There is evidence showing mirror therapy to reduce phantom limb pain in adult clients with lower limb amputations

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There is evidence showing mirror therapy to reduce phantom limb pain in adult clients with lower limb amputations

Disciplines
Occupational Therapy | Rehabilitation and Therapy

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There is evidence showing mirror therapy to reduce phantom limb pain in adult clients with lower limb amputations.

### CLINICAL SCENARIO:
An estimated number of 1.7 million people are living with limb loss today in the United States and this number is expected to increase due to ongoing military conflicts. The incidence of phantom limb pain among amputees is 60%-80% (Black et al., 2009), and about 64% of these individuals with limb-loss report their phantom limb pain as “bothersome” while 21% experience a “severely bothersome” pain (Darnell, 2009). This phantom pain is perceived as coming from the amputated body part and can affect the individual’s quality of life because of the distress, physical limitation, and disability the phantom pain may cause. This pain may be induced by a conflict between visual feedback and proprioceptive representations of the amputated limb.

Mirror therapy is an alternative approach to treating typical phantom pain seen in the clinic. Mirror therapy is premised on the idea that vision and sensorimotor interactions can alter phantom limb perception. By creating a mirror image that represents the missing limb, artificial visual feedback can be generated through the visible transposition of the intact limb’s movement to the amputated side (Desmond et al. 2006).

Mirror therapy is appropriate for adult clients (>18 years) who have acquired a limb loss and are experiencing phantom limb pain. The typical approach to mirror therapy involves placing one limb behind a mirror that is situated along the client’s midline while performing synchronous movement tasks with the intact and phantom limbs. When a client views their limb through the mirror, it may feel as though the phantom has ‘come alive’ and the illusions or imagery of movement of the amputated limb might increase motor control over the phantom which may alleviate the phantom limb pain.

### Focused clinical question:
What is the evidence showing mirror therapy to reduce phantom limb pain in adult clients post-amputation?

### SUMMARY of Search, ‘Best’ Evidence’ appraised, and Key Findings:
10 databases were searched and 5 articles were located that met the inclusion/exclusion criteria. 3 were randomized controlled trials (Chan et al. 2007; Moseley, 2006; Brodie et al. 2007) and 2 were case studies (Darnell, 2009; MacLachlan et al. 2004). Reference lists of retrieved articles were also searched. The best evidence for mirror therapy was a randomized controlled trial by Chan et al. (2007). Results from Chan et al. are as follows:
- 100% of the participants in the mirror therapy group had a decrease in phantom limb pain level (rated on the 100-mm visual-analogue scale) after 4 weeks of using the mirror to perform exercises in front of.
- The control group which consisted of completing exercises in front of an opaque covered mirror had 17% of the group report a decrease in pain whereas 50% reported an increase in pain after 4 weeks of performing this treatment method (rated on the 100-mm visual-analogue scale).
- The comparison group consisted of completing mental-visualization techniques. In this group, 33% of the participants reported a decrease in pain after 4 weeks while 67% of the group reported an increase in phantom pain on the 100-mm visual-analogue scale.
- After the first 4 weeks, both the control and comparison group switched to mirror therapy for the second 4 weeks of the study. Results concluded that phantom pain decreased in 89% of the participants that made this switch.
CLINICAL BOTTOM LINE:
There is some evidence suggesting mirror therapy to be a successful alternative approach to treating lower limb phantom pain in adult clients post-amputation.

Limitation of this CAT: This critically appraised paper has been individually prepared as a part of a university project, reviewed and marked by a faculty member, but has not been externally peer-reviewed. It is not an exhaustive review of all literature research nor was it prepared by an expert on this topic.

SEARCH STRATEGY:

Terms used to guide Search Strategy:

- **Patient/Client Group**: Upper limb/upper extremity amputation, lower limb/lower extremity amputation, phantom pain, phantom limb pain
- **Intervention (or Assessment)**: Mirror therapy, mirror treatment, virtual limb
- **Comparison**: Nil
- **Outcome(s)**: Reduced phantom limb pain, decreased phantom limb pain

