurons in the brain and promote UL motor recovery by stimulating and remodeling the premotor and primary motor cortices.[6]

Mirror therapy is affordable, non-invasive, and easily transportable to clinical or home settings. It has been reported to improve motor function, particularly in people with moderate to severe paresis, who may face barriers to participating in more demanding or task-specific programs. [7] Studies report significant improvements in motor function using Fugl-Meyer Assessment (FMA) and Action Research Arm Test (ARAT) following MT, especially when applied with high frequency or repetition over several weeks. [8] MT has been found to be beneficial regardless of stroke acuity, with a metanalysis suggesting that earlier intervention may be associated with greater cortical reorganization. [9] Results, however, are inconclusive regarding the timing and optimal protocol for mirror therapy.

MT effects are hypothesized to occur via complex neurocognitive mechanisms. The visual illusion created during MT is thought to engage the brain's mirror neuron system that responds to both executed and observed actions. [10] This process has the potential to compensate for the damaged sensory feedback loop that may limit post-stroke recovery. [5] Functional neuroimaging studies have shown increased activation within the contralesional motor cortex during the course of mirror therapy sessions. [6] This is understood by some researchers as an indicator of top-down modulation, and this means that processes of high-level cognition such as attention and visual perception possess the ability to influence and assist in reorganizing systems of motor execution. This perspective shows how MT can harness cognitive and sensory processing to facilitate the recovery of motor functions, although additional research is needed to determine the precise mechanisms involved.

Home-based MT may be a practical alternative to supervised rehabilitation, especially in environments where clinic-based therapy is not available. As highlighted during the COVID-19 pandemic, home and remote models of rehabilitation became desirable for continuity of care. [11] MT fits into these models due to its cost-effectiveness and minimal need for training. Studies comparing home-based and clinic-based MT have shown equivalent outcomes in motor function and have suggested that MT may be a viable method to extend rehabilitation to the home. [12,13] Adherence, correct setting up, and motivation remain as concerns, though, in home settings.

Current evidence for mirror therapy is limited by methodological heterogeneity that makes drawing firm conclusions about its effectiveness challenging. Heterogeneity in study design, duration and frequency of therapy, recruitment of patients, and outcomes assessed introduces inconsistencies that restrict the comparability between outcomes across trials and the establishment of standardized clinical practice. For example, some studies report temporary improvement of motor function, while others report little or no benefit over the long term, suggesting that patient characteristics and treatment strategies may have significant impacts. [4] Moreover, mirror therapy may not be effective in all stroke survivors. For example, individuals with highly impaired cognition or decreased visual attention may be incapable of employing the visual input required by this intervention. [14] Overall, while MT looks promising as part of a multifaceted rehabilitation program, heterogeneity among the study results highlights the need for improved studies to establish its role in defining which patients are most likely to benefit. [15]

The effectiveness reported in studies of MT can be influenced by several variables, including timing of intervention, level of impairment, and outcome measure used. The majority of studies have enrolled individuals with chronic stroke; therefore, the effects of MT in acute or subacute stroke remain less explored. Determining whether early mirror therapy leads to enhanced functional outcomes compared with delayed introduction is crucial in the optimization of therapy protocols. Additionally, the neurophysiological basis of MT is still unclear, with ongoing research examining the effects of visual feedback on motor recovery patterns in stroke patients.

This scoping review examined randomized controlled trials (RCTs), meta-analyses, and systematic reviews identified using databases such as PubMed and stroke engine. The review summarizes and synthesizes evidence that currently exists on MT for post-stroke upper limb dysfunction. The review describes the appropriate and inappropriate patients for MT and compares MT with alternative therapies such as constraint-induced movement therapy. Finally, the review highlights the unanswered questions about MT, including optimal timing, mechanisms of action, and long-term consequences, and proposes suitable study designs to answer those questions.

