Use of Mirror Therapy for Phantom Limb Pain in Lower Limb Amputees: A Narrative Review

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***Abstract*: Phantom Limb Pain (PLP) remains a pervasive and debilitating consequence of amputation, affecting up to 80% of lower limb amputees. Pathophysiological theories suggest that PLP arises from maladaptive neuroplasticity, specifically between the motor cortex's output and the lack of sensory feedback from the missing limb. Mirror Therapy (MT) addresses this by providing a visual surrogate for the absent limb, theoretically resolving the sensorimotor conflict in the primary somatosensory and motor cortices. This narrative review evaluates the current state of clinical evidence regarding the use of MT for managing PLP in lower limb amputees. A comprehensive qualitative synthesis was performed by searching major medical databases (PubMed, CINAHL, Scopus, and PEDro) for studies published between 2010 and 2026. Selection criteria included Randomized Controlled Trials (RCTs), case-control studies, and systematic reviews involving adult lower limb amputees experiencing chronic or acute PLP. Key findings suggests that MT facilitates the "re-mapping" of the cortical representation of the limb, reducing the invasion of adjacent cortical areas into the deafferented zone. Active, bilateral synchronous movements (e.g., ankle dorsiflexion/plantarflexion) under the mirror illusion yield higher pain reduction scores compared to static viewing. Mirror therapy is a highly effective, low-cost adjunct for lower limb phantom limb pain, though it currently lacks standardized dosage guidelines.**

***Keywords*: Phantom Limb Pain, Mirror Therapy, Lower Limb Amputation, Neuroplasticity, Physical Therapy, Rehabilitation.**

1. Introduction

Amputation of a lower extremity is a life-altering event that extends far beyond the physical loss of a limb, often resulting in complex psychological and neurological sequelae. Among the most challenging of these is Phantom Limb Pain (PLP), defined as a painful sensation perceived in the part of the body that has been removed [1]. Unlike non-painful "phantom sensations," PLP is characterized by debilitating symptoms such as cramping, burning, shooting, or electric-shock sensations. Current longitudinal data suggests that nearly 60% to 80% of lower limb amputees experience PLP within the first year post-surgery, with a significant portion transitioning into chronic, long-term pain states [2].

The etiology of PLP is multifactorial, involving peripheral, spinal, and supraspinal mechanisms. However, the most widely accepted theory is that of maladaptive cortical reorganization [3]. Following the loss of sensory input from a lower limb, the area of the primary somatosensory cortex (S1) and motor cortex (M1) that previously represented the leg begins to be "invaded" by adjacent cortical representations. This neural "re-mapping" creates a sensorimotor incongruence—a conflict between the brain's motor commands to the missing limb and the lack of corresponding visual and proprioceptive feedback [4]. This mismatch is interpreted by the brain as pain, a concept often referred to as "learned paralysis" [5].

Management of PLP in the lower limb has traditionally relied on pharmacological interventions, including gabapentin, antidepressants, and opioids. Unfortunately, these often yield sub-optimal results and are accompanied by systemic side effects that can hinder active physical rehabilitation and prosthetic gait training [6]. Consequently, there has been a shift toward non-pharmacological, neuromodulatory approaches that target the brain's plasticity directly.

Mirror Therapy (MT), first introduced by Ramachandran and Rogers-Ramachandran in the 1990s, has emerged as a cornerstone of this shift [7]. In the context of lower limb rehabilitation, MT involves placing a mirror sagittal between the patient's legs, such that the patient views the reflection of their intact limb in the position of the missing one. By performing synchronous bilateral movements, the patient receives a vivid visual illusion of a functional, pain-free phantom limb [8]. This visual input is hypothesized to provide the "missing link" in the sensorimotor loop, thereby inhibiting the maladaptive reorganization and reducing pain intensity [9].

Despite its widespread clinical use, the application of MT in lower limb amputees presents unique challenges compared to upper limb cases, including the scale of the mirror required and the integration of the therapy into weight-bearing protocols [10]. This narrative review aims to synthesize current evidence on the efficacy of MT specifically for lower limb PLP, examine the neurological mechanisms involved, and provide a framework for standardized clinical application.

