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Original Research

Comparison of Relative Benefits of Mirror Therapy and Mental Imagery in Phantom Limb Pain in Amputee Patients at a Tertiary Care Center

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KEYWORDS
Phantom limb;
Rehabilitation

Abstract *Objective:* To determine the relative benefit of mirror therapy and mental imagery in phantom limb pain.
Design: Prospective randomized controlled trial.
Setting: Physical Medicine and Rehabilitation Department, All India Institute of Medical Sciences, Patna.
Participants: Amputees (N=92) with no significant difference in baseline characteristics. There was a male predominance in both groups (mirror therapy: 36 men, 10 women; mental imagery: 37 men, 9 women).
Intervention: Patients of both groups underwent a conventional amputee rehabilitation program and daily treatment of either mirror therapy or mental imagery on a regular basis, first in a rehabilitation care unit and later at home.
Main Outcome Measures: Phantom limb pain (PLP) was measured by visual analog scale (VAS) score at baseline (0) and at 4, 8, and 12 months.
Results: This study included 92 patients ranging in age from 12 to 75 years (average, 34.79y). There was no significant difference in VAS score between the groups at baseline, but we found a significant reduction of pain in both groups at follow-up. However, upon comparing the improvement in both groups, we determined that the mirror therapy group had better improvement (from 7.07±1.74 to 2.74±0.77) compared with the mental imagery group (from 7.85±0.76 to 5.87±1.41).

List of abbreviations: PLP, phantom limb pain; VAS, visual analog scale.
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Conclusions: Mirror therapy and mental imagery are both good and cost-effective rehabilitation aids for amputee patients to reduce PLP, but mirror therapy appears to be more effective than mental imagery.

Throughout history, phantom limbs have attracted the attention of researchers and prompted numerous investigations to define the phantom phenomena and understand why it occurs. Painful sensations in the absent limb are defined as phantom limb pain (PLP). Any sensation other than pain in the absent limb is defined as phantom sensation.[1,2] The prevalence of PLP is approximately 60% to 80%.[3] PLP is very distressing for an amputee, particularly when informed about its likely presence before amputation.[4] Immediately after surgery, pain in the residual limb is usually expressed as a "stabbing," "shocking," or "burning" and is reported to occur at the lower end of the residuum, close to the scar.[5] Sometimes the pain intensity experienced in the residuum far exceeds any stimulation. This residual limb pain is described as a "nerve storm," and spontaneous movement, cold surface temperature, sweating, and reduced blood flow to the stump are characteristics.[6]

Stump examination frequently reveals pathology that may be related to the pain. This may include skin pathology, infection, bone spurs, or neuroma. There is an association between stump pathology and increased PLP.[1] When PLP and pain in the residual limb are present, their nature are usually similar and intensity can covary.[7,8]

However, it is to be noted that both phantom limb and phantom pain are present in many amputees who do not have obvious stump pathology.[1,9]

Intensity

According to studies, only 0.5% to 5% of all amputees felt "severe" PLP.[10-12] These figures contrast with a study of 2694 amputees, which reported that 51% experienced PLP "severe" enough to hinder lifestyle more than 6 days per month.[13] Twenty-seven percent of this sample experienced PLP for more than 15 hours every day; another 21% reported daily pain during a 10- to 14-hour period. Clearly, differences in the definition of "severe" PLP account for the differences among these studies. The literature discussing the intensity of PLP is difficult to evaluate because many reports are case studies that do not describe how PLP is measured or describe how PLP is measured but the sample population comprises only those seeking treatment for their pain.[5,7,11,14-26] One study assessed pain using the McGill Pain Questionnaire and found that PLP is similar in intensity to chronic low back pain, nonterminal cancer pain, and labor pain.[27]

Localization

PLP is also primarily localized to the distal part of the missing limb. Phantom pain is usually felt in the fingers, palm of the hand, and occasionally the wrist in the case of upper limb amputees and is normally experienced in the toes, ball of the foot, top of the foot, and ankle in lower limb amputees.[13,28-31] There is a possibility that the changes in receptive fields and cortical reorganization observed after limb amputation are related to both PLP and phantom sensation.[3]

Duration

The duration of PLP may vary from patient to patient and may range from 2 to 30 years according to different studies.[7,13,28,32] In a study conducted by Sherman et al,[13] 44% of patients reported that their phantom pain had not diminished over a 30-year period. Latter studies were also carefully conducted but differed from those of Parkes[7] and Jensen et al[28] in a number of ways, namely variation in the study populations. Studies that reported a decline in pain in the first 2 years postamputation, primarily described elderly amputees. Differences in the research design of these studies also limit comparisons. Both Parkes and Jensen et al conducted prospective studies, collecting data at several time points during a 2-year period, whereas both Hill and Sherman et al[13] performed retrospective studies, meaning that they collected data at only 1 timepoint.

