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Original article

MIRROR THERAPY IN HAND TRAUMA REHABILITATION: THERAPEUTIC MECHANISMS AND CLINICAL IMPLICATIONS

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Abstract

Hand injuries represent a significant proportion of musculoskeletal trauma and frequently involve fractures, tendon lesions, nerve damage and soft tissue loss. These complex conditions often require surgical treatment and prolonged rehabilitation, yet outcomes remain suboptimal due to fragile tendon repairs, delayed nerve regeneration, maladaptive cortical plasticity, pain syndromes and psychological barriers such as fear of movement. Addressing these challenges requires innovative strategies that can stimulate motor relearning and sensory reintegration without imposing stress on healing structures.

Mirror therapy (MT) uses visual feedback to modulate somatosensory and motor representations. Over the past three decades, MT has progressed from an experimental pain intervention to an established adjunct in stroke rehabilitation and, more recently, an emerging tool in hand trauma recovery. Its mechanisms of action include activation of the mirror neuron system, promotion of adaptive cortical reorganization, restoration of sensorimotor congruence, modulation of pain perception and motivational effects that enhance adherence and reduce fear of movement.

Clinical applications of MT in hand trauma are increasingly recognized. In tendon injuries, MT provides cortical activation during the vulnerable healing phase, helping to prevent adhesions while avoiding mechanical stress. In peripheral nerve injuries, MT supports cortical representation during prolonged reinnervation and facilitates motor and sensory reintegration once recovery begins. In complex regional pain syndrome, MT has consistently demonstrated analgesic effects and functional improvements, supported by randomized controlled trials. Orthopedic trauma, particularly distal radius fractures with prolonged immobilization, may also benefit, with clinical evidence showing improvements in range of motion, grip strength and independence. In multi-structural injuries, MT contributes both neurocognitive and psychological benefits, increasing confidence, motivation and active participation in rehabilitation.

The strengths of MT include simplicity, non-invasiveness, low cost and adaptability to both hospital-based and home programs. It integrates easily with physiotherapy, occupational therapy, sensory retraining and advanced modalities such as graded motor imagery and virtual reality. Nevertheless, limitations persist: most studies remain small and heterogeneous, with limited standardization of protocols, variable patient responsiveness and a lack of long-term outcome data.

In conclusion, MT should be considered a safe and promising adjunct in hand trauma rehabilitation, capable of enhancing motor relearning, sensory reintegration and pain control. High-quality trials are needed to establish standardized protocols, define optimal patient selection and confirm its role in evidence-based rehabilitation guidelines.

Keywords: mirror therapy, hand trauma, rehabilitation, neuroplasticity

1.Introduction

Hand injuries represent a significant proportion of all musculoskeletal trauma, estimated between 6% and 28%, with occupational and domestic accidents being frequent causes (Arroyo-Berezowsky et al., 2021). These injuries range from fractures and tendon lacerations to peripheral nerve and vascular damage, often requiring surgical intervention and prolonged rehabilitation. Functional impairment may involve reduced range of motion, loss of strength, altered sensibility and chronic pain, with major consequences for daily activities, professional performance and quality of life.

In the rehabilitation of hand trauma, several serious challenges are commonly specified. Flexor tendon repairs remain fragile and prone to rupture with premature loading (Dy & Daluiski, 2014), while peripheral nerve injuries disrupt cortical representation, hindering motor relearning (Nordmark et al., 2018; Grinsell & Keating, 2014). Maladaptive cortical plasticity (Li et al., 2021; Lustenhouwer et al., 2020), pain syndromes and psychological barriers such as fear of movement further complicate recovery.

These challenges underscore the need for innovative approaches that promote motor relearning without imposing mechanical stress on healing tissues. Mirror therapy, first described by Ramachandran and Rogers-Ramachandran (1996)

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for phantom limb pain, harnesses visual feedback to modulate somatosensory and motor representations. Initially applied in amputees, it has since been integrated into rehabilitation for stroke-related hemiparesis and, more recently, hand trauma.

Comprehensive analyses of MT in traumatic hand injuries are limited. Most reviews focus on stroke or phantom limb pain (Campo-Prieto & Rodríguez-Fuentes, 2022; Thieme et al., 2012), leaving its role in trauma underexplored. Early reports suggest benefits in tendon, nerve and complex injuries. This article synthesizes current evidence and theoretical perspectives on MT in hand trauma, addressing mechanisms, clinical applications, limitations and priorities for future research.