<table>
<thead>
<tr>
<th>Databases and sites searched</th>
<th>Search Terms</th>
<th>Limits used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medline-OVID</td>
<td>Mirror therapy, amputation</td>
<td>Focus on phantom limb with sub-headings ‘therapy’ and ‘rehabilitation’, English language, Peer-reviewed</td>
</tr>
<tr>
<td>CINHAL</td>
<td>Mirror therapy, mirror treatment, phantom pain, amputation, upper limb amputation, upper extremity amputation, lower limb amputation, lower extremity amputation.</td>
<td></td>
</tr>
<tr>
<td>Web of Science</td>
<td>Mirror therapy, mirror treatment, phantom pain, phantom limb pain</td>
<td></td>
</tr>
<tr>
<td>ERIC (FirstSearch)</td>
<td>Mirror therapy, mirror treatment, phantom pain, phantom limb pain</td>
<td></td>
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<tr>
<td>OT Search</td>
<td>Mirror therapy, mirror treatment, phantom limb</td>
<td></td>
</tr>
<tr>
<td>Cochrane Database</td>
<td>Mirror therapy, phantom pain, amputation</td>
<td>English language</td>
</tr>
<tr>
<td>Cochrane Library</td>
<td>Mirror therapy, phantom pain</td>
<td></td>
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<tr>
<td>EBM Rev Multifile</td>
<td>Mirror therapy, amputation, virtual limb, phantom pain</td>
<td></td>
</tr>
<tr>
<td>PEDro</td>
<td>Mirror therapy “mirror therapy for phantom pain”</td>
<td></td>
</tr>
<tr>
<td>Science.gov</td>
<td>Mirror therapy, phantom pain, amputation, phantom limb pain, virtual limb</td>
<td></td>
</tr>
</tbody>
</table>
INCLUSION and EXCLUSION

- **Inclusion:**
  - Participants were adults (>18 years)
  - Studies published in English
  - Studies which were peer-reviewed
  - Studies that investigated mirror therapy as an intervention for adults with upper or lower limb amputations
  - Studies with participants who had an amputation due to traumatic injury

- **Exclusion:**
  - Participants < 18 years old
  - Studies that investigated mirror therapy with other diagnosis
  - Studies published in languages other than English
  - Studies with participants who had an amputation due to a congenital disorder

RESULTS OF SEARCH

5 relevant studies were located and categorised as shown in Table 1 (based on Levels of Evidence, Centre for Evidence Based Medicine, 1998)

**Table 1:** Summary of Study Designs of Articles retrieved

<table>
<thead>
<tr>
<th>Study Design/ Methodology of Articles Retrieved</th>
<th>Level</th>
<th>Number Located</th>
<th>Author (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic reviews or meta Analysis of randomized controlled trials</td>
<td>1a</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
| Individual randomized control trials                                 | 1b    | 3              | 1. (Chan, Witt, Charrow, Magee, Howard, Pasquina, Heilman, & Tsao, 2007)  
2. (Brodie, Whyte, & Niven, 2007)  
3. (Moseley, 2006) |
| Systematic reviews of cohort studies                                 | 2a    | 0              |                                                   |
| Individual cohort studies and low quality RCT’s                      | 2b    | 0              |                                                   |
| Systematic review of case control studies                            | 3a    | 0              |                                                   |
| Case-control studies and nonrandomized controlled trials             | 3b    | 2              | 1. (Darnell, 2009)  
2. (MacLachlan, McDonald, & Waloch, 2004) |
| Case-series and poor quality cohort and case-control studies         | 4     | 0              |                                                   |
| Expert opinion including literature/narrative reviews                | 5     | 0              |                                                   |
BEST EVIDENCE
The following study by Chan, Witt, Charrow, Magee, Howard, Pasquina, Heilman, & Tsao (2007) was identified as the ‘best’ evidence and selected for critical appraisal. Reasons for selecting this study were:

- The study is the most recent RCT (2007) found and was published in the *New England Journal of Medicine*, a well-respected high quality journal.
- One of highest levels of evidence found from research.
- This study focused on the clinical question and compared mirror therapy to the control (covered mirror) and a mental-visualization treatment (comparison group) on adults with lower limb amputations only.