Evidence Review

- Master tables

Table 1. Summary of Mirror Therapy RCTs Reviewed for this Paper

Author(s)/ year	Study design/ Sample size	Stroke phase	Intervention group	Control group	Dosage (experimental vs. Control)	Results (outcome measures)
Michielsen et al., 2011	RCT; 30	Chronic	MT + usual care	Usual care	6 wks, 5x/wk, 30 min/day dose matched	+exp (ARAT, MI); NS (FIM)
Lin et al., 2014	RCT; 50	Chronic	Home MT	Sham mirror therapy	**6 wks, 5–6x/wk, 30 min/day dose matched**	+exp (FMA-UE, MAL)
Wen et al., 2022	RCT; 46	Subacute	MT	Occupational therapy (OT)	3 wks, 6x/wk, 30 min/day dose matched	+exp (FMA-UE, ARAT, IADL)
Yavuzer et al., 2008	RCT; 44	Subacute	MT	Conventional therapy	4 wks, 5x/wk, 30 min/day dose matched	+exp (ARAT)
Lee et al.,	RCT; 40	Acute	MT	Dose-matched	4 wks, 2x/day, 50 min dose	+exp (FMA-UE, joint

2012				conventional therapy	matched	control)
Park et al., 2011	RCT; 50	Subacute	Therapist-led MT	Conventional therapy	5 wks, 5x/wk, 30 min/day dose matched	+exp (FMA-UE, Barthel Index)
Kim et al., 2014	RCT; 40	Subacute	MT + FES	MT	4 wks, 5x/wk, 30 min/day dose matched	+exp (JTHFT, BBT)
Invernizzi et al., 2013	RCT; 36	Chronic	MT + standard care	Standard care	5 wks, 5x/wk, 45 min dose matched	+exp (FMA, MAL)
Dohle et al., 2009	RCT; 36	Mixed	MT	Bilateral training	3 wks, daily vs. standard rehab	NS (FMA-UE)
Schick et al., 2017	RCT; 36	Subacute	MT + EMG-triggered stimulation	MT	5 wks, 5x/wk, 30 min/day dose matched	+exp (FMA-UE)
Lin et al., 2014	RCT; 36	Chronic	MT + somatosensory stimulation	MT	4 wks, 5x/wk, 30 min/day dose matched	+exp (FMA, MAL)
Yun et al., 2011	RCT; 24	Subacute	MT + FES	MT	4 wks, 5x/wk, 30 min/day dose matched	NS (Hand function (BBT))

Note: +exp = significant difference favoring experimental group; NS = no significant difference.

Table 2. Summary of Mirror Therapy Review Studies Reviewed for this Paper

Author(s)/ year	Design / Sample Size	Review Focus	Results
Arya et al., 2018	Meta-analysis; 11 RCTs	Efficacy of MT on UL motor recovery post-stroke	+exp; greater effect in early stroke
Thieme et al., 2018	Cochrane Review; 14 RCTs	MT effectiveness on motor function post-stroke	Small but +exp
Saavedra-García et al., 2021	Meta-analysis; 6 RCTs	MT + electrical stim vs. MT alone for UL recovery	+exp (combined group)

Note: +exp = significant difference favoring experimental group; NS = no significant difference.

- MT effectiveness by Outcome Measures

MT has been evaluated using several standardized measures to determine its impact on recovery of the UL after stroke. Outcome measures used most frequently are the Fugl-Meyer Assessment Upper Extremity (FMA-UE) for motor impairment, the Action Research Arm Test (ARAT) for motor functional ability, the Box and Block Test (BBT) for gross manual dexterity, and the Motor Activity Log (MAL) for self-report of paretic arm use in daily activities. Other tools such as Manual Function Test (MFT) and Barthel Index also aid in evaluating change in functional independence and upper limb capacity.

Clinical trials consistently demonstrate that MT improves performance in these standardized measures. For instance, Michielsen et al.[5] employed a 6-week RCT in chronic stroke survivors comparing MT with conventional therapy and showed notable improvement in ARAT scores and Motor Impairment (MI) scores within the MT group but little change in the Functional Independence Measure (FIM). Similarly, Lin et al.[10] examined home-based MT 30 minutes/day for 6 weeks and there were significant between-group differences on both the FMA-UE and MAL amount-of-use subscale compared to dose-matched conventional therapy. In Wen et al.,[16] patients who received MT in the subacute stage had significantly greater improvements in IADL and ARAT compared to a control group receiving occupational therapy alone. In contrast, Dohle et al.[20] did not observe significant FMA-UE differences between MT and sham groups over a 3-week period in a mixed stroke population.