Quality

The 2 most common descriptions applied to PLP are "burning" and "cramping." Other terms used include "numb," "smarting," "stinging," "throbbing," "piercing," and "tearing."[15,28,30,33-38]

The evaluation of quality associated with PLP is difficult because of differences in methods used to generate the descriptors. In many cases, patients had spontaneously reported their PLP. In others, the clinician, who was usually familiar with the literature, prompted the patients (eg, "Is it a burning pain?"). Some studies provided a list of responses from which the patient selected those that are appropriate.[34] These studies are also difficult to evaluate, as the lists vary from study to study. In addition, many of these studies include patients seeking treatment for their pain, and the resulting description may not be applicable to the general amputee population. Finally, PLP may change over time. In some of the above studies, patients were sought for immediate postamputation pain, whereas in others, the patient may have been experiencing PLP for many years.[36,37,39] Many patients reported similarity in pre and postamputation pain, in terms of both quality and location. For example, in a study of somatosensory pain memories, Katz and Melzack[31] noted that amputees

Table 1 Variables in the mirror therapy and mental imagery groups

Variables	Mirror Therapy, n (%)	Mental Imagery, n (%)	*P* Value
Age			.249
<20	4 (8.7)	9 (19.6)	
20-30	10 (21.7)	11 (23.9)	
31-40	17 (37)	10 (21.7)	
41-50	10 (21.7)	11 (23.9)	
>50	5 (10.9)	5 (10.9)	
Total	46 (100)	46 (100)	
Mean ± SD	36.70±11.43	33.65±13.61	
Sex			.797
Female	10 (21.7)	9 (19.6)	
Male	36 (78.3)	37 (80.4)	
Total	46 (100)	46 (100)	
Cause			>.99
RTA	25 (54.3)	24 (52.2)	
Burn	8 (17.4)	8 (17.4)	
Tumor	4 (8.7)	5 (10.9)	
DM	3 (6.5)	4 (8.7)	
Infection	3 (6.5)	3 (6.5)	
PVD	3 (6.5)	2 (4.3)	
Total	46 (100)	46 (100)	
Handedness			>.99
R	10 (21.7)	13 (28.3)	
L	36 (78.3)	33 (71.7)	
Total	46 (100)	46 (100)	
Amputated limb			.986
AE	8 (17.4)	8 (17.4)	
AK	10 (21.7)	12 (26.1)	
BE	3 (6.5)	3 (6.5)	
BK	25 (54.3)	23 (50)	
Total	46 (100)	46 (100)	

Abbreviations: AE, above elbow; AK, above knee; BE, below elbow; BK, below knee; DM, diabetes mellitus; L, left; PVD, peripheral vascular disease; R, right; RTA, road traffic accident.

reported similar qualities and experienced PLP in the same location as preamputation pain. This was graphically demonstrated in a case study conducted by Bailey and Moersch,[40] in which a man had undergone amputation 22 years before the study. The patient had an accident that left a painful sliver under his fingernail. One week later, his arm was torn off in a machine accident at work. For 2 years after this accident, the patient experienced pain of the same quality and in the same location as that experienced when he had the sliver under his fingernail. A more recent case study reported an individual who experienced recurrences of pain during dressing of a wound before amputation.[31]