2. Historical development of mirror therapy

The origins of mirror therapy (MT) are deeply rooted in the study of phantom limb pain. In their relevant work, Ramachandran and Rogers-Ramachandran (1996) demonstrated that amputees could obtain relief from pain and cramping sensations by observing the reflection of their intact limb in a mirror, effectively "tricking" the brain into perceiving movement of the absent limb. This pivotal discovery laid the foundation for the subsequent development of MT as a rehabilitation approach based on visual feedback and cortical reorganization. This discovery sparked interest in the potential of visual feedback to modulate sensory and motor processing.

The development of mirror therapy (MT) has followed a progressive trajectory over the past three decades. In the 1990s, early reports documented rapid reductions in phantom limb pain when patients used mirror boxes to provide visual feedback of the missing limb. During the 2000s, the technique was adapted to neurological rehabilitation, particularly after stroke, where systematic reviews confirmed significant improvements in upper-limb motor recovery and activities of daily living (Deconinck et al., 2015; Ezendam et al., 2009). In 2005, Rosén and colleagues pioneered the introduction of MT into hand surgery rehabilitation, reporting preliminary success in trauma patients. Throughout the case series and small-scale clinical studies expanded the evidence base, showing benefits for patients recovering from peripheral nerve injuries, tendon repairs, and complex regional pain syndrome (McCabe et al., 2003). More recently, MT has increasingly been combined with adjunctive approaches such as graded motor imagery (GMI), virtual reality (VR) and digital platforms, broadening both its accessibility and clinical application (Rothgangel et al., 2011). Thus, MT has evolved from an experimental pain management tool to a recognized adjunct in multidisciplinary rehabilitation programs.

3. Neurophysiological mechanisms of mirror therapy

The theoretical basis of mirror therapy (MT) lies in its ability to exploit neuroplasticity by combining visual feedback with motor intention. The method involves placing a mirror in the sagital plane so that the patient sees the reflection of the unaffected hand, creating the illusion that the injured hand is moving normally. Several mechanisms have been proposed to explain its clinical effects:

3.1 The mirror neuron system

The discovery of mirror neurons in the premotor cortex and inferior parietal lobule provided the neurophysiological foundation for the development of mirror therapy (Rizzolatti & Craighero, 2004). These neurons are unique in that they become active both when an individual performs an action and when the same action is merely observed. Within the context of mirror therapy, observing the reflection of the unaffected hand creates a visual illusion that the affected hand is moving. This visual feedback engages motor circuits bilaterally, including those representing the injured limb, thereby promoting cortical reorganization and facilitating motor relearning. Through this mechanism, mirror therapy harnesses neuroplasticity to restore function in patients with neurological or orthopedic impairments. (Figure 1)

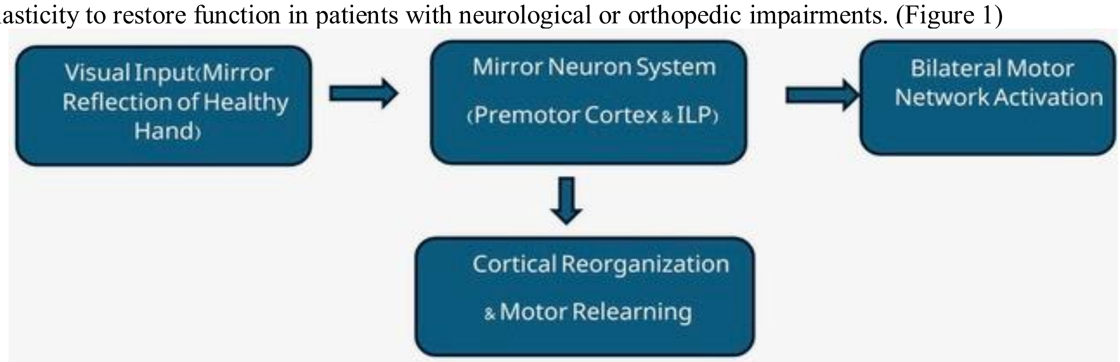

Figure 1. Mechanism of mirror therapy

3.2 Neuroplasticity and cortical reorganization

Neuroimaging studies demonstrate that trauma, immobilization or nerve injury may lead to maladaptive cortical changes, including shrinkage of the cortical area representing the affected limb. Michielsen et al. (2011) showed that MT induces cortical reorganization in chronic stroke patients, leading to improved motor function. A randomized controlled trial demonstrated that initiating sensory and motor re-learning immediately after nerve repair, with interventions such as

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mirror visual feedback and tactile observation, significantly improved discriminative touch at six months compared to delayed re-learning (Rosén et al., 2015).The pilot study by Yeldan et al. (2015) found no statistically significant effects of very early mirror therapy on upper extremity recovery in acute stroke patients but noted clinically relevant improvements and emphasized the need for larger multicenter trials to clarify its potential role in early rehabilitation. These findings support the role of MT in promoting adaptive neuroplasticity in hand trauma.