2. Methodology

This narrative review employed a comprehensive search strategy to identify peer-reviewed literature focusing on the clinical application and efficacy of mirror therapy (MT) for lower limb phantom limb pain (PLP). The methodology was designed to capture a broad spectrum of evidence, ranging from foundational neurophysiological studies to contemporary

clinical trials.

A. Search Strategy and Data Sources

A systematic search was conducted across several electronic databases, including PubMed/MEDLINE, PEDRO (Physiotherapy Evidence Database), The Cochrane Library, Scopus, and Google Scholar. The search covered the period from January 2010 to March 2026 to ensure the inclusion of the most recent advancements in neuromodulation and virtual mirror technologies [11].

The search utilized a combination of Medical Subject Headings (MeSH) and Boolean operators. Keywords included:

- "Mirror Therapy" OR "Mirror Visual Feedback"
- "Phantom Limb Pain" OR "Phantom Sensation"
- "Lower Limb Amputation" OR "Leg Amputation"
- "Neuroplasticity" OR "Cortical Reorganization"

Inclusion and Exclusion Criteria

To maintain the focus of the review, specific criteria were applied to the literature search:

B. Inclusion Criteria:

(1) Peer-reviewed studies involving adult human participants with unilateral lower limb amputations

(2) Interventions primarily utilizing mirror therapy or mirror-based visual feedback

(3) Outcomes measuring pain intensity via the Visual Analogue Scale (VAS) or Numerical Rating Scale (NRS)

(4) Studies published in the English language.

C. Exclusion Criteria:

(1) Studies focusing exclusively on upper limb amputees

(2) Articles involving non-painful phantom sensations only

(3) Dissertations, conference abstracts, or non-peer-reviewed editorials [12].

3. Literature Review

The current body of literature regarding Mirror Therapy (MT) for lower limb amputees focuses on three primary pillars: clinical efficacy trials, neuroimaging studies that validate cortical shifts, and the comparative benefits of MT against other sensory-motor interventions.

A. Evidence of Clinical Efficacy

The foundational evidence for MT in lower limb populations was significantly advanced by the landmark study of Chan et al., which demonstrated that 100% of the mirror therapy group reported a decrease in phantom pain compared to only 17% in the covered-mirror control group [13]. Subsequent trials have reinforced these findings, specifically highlighting that MT is more effective for "deep" cramping and "shooting" pains than for superficial sensations [14]. However, recent systematic reviews suggest that while the immediate analgesic effect is high, the sustainability of these results over 12 months remains a topic of active clinical debate [15].

B. Neuroimaging and Cortical Reorganization

The mechanistic "proof" for MT is found in functional Magnetic Resonance Imaging (fMRI) and Magnetoencephalography (MEG) studies. Research indicates that before treatment, lower limb amputees show an expansion of the facial or stump representation into the deafferented leg area of the motor cortex [16]. Studies involving MT have shown a significant "re-shifting" of these boundaries back toward their original anatomical locations following a 4-week intervention period [17]. This reversal of maladaptive plasticity is positively correlated with the patient's subjective report of pain reduction [18].

C. Comparison with Other Interventions

When compared to Graded Motor Imagery (GMI)—which involves laterality recognition and mental visualization—MT is often seen as the most "potent" phase due to the high-fidelity visual input it provides [19]. Some studies have investigated the use of Transcutaneous Electrical Nerve Stimulation (TENS) applied to the stump in conjunction with MT. Findings suggest a synergistic effect where the tactile input from TENS enhances the "realness" of the mirrored limb, leading to faster pain relief than MT alone[20].

Table.1. Literature Review

Year	Author	Title	Remarks
2016	Barbin et al.	"The effectiveness of mirror therapy in phantom limb pain: A Literature review"	Systematic review indicating that MT is a high-evidence, low-cost tool for PLP, but emphasizes that patient adherence is the primary predictor of long- term success.
2017	Finn et al.	"A Randomized, Controlled Trial of Mirror therapy for Upper and Lower Extremity Phantom Limb Pain"	Significant RCT proving that 4 weeks of MT [20min/day] leads to a statistically significant drop in VAS scores compared to mental imagery in lower limb patients .
2020	Limakatso et al.	"The effectiveness of GMI and its components on phantom limb pain and disability"	Meta-analysis highlighting that "ownership" of the mirrored reflection is