The role of patient characteristics in PLP

Studies of PLP have often presumed that amputees are a homogeneous group. Therefore, knowledge is limited regarding variation within this population.[1,2] Although some studies have reported the relationship between patient characteristics (age, sex, duration of pain, reason for amputation, site of amputation, etc.) and levels of PLP, many have yielded mixed results because of differences in sample selection, sample size, and study methods. Bailey and Moersch[15] reported that the incidence of phantom pain is greater in male amputees compared with female amputees, but other studies did not show any difference.[7,22,28] Similar difficulties can be found in studies investigating the role of age and medical status. For example, Buchannan and Mandel[41] found that older amputees report the presence of PLP more often than younger amputees, but Jensen et al[28] found no such difference. Kashani et al,[42] Kegel et al,[43] Parkes,[7] and Parkes and Napier[44] all report that the presence of concurrent medical conditions, such as arthritis or diabetes, predict increased PLP, whereas Morgenstern[12] contradicted that finding. The evaluation of the literature is difficult because PLP is often inferred rather than measured, and different instruments are used when PLP is measured. For example, Parkes[7] used an interview method, whereas Jensen et al[28] used both interviews and a visual analog scale (VAS) to measure PLP.

Management of PLP

Various treatment options are available for managing PLP such as medicinal management (nonsteroidal anti-inflammatory drugs, antidepressants, anticonvulsants, and local steroid or anesthetics injections), which can be administered separately or in combination with physical modalities such as ultrasound therapy, transcutaneous electrical nerve stimulation, and biofeedback.[45] Previous studies conducted on mirror therapy and mental imagery concluded that there was benefit with both the therapies.

Mirror therapy

Mirror therapy is a low-cost intervention developed by Ramachandran et al in 1995.[46] Mirror therapy is a rehabilitation technique that has shown promise in rehabilitation management. In this technique, a mirror is placed in a position that allows the patient to view a reflection of a body part. Its most common use is to relieve pain whereby the affected painful limb is hidden out of view behind the mirror while the normal limb is placed in front of the mirror so the reflected image can be seen by the patient. Thus, the patient feels that the painful limb, which is out of view, is at same position as the nonpainful limb. The illusion of having 2 intact limbs is felt by the amputee.[47] Mirror therapy can be used as alone or in combination with other techniques. Mirror therapy has been incorporated into therapeutic programs to treat painful conditions resulting from neuropathy and other causes.[48,49] It has also been used to improve functional outcomes after stroke.[50] Mirror therapy is not frequently used to treat chronic pain in India, although some authors have suggested that mirror therapy could be included in a rehabilitation program to modify behavior to improve movement and alleviate pain in different conditions.[47,51,52]

Mental imagery

MacIver et al defined mental imagery as a neuromodulatory treatment.[53] In this technique, the phantom limb is considered as a real part of the body resulting from patient-therapist interaction and interaction between the patient

Table 2 VAS assessment at different study points in the mirror therapy and mental imagery groups

VAS Score	0 month, n (%)	4 months, n (%)	8 months, n (%)	12 months, n (%)	% Difference
Mirror therapy (n=46)					
1-3	2 (4.3)	0 (0)	10 (21.7)	39 (84.8)	84.8
4-6	8 (17.4)	36 (78.3)	28 (60.9)	7 (15.2)	-2.2
7-10	36 (78.3)	10 (21.7)	8 (17.4)	0 (0)	-78.3
Mental imagery (n=46)					
1-3	1 (2.2)	0 (0)	2 (4.3)	3 (6.5)	6.5
4-6	6 (13.04)	10 (21.7)	10 (21.7)	26 (56.5)	56.5
7-10	39 (84.78)	36 (78.3)	34 (73.9)	17 (37)	-63.0
P value	.001*	<.001*	<.001*	<.001*	-

* Chi-square or Fisher exact test.

and his or her bodily images. The MacIver approach is based only on imagined movements without real movement of the residual limb. The rationale for using mental imagery is that it activates similar neural pathways to actual movement by activating the motor and sensory cortices, and hypothesized that, if practiced regularly, it provides sufficient stimulation of the deafferented neurons and potentially alter the reorganization.[54-56]

Methods

A nonblinded prospective randomized controlled trial was conducted with amputee patients admitted to the Physical Medicine and Rehabilitation ward for rehabilitation management. Permission for this study was obtained from the institutional ethics committee between January 2019 and December 2019 at the All India Institute of Medical Sciences, Patna. One hundred amputee patients were included in this study during a 1-year period, and 8 patients dropped out during the study period. Four patients did not meet the inclusion criteria, 3 patients declined to participate, and 1 patient was lost follow up. A total of 92 patients were included in the final study. Assessment of PLP was compared based on VAS score.