3.3 Sensory-motor integration

Hand trauma creates a mismatch between motor intention (the desire to move) and sensory feedback (limited movement or absent sensation): the patient "wants" to move the limb, but the expected proprioceptive or tactile input is absent. Ezendam et al. (2009), in their systematic review, emphasized that MT restores congruence by providing visual confirmation of movement, thereby reducing sensorimotor conflict and facilitating relearning.

3.4 Pain modulation and body schema

Pain relief is a hallmark of mirror therapy, particularly in conditions such as complex regional pain syndrome (CRPS) and phantom limb pain. Several mechanisms have been proposed to explain these effects. One hypothesis is that mirror therapy helps reverse maladaptive plasticity within the somatosensory cortex. Another explanation emphasizes the dominance of visual input, suggesting that the compelling visual illusion provided by the mirror can distract patients from pain and override conflicting proprioceptive signals. A further mechanism involves the restoration of body schema through congruent multisensory integration, which contributes to a more coherent perception of the affected limb (McCabe et al., 2003; Foell et al., 2014). One of the earliest and most consistent findings with MT is pain relief. Neuroimaging evidence suggests that the analgesic effects of mirror therapy in phantom limb pain are associated with cortical reorganization and altered body representation, highlighting the neuroplastic mechanisms underlying its efficacy (Foell et al., 2014). An early randomized controlled trials suggested that mirror therapy may significantly reduce phantom limb pain in amputees, providing preliminary evidence for its potential clinical efficacy (Chan et al., 2007). These effects are thought to result from restoration of the body schema and reversal of maladaptive plasticity.

3.5 Psychological and motivational factors

The effectiveness of mirror therapy is supported by both neurophysiological and psychological mechanisms (Figure 2). At the neural level, mirror visual feedback has been shown to reverse maladaptive plasticity in the somatosensory cortex, override conflicting proprioceptive input and restore body schema through coherent multisensory integration. Equally important, however, are the psychological and motivational benefits it provides. By observing the mirrored image of the affected hand moving normally, patients can reduce fear of movement and increase confidence in their functional abilities. Moreover, the simplicity and accessibility of mirror therapy promote engagement and adherence, which are essential for sustained rehabilitation and long-term outcomes (Foell et al., 2014; McCabe et al., 2003; Campo-Prieto & Rodríguez-Fuentes, 2022).

