Efficacy of Motor Imagery through Mirror Visual Feedback Therapy in Complex Regional Pain Syndrome: A Comparative Study

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Abstract

Background: Complex regional pain syndrome (CRPS) is characterized by disabling pain, swelling, vasomotor instability, sudomotor abnormality, and impairment of motor function. An integrated multimodal multidisciplinary treatment approach is recommended to treat CRPS including pharmacological treatment, interventional therapy, and physiotherapeutic management. As imaging studies indicate that CRPS is associated with manifestation of changes in brain, mirror visual feedback (MVF) therapy may also have effect in neuromodulation and cortical reorganization. Aims and Objectives: The aim and objective of this study are to compare the effectiveness of MVF therapy with other conventional treatment.

Subjects and Methods: A total 30 patients were selected and randomly allocated into three groups. Group C was treated with pharmacological management with contrast bath, Group E was additionally treated with exercises, and Group M was additionally treated with MVF therapy. Prognosis of the patients was documented on the basis of pain at rest, on movement, and swelling.

Statistical Analysis Used: Two-way (3 × 4) ANOVA test.

Results: Patients with CRPS were benefited by pharmacological therapy, physical exercises, and mirror therapy as pain in rest and on movement improved over time. However, patients, additionally treated with mirror therapy, improved to a greater extent when compared to the other groups.

Conclusion: MVF therapy has been established as a low-cost treatment technique for CRPS along with other conventional treatments.

Keywords: Complex regional pain syndrome, mirror therapy, mirror visual feedback

INTRODUCTION

Complex regional pain syndrome (CRPS) is a chronic neurological disorder characterized by nondermatomal, distal predominant disabling pain, swelling, vasomotor instability, sudomotor abnormality and impairment of motor function. Pain in CRPS can be expressed as continuing spontaneous evoked regional pain often disproportionate in time and degree to any trauma or any other lesion. CRPS has been described by a number of terminology including causalgia, Sudeck’s atrophy, reflex sympathetic dystrophy, algodystrophy and shoulder-hand Syndrome. CRPS is an uncommon disease with a prevalence of <2% in most retrospective studies. A higher incidence of CRPS is reported in patients between the ages 61–70 years and in woman (76%). [4] The upper extremity is affected twice as commonly as the lower limb, and fracture is the most common trigger (46%). In 10%–26% of patients with CRPS, no precipitating factors can be found. [4]

In CRPS, there is interplay between central and peripheral pathophysiology. Some studies conclude that an initial noxious stimulus in the periphery results in a state of hyperexcitability in the spinal cord neurons. In sympathetic-mediated pain, the nociceptive input is maintained by an interaction between primary afferent and sympathetic efferent through an adrenergic mechanism. Widespread alterations in sensory perception and peripheral changes (autoimmune and somatosensory) in CRPS must be viewed as manifestation...
of changes in brain. Brain imaging studies indicate that the alteration of afferent input leads to cortical and thalamic plasticity and reorganization of sensory representation in patients with CRPS. Increased brain responsiveness among CRPS patients in some imaging studies supports the presence of central sensitization.

CRPS is diagnosed using “Budapest Criteria” (2003) in which the entity is meant to be descriptive, general, and not to imply any pathophysiology. It includes the presence of pain, hyperalgesia, allodynia, other sensory, vasomotor and sudomotor abnormality, and motor and trophic changes.

An integrated multimodal multidisciplinary treatment approach is recommended and tailored to the individual patients with primary aim to reduce pain, restore function, and enable patients to improve their quality of life. Pharmacological treatment with simple nonsteroidal anti-inflammatory drugs and neuropathic medicine, interventional therapy with intravenous regional anesthesia, sympathetic block, spinal cord stimulation and physiotherapeutic management with Transcutaneous Electrical Nerve Stimulation (TENS), exercise, splinting, and cryotherapy are among the conventional approaches of treatment.

The use of visual illusion created by a mirror was first introduced by Ramachandran VS, Rogers-Ramachandran in 1995. Mirror visual feedback (MVF) therapy is a neurorehabilitation technique designed to remodelate the cortical mechanism of pain. In CRPS, an attempt to move the limb cause severe pain, so very attempts get linked in a Hebbian manner to pain, associated memories remained even when inflammation itself is no longer there. It is called learned pain. Mirror therapy is used to unlearn the learned pain. In this, the patients perform movement of the unaffected limb while watching its mirror reflection superimposed over the (unseen) affected limb, thus creating a visual illusion of the affected limb movement. The visual illusion of the affected limb movement generates positive feedback to the motor cortex and would restore the integrity of cortical mechanism, which might in turn interrupts with the pain cycle and restoring function in the affected limb.