SUMMARY OF BEST EVIDENCE

**Table 2:** Description and appraisal of randomized controlled trial by Chan et al. (2007)

<table>
<thead>
<tr>
<th>Aim/Objective of the Study:</th>
<th>To assess whether or not mirror therapy successfully reduces phantom limb pain in patients who have phantom pain after the amputation of a leg or foot.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Design:</td>
<td>This study is a randomized controlled trial (RCT) which randomly assigned 22 patients to one of three groups: one that viewed a reflected image of their intact foot in the mirror (mirror group), one that viewed a covered mirror (control group), and one that was trained in mental visualization (comparison group). Blinding and allocation concealment was not addressed in this study. The outcome (phantom pain level) was measured at baseline and during each of the 8 weeks of the study. No follow-up measurement was stated.</td>
</tr>
<tr>
<td>Setting:</td>
<td>Location of this study is unknown other than it was performed in the United States of America by professionals from Walter Reed Army Medical Center (Washington, MD), Malcom Randall Veterans Affairs Medical Center (Gainesville, FL), and the Uniformed Services University of the Health Sciences (Bethesda, MD).</td>
</tr>
<tr>
<td>Participants:</td>
<td>The sample originally consisted of 22 military patients who had phantom limb pain after amputation of a leg or foot, however only 18 of these patients/participants completed the study. The participants were randomly assigned into one of three groups (6 in each group). No further characteristics of these participants were included in the study.</td>
</tr>
<tr>
<td>Intervention Investigated:</td>
<td><strong>Control:</strong> The control group consisted of 6 participants who performed movements with their intact and amputated lower limbs while viewing a mirror that was covered by an opaque sheet. These participants performed this treatment for 4 weeks and then transferred to mirror therapy for the final 4 weeks of the study. The amount of hours and days per week they were engaged in performing these exercises was not stated, and the actual physical movements and the amount of repetitions performed was not included in this article.</td>
</tr>
<tr>
<td></td>
<td><strong>Experimental:</strong> The experimental group consisted of 6 participants who performed movements with the amputated limb while viewing the reflected image of their intact limb in a mirror. These participants continued this treatment approach for the full 8 weeks. The amount of hours and days per week they were engaged in performing these exercises was not stated, and the actual physical movements and the amount of repetitions performed was not included in this article.</td>
</tr>
</tbody>
</table>
**Comparison:** The comparison group consisted of 6 participants who engaged in mental-visualization by closing their eyes and imagining themselves performing movements with their amputated limb. These participants performed this treatment for 4 weeks and then transferred to mirror therapy for the final 4 weeks of the study. The amount of hours and days per week they were engaged in performing this exercise was not stated.

This study’s authors did not state whether they or other professionals provided these treatments, and it is unclear as to where these treatments took place, but it is presumed that treatments took place at Walter Reed Army Medical Center by the authors of this study.

**Outcome Measures:** The outcome measure for this study was phantom pain level and it was measured by the 100-mm visual analogue scale. The 100-mm visual analogue scale is a common scale used in measuring pain levels from 0-100 (“0” meaning the absence of pain, and “100” meaning highest pain level possible) and is presumed to be valid and reliable although this study does not emphasize the validity or reliability of the scale. Of the 5 studies I retrieved and analysed, all used either a 100-mm visual-analogue scale or a 0-10 visual-analogue scale to rate the phantom limb pain intensity because visual-analogue scales are the standard outcome measure for pain level. This measure was administered at baseline and after each of the 8 weeks of the study and is done by each participant rating their own level of pain to the study administrator at the end of each week.

**Main Findings:** The following graph shows the changes in phantom limb pain, as measured on a 100-mm Visual-Analogue Scale. The dotted lines represent the weeks during which patients in all three groups used mirror therapy. Data points show medians.

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**Baseline scores on visual-analogue scale:** Similar among all groups (P=0.62)

After 4 weeks of prescribed treatment:

**Mirror group:**
- 100% of participants reported a decrease in pain (median change on visual-analogue scale: -24mm; range: -54 to -13).
- 2 participants had brief reactions (<2 minutes) of grief upon viewing reflected intact limb.

**Covered mirror group (control):**
- 1 participant (17%) reported decrease in pain.
- 3 participants (50%) reported worsening pain.
**Mental-visualization group (comparison):**
- 2 participants (33%) reported decrease in pain.
- 4 participants (67%) reported worsening pain.

4 week comparison of mirror therapy to control and comparison group:
- Mirror group compared to covered mirror group: P= 0.04
- Mirror group compared to mental-visualization group: P= 0.02

Comparison of scores on a visual-analogue scale at 4 weeks from those at 8 weeks (after all groups switched to mirror therapy at week 4):
- Phantom limb pain decreased in 8 of 9 (89%) of participants who switched to mirror therapy after either a covered mirror or mental-visualization group.
- P=0.008 for both comparisons

**Original Authors' Conclusions:** “Findings show that mirror therapy reduced phantom limb pain in patients who had undergone amputation of lower limb. Such pain was not reduced by either covered-mirror or mental visualization treatment. Pain relief due to treatment may be due to the activation of mirror neurons in the hemisphere of the brain that is contralateral to the amputated limbs. These neurons fire when a person either performs an action or observes another person performing an action. Alternatively, visual input of what appears to be movement of the amputated limb might reduce the activity of systems that perceive protopathic pain. Although the underlying mechanism accounting for the success of this therapy remains to be elucidated, these results suggest that mirror therapy may be helpful in alleviating phantom pain in an amputated lower limb” (p. 2207).