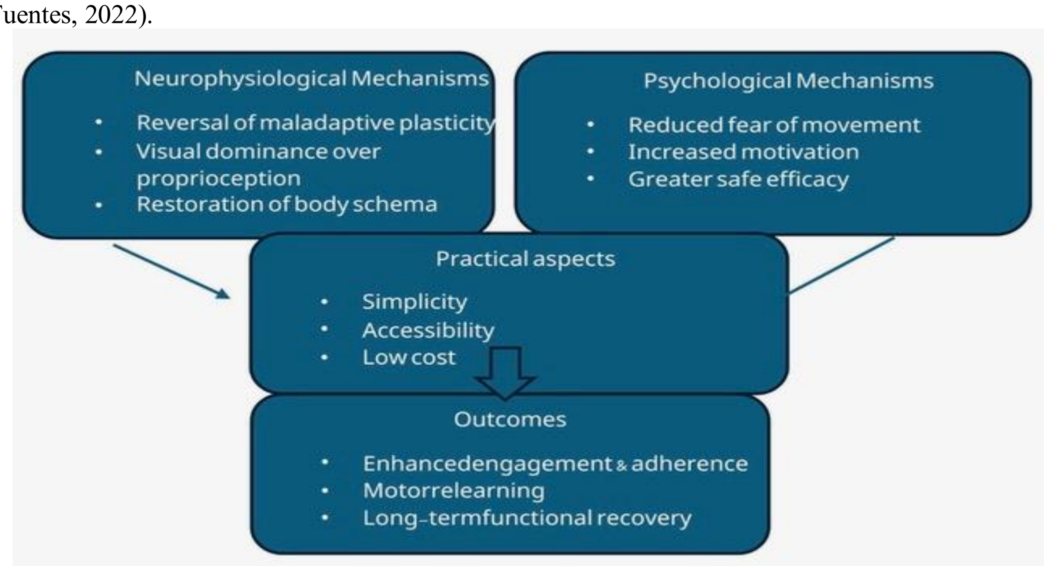

Figure 2. Bio-psycho-social model of mirror therapy effects

4. Clinical applications in hand trauma

Hand injuries frequently involve multiple structures, including bones, tendons, ligaments, nerves, vessels and soft tissues. Classification by structures affected, severity and location remains essential for guiding treatment (Ootes et al., 2012). High-energy or crush trauma is particularly complex, as it often damages several anatomical components simultaneously (Dębski & Noszczyk, 2021).

Fractures and dislocations of the metacarpals or phalanges may present as open injuries with high infection risk. Combined tendon injuries compromise grip and dexterity, while peripheral nerve lesions, ranging from neuropraxia to neurotmesis, can cause sensory loss and muscle atrophy, often requiring microsurgical repair. Vascular disruption further complicates outcomes by risking ischemia and necrosis, necessitating urgent intervention. Extensive soft tissue loss, ligament damage and mangled hand trauma pose additional reconstructive challenges, with current principles emphasizing restoration of at least three opposable, sensate digits for functional preservation. Clinicians must also consider complex regional pain syndrome, a disabling complication after trauma or surgery, marked by chronic pain, swelling, autonomic dysfunction and trophic changes.

In this context, mirror therapy has gained increasing attention. Its non-invasive, low-cost application and ability to activate cortical networks without stressing fragile tissues make it a promising adjunct in the rehabilitation of complex traumatic hand conditions:

4.1 Tendon injuries

Flexor tendon injuries represent one of the most complex challenges in hand surgery rehabilitation. Conventional protocols emphasize controlled mobilization to minimize adhesion formation while protecting the repair from rupture. Early mobilization is crucial for preventing adhesions but carries the inherent risk of tendon failure. In this context, mirror therapy offers a unique advantage, as it activates cortical motor pathways without mechanically stressing the repair. Rosén and Lundborg (2005) first introduced MT as a strategy to provide cortical stimulation during the critical healing phase, reporting improvements in dexterity, motor relearning and patient compliance. By creating the visual illusion of normal hand movement through reflection of the uninjured hand, MT allows safe engagement of motor networks, potentially enhancing functional recovery while preserving tendon integrity.

4.2 Peripheral nerve injuries

Peripheral nerve injuries require prolonged periods for axonal regeneration, often extending over several months. During this time, the cortical representation of the affected hand is at risk of maladaptive reorganization, which may compromise functional recovery. Mirror therapy provides continuous visual feedback by simulating movement of the injured hand, thereby helping to maintain cortical representation and support sensory–motor reintegration once reinnervation occurs. Rosén and Lundborg (2005) demonstrated that patients who engaged in MT after nerve repair showed enhanced early motor recovery and preservation of cortical hand representation compared with conventional therapy alone. These findings were further supported by Silva-Gallegos and Casas-Castillo (2023) who reported that MT facilitated motor relearning and cortical integration in individuals with brachial plexus injury and nerve transfer. Collectively, these results suggest that MT can serve as a protective neurorehabilitation strategy during the vulnerable reinnervation phase, bridging the gap between surgical repair and functional recovery.

4.3 Complex regional pain syndrome (CRPS)

Complex regional pain syndrome is a debilitating condition characterized by severe pain, edema, trophic changes and motor dysfunction, frequently developing after hand trauma. Maladaptive cortical reorganization is a hallmark feature of CRPS, often associated with sensory disturbances and impaired motor control. Mirror therapy has been applied successfully in this context. McCabe et al. (2003) demonstrated that MT reduced pain during treatment sessions and improved hand function over time by restoring congruence between sensory and motor inputs. Foell et al. (2014) further confirmed that MT was associated with normalization of cortical activity, correlating with pain relief. In addition, a randomized controlled trial by Cacchio et al. (2009) showed that MT was superior to conventional therapy in reducing pain intensity and enhancing motor recovery in patients with chronic CRPS. Collectively, these findings highlight MT as an effective neurorehabilitation strategy to address both the cortical and functional consequences of CRPS following hand trauma.