Although mirror therapy has been successfully used in different cases, still there is a paucity of enough literature to compare the effectiveness of MVF therapy with other conventional management in CRPS.

**Aims and objective**

- To reestablish the effectiveness of the motor imagery through MVF therapy in CRPS
- To compare the effectiveness of mirror therapy with other conventional treatments.

**Subjects and Methods**

The Institutional Ethics Committee approval has been obtained before initiation of this study. The study was registered in the Clinical Trial Registry of India with reference no REF/2017/02/013543. 30 patients, who came to an urban pain referral centre from January 2016 to June 2016 (6 months) and fulfilled the inclusion criteria, participated in the study. All of the patients in our study were male patients as our patients were industrial workers who are male predominant.

Informed written consent was obtained from each patient.

**Inclusion criteria**

- Patients diagnosed with CRPS according to the Budapest Criteria
- Age: 18–70 years
- Patients having signs and symptoms for more than 6 weeks but less than 1 year
- Patients already treated with neuropathic medicine for at least 4 weeks.

**Exclusion criteria**

- Radiculopathy or pain in single nerve distribution in the extremity
- Infection or cellulitis and other local pathologies
- Autonomic nervous system disease
- Peripheral nerve disease
- Vascular conditions such as vascular insufficiency, deep vein thrombosis, lymphedema, and erythromelalgia.

**Group distribution and related independent variables**

The patients were asked to draw a chit from a jar containing 30 chits (10 chits for each group), and they were randomly allocated into following three groups containing ten patients in each group.

- **Group A:** Control group – patients were treated by an independent investigator (single-blinded study– blinded at the level of investigator) through the following dependent variables:
  - Pain at rest: measured by Numeric pain Rating Scale (NRS), which is an 11–point scale for patient self-reporting of pain [Figure 1]. Patient will evaluate his or her pain in between 0 and 10, 0 implies no pain and 10 means highest pain patient can imagine
  - Pain on movement: measured by NRS. Patient will evaluate his or her pain in between 0 and 10, 0 implies no pain and 10 means highest pain patient can imagine
  - Swelling of the affected limb: Swelling was measured by measuring tape (making figure of “8”), where loops were surrounded the circumference of the body part, and the cross (“X”) was situated at the dorsum of the hand or
foot, where the swelling was maximum [Figure 2]. It is validated with volumetric measurement.\cite{21,22}

Assessments of all the patients were done at the time of presentation (day 0), after 1\textsuperscript{st} week (day 7), 2\textsuperscript{nd} week (day 14), and 4\textsuperscript{th} week (day 28).

**Description of the procedure**

1. **Contrast bath**: Patients were asked to immerse the affected body part (hand/foot) to cold and hot water (tolerable) alternatively for 3 min and 1 min, respectively. Procedure should start and end with cold water immersion, and total duration would be 15 min.\cite{23}

2. **Exercise**: Patients seated comfortably keeping a nonreflecting board or curtain perpendicular to his or her midline with the unaffected limb facing the nonreflective surface and affected limb hidden. Patients were asked to do exercise of the unaffected limb attending to the nonreflective surface which was followed by their painful limb (if possible) in a congruent manner. Following movements were practiced:
   - Upper extremity-wrist flexion and extension, ulnar deviation and radial deviation, metacarpophalangeal and interphalangeal joint movements – making fist and release and opponens movement
   - Lower extremity-ankle planter flexion and dorsiflexion, ankle inversion and eversion, toe at metatarsophalangeal and tarsophalangeal joint flexion-extension

Patients did exercise in a 2 min on-off mode for 20 min twice a day

3. **Mirror therapy**:\cite{17} Patient were asked to sit comfortably keeping a mirror perpendicular to midline with unaffected side in front of the reflecting surface of mirror and affected side hidden behind the mirror. The affected limb was relaxed and rested on a support surface behind the mirror throughout the period of mirror therapy. Patients were asked to look at the mirror and assume the mirror image of unaffected side as affected body part. The patient performed exercise of the unaffected body part in a full and pain-free range in all direction front of mirror. By seeing the mirror image patient imagined the affected limb was moving in pain-free manner [Figure 3]. Patients performed exercise in a 2 min on-off mode for 20 min twice a day.