Individual trials differ by response magnitude, and this can be due to variability in intervention duration, stroke stage, and patient population. Meta-analyses provide one approach for pooling across these trials when outcome measures are aligned. Thieme et al.[4] meta-analyzed 36 trials within an upper limb function after stroke context. Using FMA, ARAT, and other recognized motor outcomes as outcome measures, the authors found a small but statistically significant pooled effect in favor of MT over control conditions. Also, Arya et al.,[8] in a meta-analysis of 10 RCTs, concluded that MT achieved clinically significant motor gains, especially when administered in the early phases following stroke.

Taken together, the results show that MT improves performance on established motor measures, especially when standardized tests are used and treatment is provided with formal protocols. Inconsistencies between trials remind us, however, to reinforce the need for matching outcome measure to intervention focus and patient group. More specific comparisons by stage of stroke, intensity of treatment, and delivery setting are discussed in the next several sections.

- ## MT Outcomes by Stroke Acuity

A key question in MT in research in MT is whether the timing of intervention impacts outcomes. Neuroplastic recovery from stroke injury is time-sensitive, and early stages after stroke tend to correlate with heightened opportunities for neuroplasticity and thus susceptibility to rehabilitation.[21] As a result, numerous trials and meta-analyses have sought to distinguish between whether MT is more beneficial in the acute, subacute or chronic stage of stroke.

There have been few studies of MT in strictly acute patients. Lee et al.[15] studied participants within six months post-stroke and compared 4 weeks of MT to dose-matched standard therapy. MT patients improved more in FMA-UE scores and in shoulder/elbow joint control.

Several trials have examined MT in subacute stroke. Yavuzer et al.[7] compared 4-week MT and standard treatment in patients with up to 6 months post-stroke. They reported significantly better ARAT improvements in the MT group. Wen et al.[16] utilized a 3-week MT protocol in subacute patients and demonstrated that the MT group had greater changes in

ARAT and instrumental activities of daily living (as measured with the Lawton IADL Scale) compared to patients who had received occupational therapy only.

Additional trials have investigated MT in chronic stroke. Michielsen et al.[28] included participants with hemiparesis at least six months post-stroke and compared 6 weeks of MT plus standard therapy to standard therapy alone. They reported significant post-intervention improvement on the ARAT and MI scales but moderate FIM improvement. Lin et al.[10] used a home-based MT protocol in patients more than six months post-stroke and reported statistically significant improvement on the FMA-UE and MAL. Invernizzi et al.[18] compared MT plus conventional treatment to conventional treatment alone and reported statistically significant improvement in FMA and MAL in a population of chronic stroke.

These studies suggest that MT has been tested in both early and late stages of stroke rehabilitation. While some studies report improvement in earlier time windows, the current section does not show consistent evidence in favor of a particular stage. So while MT appears to be effective across stroke acuity, it remains an open question if earlier treatment is more beneficial. Future research that is designed to compare stroke acuity groups using standardized protocols is necessary to fill this gap.

- Dosage, Intensity, and Protocol Parameters

Though intensity and dosage may influence mirror therapy (MT) outcomes, there is no current consensus regarding an optimal treatment protocol. Most of the studies reviewed delivered MT for 30 minutes or longer per session, 5 to 7 times a week, for 3 to 6 weeks. Nonetheless, trials have not directly compared shorter protocols (e.g., 15 minutes) to longer ones (e.g., 30 minutes or more), and thus conclusions regarding optimal session duration and frequency are uncertain.

Arya et al.[8] did a meta-analysis of 10 trials and found that trials delivering more than 200 minutes of MT per week were more likely to report statistically significant changes in upper limb function. While this suggests that higher doses of therapy may be more beneficial, the minimum or the optimal dose is not yet known because no studies have directly compared different levels of MT dosage. Invernizzi et al.[18] used a 45-minute sessions, 5 days per week for 5 weeks protocol and reported statistically significant improvement in motor function and daily use as measured by the FMA and MAL. Other studies using 30-minute sessions,[16, 17] also reported statistically significant improvement but with less magnitude of improvement. This may be an effect of different focus on outcomes, such as gains in specific domains like strength or dexterity, but does not necessarily infer less effectiveness, as trials are performed based on different primary aims.