4.4 Fractures and postoperative rehabilitation

Multiple fractures and dislocations of the hand may occur simultaneously in different bones or joints, most often because of high-energy trauma or crush injuries. Such injuries, frequently involving metacarpals, phalanges or carpal bones, usually indicate significant force and are associated with complex trauma patterns.

Fractures may be simple or comminuted, while dislocations commonly affect the metacarpophalangeal or interphalangeal joints and in severe cases multiple joints may be involved. Almigdad et al. (2022) demonstrated that high-energy mechanisms are strongly correlated with distinct distributions and severity of hand bone fractures. In rare but critical cases, multiple metacarpal fractures following high-energy trauma have led to acute compartment syndrome of the hand, underscoring the importance of early recognition and timely management (Kastanis et al., 2025).

Fractures of the distal radius and other hand bones often require prolonged immobilization, which may result in stiffness, weakness and fear of movement during recovery. Dorsal stiffness and residual limitation in range of motion, particularly in rotation, are well-documented sequelae of distal radius fractures. Moreover, qualitative studies have shown that, even after surgical repair of distal radius fractures, patients often prioritize the restoration of mobility and function, needs that are frequently unmet without targeted rehabilitation interventions. In a comprehensive systematic review, Moos et al. (2024) identified recurring themes among patients with distal radius fractures: persistent concerns about dependency, fear, pain and a strong drive for recovery. All of this increases the challenges related to functional limitations and the fully recovery and healing process.

Similarly, Südow et al. (2024) conducted interviews with patients who reported not fully regaining function post-fracture, despite benign radiographic findings. Many described persistent physical, mental and activity-related limitations that were difficult to quantify but deeply impacted daily life. In this context, innovative strategies are needed to optimize outcomes.

Dilek et al. (2018) conducted a randomized controlled trial on patients with distal radius fractures and demonstrated that mirror therapy significantly improved range of motion, grip strength and functional independence compared with conventional rehabilitation alone.

These findings underscore the potential of mirror therapy not only in the treatment of soft tissue and peripheral nerve injuries, but also in orthopedic trauma rehabilitation, where immobilization-related deficits are frequent and challenging.

4.5 Multi-trauma and reconstructive surgery

Patients with severe hand trauma often present multi-structural injuries involving bones, tendons, nerves and vascular damage, frequently requiring staged reconstructive procedures. Beyond the physical consequences, these patients face significant psychological challenges, including anxiety, depression and fear of movement, which can negatively affect adherence to rehabilitation programs.

In such complex cases, rehabilitation strategies must address both functional recovery and psychosocial well-being. Mirror therapy has shown promise as an adjunct intervention by creating the visual illusion of restored movement in the injured hand. This illusion not only promotes cortical activation and motor relearning but also provides motivational and psychological benefits, helping patients regain confidence in their ability to move and function (Campo-Prieto & Rodríguez-Fuentes, 2022).

Recent evidence suggests that patients with severe hand trauma value rehabilitation methods that are simple, engaging and accessible, as these foster greater participation and adherence (Moos et al., 2024). MT aligns with these needs, as it is cost-effective, easy to implement and can be integrated alongside conventional physiotherapy and occupational therapy.

Moreover, studies in both nerve injury and chronic pain populations indicate that MT can reduce distress, improve body perception and encourage active patient involvement, which are critical factors for long-term recovery (Silva-Gallegos & Casas-Castillo, 2023; McCabe et al., 2003).

Taken together, these findings highlight MT as a valuable neurocognitive and motivational tool in the rehabilitation of patients undergoing reconstructive surgery for severe hand trauma, addressing not only physical deficits but also the psychological barriers that may affect optimal outcomes.

5. Mirror therapy protocols

Despite its simplicity, mirror therapy (MT) is applied through diverse protocols that vary in duration, frequency, type of tasks and integration with other therapies. Standardization remains limited, but several common principles can be drawn from clinical research and practice.