**Results**

**Pain on rest**

Subjects in all groups reported a decrement in pain score with time with treatment when compared with initial assessment [Table 1].

Group M, which was additionally treated with mirror therapy showed significant improvement when compared with Group C and Group E.

There was a main effect of groups \( F = 72.49, P < 0.0001 \), and time effect \( F = 70.26, P < 0.0001 \). Main effects were also qualified by Group X time interactions \( F = 8.98, P < 0.0001 \).

Tukey’s honestly significant difference (HSD) \textit{Post hoc} analysis revealed a significant difference in pain scores from pre to post in all three groups. This effect sustained in Group M for 4 weeks with continued therapy, while other two groups failed to show a significant effect in sustainability after 2\textsuperscript{nd} week. There was no significant difference found between control and exercise groups with continued treatment for 4 weeks. Group M showed significant improvement when compared with Group C and Group E which sustained with time [Bar Diagram 1].

**Pain on movement**

Subjects in all groups reported a decrement in pain on movement score with time with treatment when compared with initial assessment [Table 2].
Group M, which was additionally treated with mirror therapy showed significant improvement when compared with Group C and Group E.

There was a main effect of groups $F = 66.08, P < 0.0001$ and time effect $F = 97.01, P < 0.0001$. Main effects were also qualified by Group X time interactions $F = 13.3, P < 0.0001$.

Tukey’s HSD Post hoc analysis revealed a significant difference in pain scores from pre to post in all three groups. This effect sustained in Group M for 4 weeks with continued therapy. There was no significant difference found between control and exercise groups with continued treatment for 4 weeks. Group M showed significant improvement when compared with Group C and Group E which sustained with time [Bar Diagram 2].

Swelling

Subjects in all groups showed a decrement in swelling with time following treatment when compared to initial assessment, though it failed to touch the level of significance, might be because of type II error [Table 3].

There is no significant difference between Group M in swelling when compared to Group C and Group E.

$F$ value of groups is 0.25, $P = 0.7793$ and time = 0.63, $P = 0.5972$.

Tukey’s HSD Post hoc analysis revealed no significant difference in swelling from pre to post in all three groups. Group M also failed to show any significant improvement in swelling when compared with Group C and Group E [Bar Diagram 3].

Discussion

In the present study, motor imagery using MVF method has been proven to be effective in relieving pain in patients with CRPS when compared to conventional management [Figure 4a and b].

In MVF therapy, the centrally processed congruent visual feedback from moving unaffected limb, provided by the mirror which appears to originate from dysfunctional and painful side acts to establish the normal pain free relationship between sensory feedback and motor intention, restore the integrity of central processing, and consequently results in a rapid resolution of pain state and restoring function of the affected limb.[24]

The present observation has also been supported by multiple similar studies where mirror therapy has compared with conventional treatment while applied on CRPS and it effectively reduces pain and enhances motor function.[24‑27]

When patients look at the visual reflection of the unaffected hand, however, he sees, there is no external object causing the pain in the optically resurrected limb, so
3. Only three dependent variables of pain and swelling have been analyzed. More variables such as skin color, skin temperature, range of motion, and function could be analyzed. Functional state of the patients also should be analyzed by taking satisfaction index and disability index.

4. There are future scopes of research which can see the sustained effectiveness of mirror therapy even after stopping treatment. We will continue this study and follow-up the patients beyond 4 weeks in the future.

5. The study has been conducted in a single institute only.

**Conclusion**

Overall, the study concluded that patients with CRPS benefited by pharmacological therapy, physical exercises, and mirror therapy as pain in the rest and pain on movement improved over time. However, patients treated with mirror therapy along with the conventional therapy improved in a greater extent when compared to pharmacological therapy or exercises.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Acknowledgment**

We sincerely acknowledge the help from Dr Pradip Kumar Bhattacharjee, Director of ESI-IPM, for his kind permission, Dr Amit Chackrabarti, scientist E, ICMR, for data analysis, Ms Shagufta Kaur Bhangu for her guidance and support and Mr Debankan Bhattacharya for sincere technical assistance during this study.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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