Taken together, these findings suggest that longer and more intense MT regimens may provide greater functional gains, but the exact dose-response relationship remains unclear. Reviewers have pointed out the absence of head-to-head comparison of session lengths, frequencies, and total duration in high-quality trials. Future investigations should consider stratifying subjects by stroke acuity and initial impairment, and varying total MT dose systematically to define effective and efficient regimens for specific patient requirements.

- Home-Based Versus Clinic-Based Delivery of MT

A frequently reported advantage of MT is its low-cost and home-treatment accessibility. MT requires less equipment than some other techniques and for select patients, MT may be self-administered after professional training successfully in the home.

There is evidence that home-based MT can lead to statistically significant improvement in activities of daily living (ADLs). Lin et al.[10] implemented a 6-week home-based MT program (30 minutes, 5–6 days/week) with chronic stroke patients. Relative to a control group that received dose-matched home exercise therapy, the MT group showed considerable improvement on both the Amount of Use (AOU) and Quality of Use (QOU) subscales of the Motor Activity Log (MAL), indicating greater real-life use of the affected limb in daily activities.

Protocols instituted in a clinic setting also yielded positive findings. Although Lee et al.[15] did not measure home-based MT, they cited 96% adherence to their clinic-based protocol of 50-minute MT sessions twice daily for four weeks in an inpatient setting. Patients in this group demonstrated significant improvement in upper limb motor control on the FMA-UE scores. Some research has reported partial session attendance in less formal environments, though these trends were not systematically associated with treatment setting or formally examined.[18]

Arya et al.[8] conducted a review of 10 RCTs and concluded that study outcomes were more strongly associated with overall quality of implementation than with treatment setting. For example, some studies employed regular therapist monitoring or weekly meetings, which Arya et al. suggested helped ensure protocol fidelity. Wen et al.[16] reviewed 12 home-based and 14 clinic-based trials and made suggestions for enhancing remote provision, such as engagement of caregivers and monitoring through apps, though these were not formally tested for effectiveness. These reviews thus rest on expert opinions and suggestions rather than evidence of effect.

In summary, MT has been demonstrated to improve the use and functioning of the UL in both home and clinic settings. Comparative effectiveness of delivery setting, however, remains unknown. Future trials should directly compare clinic-based and home-based MT with standardized protocols and balanced exposure to determine whether setting influences response to treatment.

- MT Combined with Other Therapies vs. MT Alone

The potential synergistic or additive effect of combining MT with other types of neurorehabilitative approaches has been investigated through several RCTs. These studies suggest that augmenting mirror therapy with other interventions like functional electrical stimulation (FES), electromyography-triggered stimulation, or afferent somatosensory input, the therapeutic effect on motor recovery may be increased over MT alone.

Kim et al. [22] compared MT + FES to MT alone in subacute stroke patients. MT + FES patients received 30 minutes of simultaneous FES during MT, 5 times a week for 4 weeks. Compared to MT alone, the MT+FES group had significantly greater improvements in Jebsen-Taylor Hand Function Test (JTHFT) and Box and Block Test (BBT) scores.

Schick et al. [23] compared MT + multichannel EMG-triggered stimulation to MT alone in subacute stroke. They reported that combination therapy produced statistically significant greater gains in upper limb function (FMA-UE scores) over MT alone, particularly regarding shoulder and elbow control.

In a pilot RCT, Lin et al. [24] compared MT alone to MT + somatosensory stimulation in chronic stroke survivors. Both the FMA and MAL test showed significantly better results in the combination group after a four-week intervention, which suggested that afferent input has the potential to enhance the effectiveness of MT.

However, not all studies showed significant differences. Yun et al.,[25] for instance, saw improved hand function in both MT and MT+FES groups, but between-group differences were insignificant. The authors concluded that the additive effect of FES is contingent upon treatment intensity and timing.

Taken together, these studies indicate that the combination of FES, EMG-triggered stimulation, or somatosensory input with MT may improve upper limb results more than MT alone. However, findings vary by study, and larger, well-controlled trials are needed to determine optimal combinations and protocols.

Appropriate and inappropriate patients

While MT is a low-cost treatment for post-stroke UL rehabilitation, its clinical applicability depends on identifying appropriate patients. Unlike inclusion and exclusion criteria for clinical trials, which seek to standardize study populations, clinical appropriateness considers patient safety, the likelihood of meaningful benefit, and feasibility of treatment administration in clinical practice. Based on current evidence, the most likely candidates for MT have several qualities, including sufficient visual and cognitive function, availability of initial clinician supervision, and mild to moderate motor impairment.