			crucial for reducing pain-related disability during early prosthetic fitting.
2021	Paula et al.	"Comparative analysis of mirror therapy outcomes based on amputation level"	Clinical study demonstrating that transtibial amputees show 20-30% faster cortical "re-mapping" than transfemoral patients due to preserved knee proprioception.
2022	Yatmadani et al.	"Mirror therapy for phantom limb pain in lower limb amputees: A systematic review"	Recent large-scale review confirming MT as a primary non-pharmacological intervention, specially noting its efficacy in reducing "burning" phantom sensations.
2024	Moura et al.	"Digital vs.Analog Mirror Therapy: A Clinical Review"	Study exploring the shift toward Virtual Reality[VR] "digital mirrors", providing higher immersion levels for complex transfemoral cases.
2025	Smith & Varma	"Neuroplasticity and Long-term adherence in Home-based Mirror Therapy"	Longitudinal study showing that 10-minute "booster" sessions twice a week after the initial 4-week protocol prevent pain relapse over an 18- month period.
2026	Lee et al.	"The Future of Neuromodulation: Integrating MT with Wearable Biofeedback"	Leading – edge research [current] on using wearable sensors to match real-time muscle activity with mirror feedback to enhance the cortical illusion.

D. Implementation in Transtibial vs. Transfemoral Amputation

A critical subset of the literature explores how the level of amputation dictates MT success. Transtibial patients benefit from the preserved knee joint's mechanoreceptors, which provide more complex feedback loops during MT [21]. Conversely, transfemoral patients often require more immersive setups or "mirror walls" (rather than small mirror boxes) to capture the full range of hip and thigh movement necessary to trigger the neural response [22].

E. Patient- Specific Variables

The efficacy of MT is not uniform across all amputees population. Meta-analyses highlight that patients with a higher "baseline" of phantom limb movement respond significantly better to MT than those with "fixed" or paralyzed phantom limb.

4. Results

The synthesis of reviewed literature reveals a consistent, though varying, trend toward pain reduction in lower limb amputees utilizing mirror therapy (MT). The results are categorized into three primary themes: analgesic efficacy, protocol parameters, and neurophysiological changes.

A. Analytic Efficacy and Pain Reduction

Multiple studies demonstrate that MT is superior to conventional treatments (such as mental imagery or basic stump desensitization) in reducing the intensity of Phantom Limb Pain (PLP). Randomized controlled trials (RCTs) specifically targeting lower limb populations found that patients reported a significant decrease on the Visual Analogue Scale (VAS) after 4 weeks of consistent therapy [24]. Long-term follow-up data (up to 6 months) suggests that while pain intensity may fluctuate, the frequency of "pain attacks" remains lower in the MT group compared to control groups [25].

B. Standardized Protocol Parameters

The efficacy of MT is highly dosage-dependent. The reviewed evidence suggests a "therapeutic window" for optimal results:

Frequency: Daily sessions (at least 5 days per week) are more effective than intermittent therapy [26].

Duration: 15 to 25 minutes per session is the clinical standard. Sessions exceeding 30 minutes often lead to mental fatigue, which diminishes the quality of the visual illusion [27].

Action Type: Synchronous bilateral movement (moving both the intact and phantom limb simultaneously) was found to be more effective than passive observation of the mirror reflection. Specifically, for lower limb patients, ankle movements and toe flexion provide the strongest cortical "feedback" [28].

C. *Impact of Level of Amputation*

Results indicate a divergence based on the level of amputation. Transtibial (below-knee) amputees generally report a more rapid response to MT than transfemoral (above-knee) amputees [29]. This is likely due to the preservation of the knee joint, which allows for more complex, multi-joint movement patterns, thereby creating a more "robust" visual and proprioceptive illusion in the mirror [30].

D. *Psychological and Quality of Life Outcomes*

Beyond physical pain reduction, MT was associated with improved sleep quality and a decrease in anxiety related to the "learned paralysis" of the phantom limb [31]. Patients who reported a successful "ownership" of the mirrored reflection also showed higher adherence rates to subsequent prosthetic gait training [32].

E. *Adverse Effects and Limitations*

While no severe adverse effects were reported, a small percentage of patients (approx. 5-8%) experienced "mirror-induced dizziness" or a brief increase in phantom sensations (paraesthesia) during the first week of treatment [33]. These symptoms typically resolved by adjusting the duration of the sessions.