**Critical Appraisal:**

**Validity:** This study reviewed relevant background literature and justified the need for this study. The design was appropriate for the question being studied and ethical procedure was described, however, this study offered limited information about the overall design.

**PEDro Score:** 3/10
- This study scored points for random allocation, between-group comparisons, and point estimates and variability.
- This study did not score points for concealed allocation, baseline comparability, blind subjects/therapists/assessors, adequate follow-up, and intention-to-treat analysis.

**Potential biases:**
- Participants are patients, however it is not known if they were volunteers or referred to this study.
- No information is giving on whether or not the participants were also receiving medicine or any other treatment at this time.
- The assessors of this study and their educational background were not stated.
- It is unclear as to where these three treatment groups took place.
- Characteristics of participants were not described and their baseline comparisons are unknown.
- Study did not explain why 4 participants dropped out or how they handled this situation.
- Study did not state subject inclusion/exclusion criteria.
- Interventions were not described in detail and cannot be 100% replicated because the physical movements and mental-visualizations performed were not stated or described.
Interpretation of Results: The results of this study were positive and showed 100% of the mirror therapy group to have a reduced level of pain after the treatment and that 89% of the control and comparison group that later switched to mirror therapy had a reduced level of pain. These results are also supported by 3 of the 4 other studies that were analysed while gathering findings on this topic. This study supports the use of mirrors to treat phantom limb pain as an alternative treatment approach, however this study has failed to inform its readers potential sources of bias and was rated a 3/10 on the PEDro scale which weakens the overall results.

Summary/Conclusion: Although this study has many limitations due to biases, these findings suggest that mirror therapy is a promising approach in reducing lower-limb phantom pain in adult clients with an amputated leg or foot. This study’s findings also suggest that mental-visualization techniques and performing exercises in front of a covered mirror may produce a higher level of phantom pain. Further studies are recommended and should include randomized controlled trials that also control for potential biases.

Table 3: Characteristics of included studies

<table>
<thead>
<tr>
<th>Study 1- RCT (Brodie et al., 2007)</th>
<th>Study 2- Case study (Darnell, 2009)</th>
<th>Study 3- Case Study (MacLachlan et al., 2004)</th>
<th>Study 4- RCT (Moseley, 2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention investigated</td>
<td>Mirror therapy for lower limb phantom limb pain, sensation, and movement. Participants placed intact leg into a mirror box and viewed mirror image of intact leg while carrying out 10 movements that were each repeated 10 times with both the phantom and the intact limb.</td>
<td>Self-delivered home-based mirror therapy for lower limb phantom pain. Participant followed a largely unstructured exercise protocol he designed by himself which included exercising his intact foot and watching the movements in the mirror.</td>
<td>The effects of mirror treatment on a person experiencing distressing lower limb phantom pain. Participant completed 10 different exercises 10 times each seated in front of mirror. Treatment protocol was performed in the clinic with a therapist and in participant’s home on his own.</td>
</tr>
<tr>
<td>Comparison intervention</td>
<td>Comparison group participants performed the same exercises that the mirror therapy group performed 10 times each while intact leg and phantom leg</td>
<td>Nil</td>
<td>Nil</td>
</tr>
</tbody>
</table>
| | | A 6 week physiotherapy treatment program while maintaining usual medical care. Treatment was once a week and included a
was placed to either side of the mirror box mirror while it was obscured. This allowed the participants to view the intact limb but not its mirror image.