The essential equipment for mirror therapy (MT) is either a mirror box or a flat vertical mirror positioned at the patient's midline. In the standard setup, the uninjured hand is placed in front of the reflective surface, while the injured hand is hidden behind it. When the patient moves the healthy hand, the mirror produces the visual illusion that the affected hand is also moving symmetrically. This illusion of movement provides congruent visual feedback, which engages bilateral motor and sensory cortices and promotes cortical reorganization (Ramachandran & Rogers-Ramachandran, 1996; Deconinck et al., 2015). The setup is simple, low-cost and portable, making MT feasible for use in both hospital-based rehabilitation and home exercise programs (Thieme et al., 2012).

The mirror therapy sessions *duration and frequency* vary across clinical studies:

- Short, frequent sessions: 5–10 minutes, 2–3 times per day, are often recommended in the early postoperative period when patient tolerance is low (McCabe et al., 2003).
- Intermediate sessions: 15–20 minutes once or twice daily, have been reported as effective in stroke and *CRPS* rehabilitation (Cacchio et al., 2009; Thieme et al., 2018).
- Extended sessions: up to 30 minutes, are frequently applied in structured clinical programs for nerve repair or orthopedic rehabilitation, such as distal radius fractures (Dilek et al., 2018).

Ezendam et al. (2009) emphasized that frequency may be more critical than total duration, as repeated exposure helps consolidate cortical reorganization and motor relearning.

Exercises in mirror therapy typically progress from simple motor movements to more complex functional and sensory tasks:

- *Simple symmetrical movements* – opening and closing the hand, finger tapping and wrist flexion/extension. These foundational exercises are widely used to engage bilateral motor networks (Thieme et al., 2018).
- *Isolated finger control* – sequential finger opposition, finger lifting, abduction/adduction, which promote fine motor activation and cortical reorganization (Michielsen et al., 2011).

- *Functional tasks* – grasping, pinching and manipulating small objects such as coins, pegs or balls. Cacchio et al. (2009) demonstrated that integrating motor and functional tasks within MT produced greater improvements in pain reduction and motor recovery in CRPS patients compared to motor tasks alone.
- *Sensory training* –simulated touch, object recognition and texture exploration performed while observing the mirror reflection. These strategies aim to enhance sensory feedback and perceptual integration during the rehabilitation process (Paula et al., 2016).

6. Discussions

Mirror therapy (MT) has evolved from an experimental intervention for phantom limb pain into a promising adjunct for a wide range of neurological and orthopedic conditions, including hand trauma. The body of evidence to date suggests that MT facilitates motor relearning, sensory reintegration and pain modulation through mechanisms of neuroplasticity and multisensory integration.

In hand trauma specifically, MT addresses one of the greatest clinical challenges: the need to stimulate cortical areas responsible for hand function while the injured structures remain fragile and cannot yet tolerate intensive mobilization.

Neurophysiological rationale in rehabilitation practice

The mirror neuron system, cortical reorganization and sensorimotor congruence provide a robust theoretical foundation for MT. Neuroimaging studies (Michielsen et al., 2011; Foell et al., 2014) confirm that MT activates ipsilesional motor cortices and normalizes maladaptive cortical changes. This aligns with clinical outcomes such as improved dexterity after tendon repair (Rosén and Lundborg (2005) and enhanced recovery after nerve repair (Rosén et al., 2015). Similarly, the strong evidence base in CRPS demonstrates that pain reduction is closely linked to restored cortical representation (Cacchio et al., 2009).

Implications for clinical practice

Mirror therapy may be considered a valuable adjunct in specific rehabilitation contexts. It appears particularly useful in early tendon rehabilitation, when active motion must be restricted and in peripheral nerve injuries, where it may help preserve cortical representation during lengthy reinnervation. MT also shows promise as a non-pharmacological pain management strategy in post-traumatic complex regional pain syndrome and as a supportive intervention in fracture rehabilitation, especially in distal radius fractures requiring prolonged immobilization. MT should not replace conventional therapy but rather complement it, ensuring continuous cortical stimulation even when mechanical loading is limited. Importantly, patient education and adherence monitoring are critical, as consistent practice strongly determines outcomes.

Clinical strengths of mirror therapy

A major strength of MT lies in its *simplicity, accessibility and adaptability*. Unlike complex or costly interventions, MT requires only a mirror and can be applied at the bedside or at home. This makes it particularly attractive in resource-limited settings. Furthermore, it is *non-invasive, safe and easily combined with conventional physiotherapy*, occupational therapy, sensory retraining or advanced modalities such as graded motor imagery (GMI) and virtual reality (VR).