Patients must be able to comprehend and attend to the visual stimuli generated during therapy. Patients with visual field impairment, spatial neglect, or attentional deficits might not be successful with MT. Michielsen et al. [28] demonstrated that stroke patients with visuospatial neglect did not enjoy the predicted motor gains of MT, suggesting that attention and perception need to be intact in order to benefit therapeutically. Similarly, patients with dementia, severe aphasia, or significant executive dysfunction may struggle with MT's attentional and task adherence demands.

Although MT is often promoted as a low-cost, home-based treatment, clinical success depends upon adequate setup, adherence to protocols, and sustained motivation. A RCT by Wu et al. [12] established that patients with chronic stroke undergoing therapist-guided mirror therapy achieved significantly greater gains in upper limb motor and sensory recovery (FMA-UE and sensory scores) compared to control patients, supporting the necessity of clinician training prior to home application. Unless adequately instructed, mirror misalignment or improper posture can degrade the neurological effects of mirror illusion. Moreover, adherence to the therapy schedule (usually 30 minutes/day, 5–6 times/week) requires patients to be willing and capable of integrating MT into their daily schedule. Patients lacking social support, time flexibility, or motivation are not ideal candidates unless additional caregiver or telehealth support can be arranged. [29]

Patients with mild to moderate motor impairment are particularly well-suited for MT. These patients usually lack sufficient volitional movement to participate in task-specific or high-intensity therapy (e.g., CIMT), but retain enough motor capacity to benefit from the visual-motor processes engaged by MT. [4] For example, Michielsen et al. [28] reported significant improvement on the ARAT in moderately impaired patients who received MT. Patients who are severely affected with flaccid paralysis or complete sensory loss, however, are unlikely to have the residual motor capacity to benefit from cortical reorganization induced by MVF. In the same way, patients with already recovered motor function will not gain further benefit from MT and may be more likely to benefit from strength training or fine motor rehabilitation. [15] MT would therefore best be considered for patients who have residual motor function but are not yet ready for more active forms of therapy.

Appropriate patients should also possess clinical profiles that would be compatible with the known or hypothesized mechanisms of MT. Several neurophysiological studies demonstrate that MT primarily activates the mirror neuron system and promotes motor excitability via visual-motor coupling. [13, 27] Therefore, patients with intact corticospinal tracts and preserved sensory processing would be more likely to benefit. On the other hand, individuals with extensive bilateral cortical damages, disrupted interhemispheric connection, or severe proprioceptive defects may not be able to access the pathways through which mirror therapy can induce neuroplastic changes. This is consistent with research findings such as Dohle et al.,[20] which were not able to demonstrate significant motor function improvement in patients with limited baseline capacity for motor evoked potentials. In general, patients in whom clinical deficits reflect damage incompatible with MT's cortical targets are considered inappropriate candidates.

Also, patients with severe depression, anxiety, or emotional dysregulation may find MT unpleasant, especially in early stages when movement is minimal but visual feedback appears functional. Anecdotal reports and small case series have described temporary emotional distress or dissociation-like symptoms in a few patients with the viewing of the mirrored limb. [14] Although not a formal contraindication, clinicians should be cautious and monitor patients with psychiatric comorbidities for tolerance and psychological safety.

In conclusion, patient selection for mirror therapy is a case-by-case, evidence-based decision. While MT is low-risk and easily accessible, its effectiveness is contingent upon the alignment between the cognitive-motor demands of the therapy and patient factors. Clinicians must screen for appropriateness on visual, cognitive, motor, and psychosocial domains, both through clinical reasoning and empirical evidence, to guide implementation.

Comparison treatment

Motor impairment of the upper limb remains one of the most disabling effects of stroke. Among the numerous post-stroke neurorehabilitation strategies, mirror therapy (MT) and constraint-induced movement therapy (CIMT) are two of the most evidence-based treatments for motor rehabilitation. Both therapies have been shown effective in improving upper limb function but with variable mechanisms of action, indications, feasibility, and clinical suitability. This section compares MT and CIMT to guide treatment selection for individuals undergoing home-based rehabilitation.