<table>
<thead>
<tr>
<th>Outcomes used</th>
<th>Pain level, sensation, and limb awareness was measured by the <strong>Visual Analogue Scale</strong>, <strong>The McGill Pain Questionnaire</strong>, <strong>The Total Pain Ranking Index Score</strong>, and verbal descriptions of changes in the phantom limb. Measurements were taken before, during, and after intervention.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phantom pain was scored on a 0-10 <strong>Visual Analogue Scale</strong>, and the impact of pain level on mood, work, and sex was assessed by the participant’s <strong>brief pain inventory on a scale of 0-10</strong>. These measures were taken pre, post, and after a 4 month follow-up.</td>
</tr>
<tr>
<td></td>
<td>Phantom pain and stump pain was rated on a scale from 1-10, and control over the phantom limb was rated from 0-100%. Indication of phantom limb position was done by verbal report. These measurements were taken during the afternoon of the first session when pain was highest, and after the third and final week of treatment.</td>
</tr>
<tr>
<td></td>
<td>Pain and function were measured pre, post, and follow-up after 6 months. Estimated functional level of participants was done prior to randomization and included The <strong>Patient-Specific Task-Related Numerical Rating Scale (NRS)</strong> which rated current performance ability on a scale of 0-10 on 5 regularly performed tasks that they find difficult due to pain. <strong>The McGill Pain Questionnaire (MPQ)</strong> was completed in regard to current pain level, and the <strong>Visual Analogue Scale</strong> was completed for pain intensity and referred to level of pain over the previous 2 days. <strong>Clinical assessments</strong> that recorded symptoms and signs of hyperalgesia and allodynia of the stump, and symptoms of swelling and temperature in the limb, and symptoms of...</td>
</tr>
</tbody>
</table>
Findings

Viewing a virtual limb through the mirror while moving both the phantom limb and the intact limb did not attenuate phantom limb pain and sensations any more than the control condition, however viewing the virtual limb increased the ability to be aware of and to move the phantom limb.

Participant showed 100% change in pain, mood, work, and sex after engaging in mirror therapy. Study suggests that the frequency and duration of practice may be variables of greater importance than following a structured protocol of exercises. The success of this study implies that patient-delivered home-based mirror therapy may be a promising approach.

Mirror therapy reduced the participant’s phantom pain from a pain level ranging from ‘5-9’ during the first week to a pain level of ‘0’ after the third week and helped the participant experience a greater sense of control over his lower limb. This study also demonstrated that increased control over the phantom can be associated with a reduction in phantom limb pain. This study supports the possible value of mirror treatment but it cannot indicate the extent to which beneficial effects are due to.

Graded motor imagery reduced pain and disability in participants with CRPS1, phantom limb pain after amputation, and brachial plexus avulsion injuries. How progressive motor imagery reduced pain and disability is unknown and further studies are needed to replicate this study’s data and elucidate the mechanisms involved.

IMPLICATIONS FOR PRACTICE, EDUCATION and FUTURE RESEARCH

- This study has limitations in methodology, intervention, and sample biases; however it represents the highest level of evidence on the effectiveness of mirror therapy on lower limb phantom pain due to an amputation of a leg or foot.
- Mirror therapy is a low-cost treatment. A full-length mirror (4ft x 1.5ft) can be purchased from almost any store for under $10.00.
- Mirror therapy as a home program for a patient is also a promising possibility. Two of the five articles analysed but not included in this CAT were case studies that used mirror therapy as a home-based program. These studies found using a mirror at home to view and move the amputated limb decreased phantom limb pain (Darnell (2009) & MacLachlan et al. (2004)).
- Any therapist should be able to use a mirror therapy approach to treat a patient experiencing phantom limb pain without much extra educational training. If a therapist is educated in amputations, phantom pain, proper exercises to perform with the correct amount of repetitions, and understands the reasoning behind why viewing a reflection of the intact leg may help decrease pain, then the therapist should be able to start this intervention with a patient.
- Using a mirror therapy approach to reduce phantom limb pain in upper extremity amputations is also a possibility and should be further looked into.
- Using a visual-analogue scale to measure the patient’s pain level is a quick and easy outcome measure.
• Details of the mirror therapy exercises were not included in the Chan et al. study. However, two articles that were analysed and listed in Table 3 followed an exercise protocol in front of the mirror which showed positive results. The following 10 exercises were to be completed 10 times each (Brodie et al. (2003); MacLachlan (2004)).
  1. Slowly straighten knee and then bend your legs at the knee at the same time.
  2. Slowly straighten and then bend your legs at the knee alternatively as if walking.
  3. Point your feet upward, and then point your feet downwards at the same time.
  4. Turn your sole in towards each other and then away from each other at the same time.
  5. Move your feet around in a circle to the left and to the right.
  6. Lift your feet off the ground in a walking movement.
  7. Point your toes upwards and then downwards while trying to keep your ankle and foot still.
  8. Clench and unclench your toes.
  9. Spread your toes and then relax them.
 10. Point up your big toes and point down the other toes, then reverse it so that your big toe is pointing down and your other toes are pointing up.

REFERENCES