Another important strength is its *psychological impact*. Trauma patients often experience fear of movement, anxiety or frustration due to slow recovery. By providing the visual illusion of normal hand movement, MT promotes confidence, motivation and adherence. These psychological factors are crucial, as they directly influence participation in rehabilitation and long-term functional outcomes.

One of MT's strongest advantages is its *accessibility in home settings*. Patients can perform exercises independently with minimal instruction, provided they understand the purpose and remain motivated.

Limitations and gaps in current evidence

Despite its promising potential, the existing literature on mirror therapy (MT) in hand trauma remains constrained by several critical limitations. Many available studies are characterized by *small sample sizes and substantial heterogeneity*, as research on tendon and nerve injuries largely consists of case reports or small randomized controlled trials (RCTs), which restricts the generalizability of findings.

In addition, there is considerable *variability in intervention protocols*, with marked differences in session duration, frequency and exercise content and no consensus regarding the most effective parameters.

Another important limitation concerns the outcome measures, which are often restricted to short-term improvements in pain or basic functional performance, while long-term indicators, such as return to work, fine motor dexterity and overall quality of life, are rarely assessed.

Moreover, patient response to MT appears inconsistent; some individuals fail to experience the mirror illusion, while others obtain only marginal benefit and predictors of responsiveness remain poorly defined.

Finally, MT has yet to be systematically integrated into trauma-specific rehabilitation guidelines. Although widely acknowledged in stroke and complex regional pain syndrome (CRPS) rehabilitation, standardized protocols for hand trauma rehabilitation have not yet incorporated this approach.

Future perspectives

From our perspective, a few key directions may guide future research and clinical development in the field of mirror therapy (MT) for hand trauma.

Large-scale randomized controlled trials are required to standardize protocols and establish evidence-based recommendations regarding session length, frequency, progression and integration with other therapies across different patient subgroups.

Future investigations should also extend beyond short-term recovery and systematically assess long-term outcomes, including functional independence, return to work and overall quality of life.

Another objective is patient stratification, with efforts focused on identifying predictors of responsiveness, such as age, type of injury or psychological profile, in order to enable more personalized and effective interventions.

At the same time, integration with advanced technologies such as virtual and augmented reality holds promise for creating gamified and immersive rehabilitation environments that may enhance adherence, motivation and cortical engagement.

Neuroimaging and biomarker studies, including functional MRI and EEG, could further elucidate the neuroplastic mechanisms underpinning MT in tendon, nerve and fracture populations, thereby supporting mechanism-driven rehabilitation strategies.

The widespread adoption of MT will depend on its systematic inclusion in multidisciplinary hand trauma rehabilitation guidelines, alongside physiotherapy, occupational therapy, sensory retraining and psychological support.

7. Conclusions

Mirror therapy (MT) has progressed from an innovative approach for phantom limb pain into a clinically relevant adjunct for the rehabilitation of traumatic hand injuries. Its foundation in neuroplasticity, mirror neuron activation and sensorimotor congruence provides a strong theoretical rationale for its use.

Clinical studies, although heterogeneous, demonstrate consistent benefits in pain reduction, motor recovery, sensory reintegration and patient motivation across a variety of conditions including tendon injuries, peripheral nerve lesions, fractures and complex regional pain syndrome (CRPS).

The evidence suggests that MT is particularly valuable in the early phases of rehabilitation, when injured tissues are fragile and conventional mobilization is restricted. By providing visual feedback of normal movement, MT allows cortical stimulation without imposing biomechanical stress, bridging the gap until active therapy is feasible.

In addition, the psychological benefits, enhanced motivation, reduced fear of movement and improved adherence, further reinforce its utility in comprehensive rehabilitation programs. However, current knowledge is limited by small sample sizes, variable protocols and lack of long-term outcomes.

While MT is now well established in stroke and CRPS rehabilitation, its role in tendon and nerve injuries requires larger randomized controlled trials to confirm efficacy and define standardized treatment parameters. Integration with emerging technologies such as virtual reality and graded motor imagery represents a promising future direction that could expand its clinical impact.

In conclusion, MT should be regarded as a safe, low-cost and effective adjunct in hand trauma rehabilitation. Its incorporation into multidisciplinary treatment protocols has the potential to enhance functional outcomes, reduce disability and improve quality of life for patients with traumatic hand injuries. Future high-quality research will determine its place in evidence-based rehabilitation guidelines, enhancing the next generation of hand trauma care.

Authors' contributions

All authors have equally contributed to the article.

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