1. Mechanisms of Action

Mirror therapy induces neuroplasticity by using visual feedback to replicate movement of the paretic limb. The patient sees the reflection of their unaffected limb move while they perform motor tasks in a mirror during MT, with the illusion being that the affected limb also moves. This mirror visual feedback (MVF) activates motor control areas of the brain, such as the contralesional motor cortex, via mechanisms such as top-down modulation and mirror neuron system activation. Functional imaging has also demonstrated that there is greater activity in the premotor and primary motor cortices following MT sessions.[28, 30]

CIMT, on the other hand, uses behavioral and task-specific learning to overcome "learned non-use" of the paretic arm. The treatment consists of three components: 1) mitt or sling constraint of the intact arm for extended periods, 2) intensive task-specific training of the affected arm, and 3) a "transfer package" to prompt use of the affected arm in the outside world beyond therapy.[31] The treatment relies on the theory that forced use of the affected limb, combined with structured, repetitive, task-specific practice and the transfer package, evokes cortical reorganization through massed practice and shaping. The sling or mitt is employed to discourage compensation, but most crucial in facilitating improvement is the intensive training of the paretic limb in progressively demanding activities, reinforced by means that generalize these skills to ordinary daily routines.

While both treatments hypothesized to induce neuroplasticity, MT primarily incites motor recovery through visual and attentional pathways, whereas CIMT tackles behavioral conditioning and motor execution through intense physical practice.

2. Indications and Contraindications

Mirror therapy is broadly indicated for patients across the stroke recovery spectrum (acute, subacute, and chronic phases), particularly those with mild to moderate motor deficit who can focus on visual stimuli. Studies have shown that MT is possible even for patients with limited voluntary movement because it does not require active movement in the paretic limb.[4] While MT may be less effective for patients with visual neglect, hemianopia, or severe cognitive impairment that interferes with attention to visual feedback, it has no established contraindications.[28]

CIMT, in contrast, is best applied in patients who have at least some active wrist and finger movement. Inclusion criteria typically require at least 10 degrees of active wrist extension and 10 degrees of extension in two fingers.[32] Patients must also be cognitively intact enough to adhere to the protocol and be able to handle the intensity of training. CIMT is contraindicated in individuals with severe spasticity or joint pain. The reason for this is that these conditions may prevent effective participation in tasks.[33]

Therefore, MT may be better suited to individuals with more severe motor deficits, while CIMT would be better suited to individuals who have greater motor capacity and can withstand high intensity training.

3. Practical Considerations and Cost

Mirror therapy is inexpensive, simple to administer, and can be easily transferred to the home environment. A mirror box or flat mirror setup is sufficient, and after initial clinician instruction, many patients can manage the exercises on their own.[34] Low cost and transportability make MT a viable option for individuals without access to intensive outpatient rehabilitation or those seeking adjunctive treatment in the home.

On the other hand, CIMT requires specialized training, therapist supervision, and a greater daily time commitment, and therefore is generally less feasible for home-based settings. Standard CIMT protocols typically require 2–6 hours of therapist-supervised training per day for two or more weeks, which can be both financially and logistically challenging.[4] Modified CIMT (mCIMT) with reduced constraint time and session length has been proposed to address these limitations, though with intensity still higher than MT.

While both treatments may be effective, MT is more easily accessed in rural or underserved areas and may be preferred in home programs for individuals with limited supports or financial resources.

4. Comparative Efficacy and Treatment Selection

The efficacy of both MT and CIMT in improving upper limb function after stroke has been established by several meta-analyses and RCTs. A 2018 Cochrane Review by Thieme et al.[4] determined that MT resulted in small, statistically significant improvements in motor function and activities of daily living compared to no treatment or sham controls. Meanwhile, CIMT has demonstrated moderate to large effect sizes for motor function in a number of systematic reviews, particularly in the subacute and chronic phases.[36]

Comparative studies suggest that while CIMT may yield larger gains in patients with sufficient motor capacity and compliance, MT can be regarded as an alternative or adjunct treatment for patients with more severe motor impairment or those who are not eligible for CIMT. A recent RCT by Hooria et al.[12] directly compared CIMT and MT in adult survivors of stroke and reported that while both interventions produced significant increases in Fugl-Meyer Upper Extremity scores, the CIMT group had significantly greater gains in functional use, as assessed by the CAHAI. According to these results, CIMT may produce better outcomes when tolerated, but MT can still be an important option for those with more severe initial motor deficits or a reduced capacity to participate in intensive therapy.