5. Discussion

The results of this review underscore Mirror Therapy (MT) as a cornerstone of neuromodulatory rehabilitation for lower limb amputees. The discussion primarily revolves around the neuroplastic mechanisms, the clinical "proprioceptive gap," and the practical challenges of implementing MT in a lower limb population.

A. *Mechanisms of Cortical Reorganization*

The efficacy of MT is best explained by its ability to resolve sensorimotor incongruence. In lower limb amputees, the brain continues to send motor signals to the absent limb; however, the lack of visual and proprioceptive confirmation results in a "prediction error" that the brain interprets as pain [34]. MT provides the missing visual feedback, which activates the mirror neuron system and "tricks" the motor cortex into perceiving successful movement. This inhibits the maladaptive reorganization where the representation of the intact limb or the residual stump "invades" the cortical territory of the phantom limb [35].

B. *The Lower Limb "Proprioceptive Gap"*

A significant point of discussion is the difference between upper and lower limb MT. Lower limb movements are primarily driven by gait-related, rhythmic spinal patterns and heavy proprioceptive feedback from weight-bearing. Unlike the hand, which is used for fine motor tasks, the leg is used for stability. This creates a "proprioceptive gap" where visual feedback alone may not be sufficient for some patients [36]. Studies suggest that adding tactile stimulation to the intact limb while the patient views the mirror can enhance the illusion, a technique known as "dual-sensory" mirror therapy [37].

C. *Therapeutic Dosage and Adherence*

While the consensus points toward 20-minute daily sessions, the "narrative" in the literature highlights a significant drop-off in patient adherence after the first two weeks [38]. As clinicians, we must recognize that MT is mentally taxing. The cognitive load required to maintain the illusion is high. Therefore, integrating MT into a broader Graded Motor Imagery (GMI) framework—which includes laterality reconstruction and mental visualization—may provide a more sustainable pathway for chronic sufferers [39].

D. *Psychological Factors and Patient Selection*

The success of MT is not purely mechanical; it is deeply tied to the patient's psychological state. Patients with high levels of "catastrophizing" or those who cannot mentally "own" the reflected image (low embodiment) tend to see poorer results [40]. This suggests that MT should be part of a multidisciplinary approach that includes psychological support to address the emotional trauma of limb loss [41].

E. *Future Directions: VR and Beyond*

The evolution of MT is moving toward Immersive Virtual Reality (IVR). IVR allows for 360-degree feedback and can simulate weight-bearing environments that a static mirror cannot. Preliminary data suggest that VR-based "digital mirror therapy" might provide more significant pain relief for transfemoral amputees by simulating complex gait cycles, which are difficult to replicate with a physical mirror box [41,42].

6. Conclusion

Mirror Therapy (MT) represents a significant paradigm shift in the rehabilitation of lower limb amputees, moving away from purely peripheral treatments toward a central, neuromodulatory approach. By providing a coherent visual representation of the missing limb, MT effectively disrupts the maladaptive cortical reorganization that underlies Phantom Limb Pain (PLP) [43].

The synthesis of current evidence indicates that MT is an evidence-based, cost-effective, and low-risk intervention that consistently reduces pain intensity and improves the quality of life for lower limb amputees [44]. However, its success is inherently tied to the quality of the visual illusion and the patient's cognitive engagement. Clinical outcomes are most robust when MT is initiated early in the post-operative phase, serving as a "neural bridge" before the introduction of a prosthetic limb [45].

While the analgesic benefits are well-documented, this review highlights a lack of standardized universal protocols regarding the optimal "dosage" of MT. Furthermore, the transition from the seated, static mirror illusion to dynamic, weight-bearing functional tasks remains a significant clinical challenge that requires further investigation [46].

A. Recommendations for Clinical Practice:

- Early Intervention: Integrate MT as soon as the surgical wound allows for comfortable positioning.
- Graded Approach: Utilize MT as part of a broader Graded Motor Imagery (GMI) program to prevent mental fatigue [47].
- Technological Integration: Explore the use of digital mirrors or basic Virtual Reality (VR) to enhance immersion for patients who struggle with the physical mirror setup [48].

In summary, as we move toward 2026 and beyond, the role of the physiotherapist is evolving into that of a "cortical architect." Mirror Therapy remains one of our most potent tools in restructuring the brain's representation of the body to eliminate the ghost of pain [49].

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