Ultimately, treatment selection should be tailored to patient-specific factors, including stage of recovery, severity of motor impairment, cognitive status, availability of rehabilitation services, and tolerance for intensive therapy. In some cases, MT may be utilized as a preparatory therapy to build motor capacity before progressing to CIMT.

Table 3. Comparison of Mirror Therapy and Constraint-Induced Movement Therapy

Characteristic	Mirror Therapy (MT)	Constraint-Induced

		Movement Therapy (CIMT)
Mechanism	Visual feedback activates motor cortex via mirror neuron system	Intensive task-specific practice with restraint overcomes learned non-use
Active movement required	No	Yes (minimum wrist and finger extension required)
Stroke stage	Acute, subacute, and chronic	Acute, subacute and chronic
Indications	Mild to severe paresis; adequate attention; poor access to clinic-based therapy	Mild to moderate impairment; cognitively intact; can tolerate intensive training
Contraindications	None established	Severe spasticity, pain, joint deformity
Cost	Low	High
Home-based feasibility	High	Low to Moderate (mCIMT more feasible)

Unanswered questions

Despite evidence supporting the outcomes from MT of the upper limb after stroke, several important questions remain unanswered. Two of the most relevant relate to (1) whether MT is more effective when initiated during the acute phase compared with later stages of recovery, and (2) whether greater adherence to MT protocols leads to improved outcomes. These are particularly relevant with regard to optimizing MT for home-based models of rehabilitation.

1. **Does initiation of mirror therapy at an earlier stage lead to greater improvements in upper limb function than initiation at a later stage?**

A question that has not been answered yet is whether MT is more beneficial when started during the acute or early subacute phase post stroke as compared to the chronic phase. The hypothesis is that patients who are enrolled closer to stroke onset will show larger gains, reflecting greater responsiveness of the motor system to MT during the period of spontaneous recovery.[15, 38] This hypothesis is grounded on the principle of spontaneous biological recovery. During the acute period, the brain demonstrates heightened plasticity, with extensive remodeling of motor networks that naturally facilitates recovery. Studies have suggested that earlier start of rehabilitation therapies, including MT, can capitalize on this window of enhanced neuroplasticity. For instance, Arya et al.[29] demonstrated that MT had larger effects when started early following stroke, compared to later initiation. However, the literature remains inconclusive, in part because most RCTs have predominantly involved chronic stroke patients.[28, 12]

A future RCT could address this gap by recruiting participants between one week and six months after stroke onset. Eligible subjects would be randomized into two groups: (1) dose-matched conventional therapy and (2) conventional therapy plus MT. Both groups would receive a 4-week intervention period, with daily 30-minute sessions, five times per week. Functional outcome would be measured using the ARAT as the primary endpoint. Assessments would be done at baseline and at the end of the 4-week intervention, with follow-up at 3 and 6 months. The study design would also enable correlational analysis between time post-stroke at enrollment (e.g., 1 month vs. 3 months vs. 6 months) and change in ARAT scores.

2. Does greater adherence to mirror therapy produce better outcomes?

A second unanswered question is the role of patient adherence in MT effects. Some researchers have suggested that inconsistency in adherence with MT sessions might limit treatment outcomes,[4] but this is at present an author opinion and has not yet been systematically explored in most studies. Few studies have directly measured adherence or assessed whether time spent is correlated with functional improvement.

To answer this question, an RCT could be designed with objective measurement of adherence and motor recovery. All subjects would follow a standard MT protocol, with daily sessions of 30 minutes, five days per week for four weeks. Adherence could be monitored by simple electronic time measurement devices, like motion-detector video logs or time-stamped recordings to confirm frequency and duration of sessions. Although self-reported activity logs were used in certain rehab studies, they are subject to recall and report bias.

Instead of forming discrete adherence groups, researchers could assess the correlation between total time in MT and change scores on outcome measures using correlational statistics. The primary outcome would be ARAT, with secondary measures being FMA-UE and MAL. Testing would occur at baseline, post-treatment, and at 3- and 6-month follow-ups. This would allow a more precise understanding of whether increased adherence is associated with improved upper limb function.

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