Selection criteria

Patients were chosen from patients presenting to the Physical Medicine and Rehabilitation outpatient department and those referred from other departments. We included all patients available during the 12-month recruitment period. The study period was from January 2019 to December 2019, with follow-up at 4, 8, and 12 months. Patients with the following inclusion criteria were selected in this study.[57] The inclusion criteria were (1) amputees with PLP, (2) age older than 12 years and younger than 75 years, (3) ability to communicate in English or Hindi, (4) intact vision, and (5) gave written informed consent. Patients were excluded if they had traumatic brain injury, major psychiatric illness, or sensory deficit, or if they did not give written informed consent.

Intervention

Patients in both groups participated in a conventional amputee rehabilitation program, including flexibility (eg, dynamic and static stretching of major muscle groups), strengthening (eg, concentric and eccentric dynamic exercises such as squats, sit-ups, step-ups, calf raises, and hip abduction, with the optional use of therabands, kettlebells, or dumbbells), dynamic balance (eg, picking up objects from the floor and balancing on a compliant surface), and cardiovascular fitness (eg, cycle ergometer).[58]

Mirror therapy

Each patient in the mirror therapy group had 30 minutes of mirror therapy.[59] Patients were seated close to a table on which a mirror was placed vertically. The normal (ie, nonamputated limb) was placed in front of the mirror and

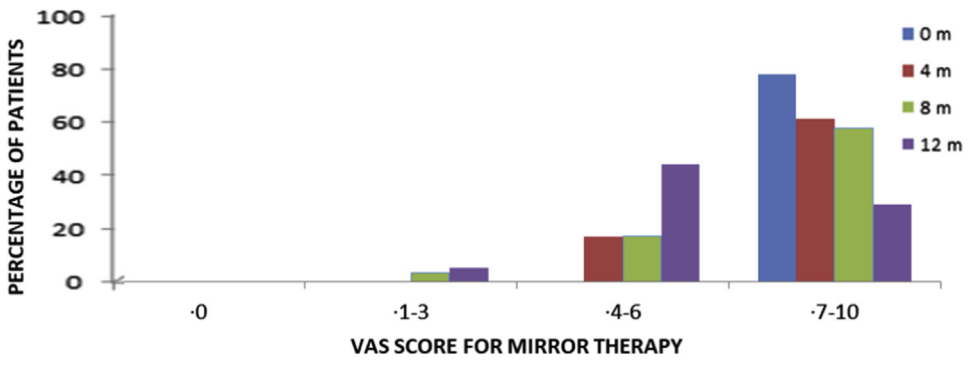

Fig 1 VAS score for mirror therapy.

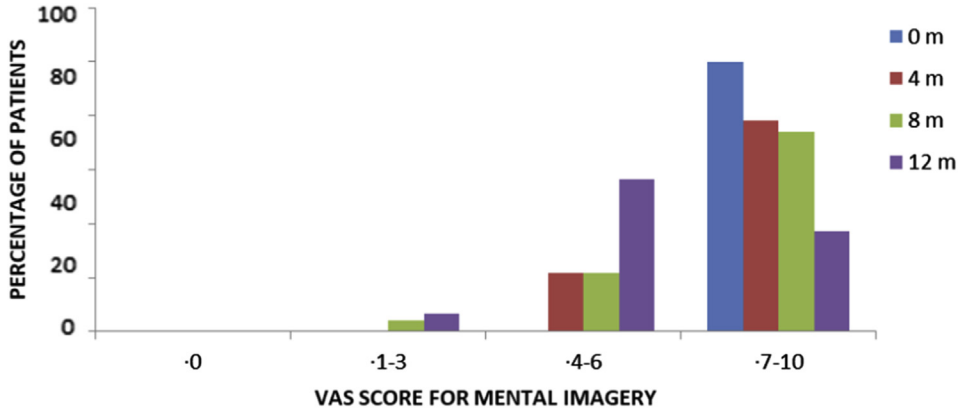

Fig 2 VAS score for mental imagery.

made to perform movements of the different joints while the patient looked into the mirror. Patients were advised to purchase a mirror according to their needs, and discharge was done with the mirror from rehabilitation ward.

Mental imagery

Patients in the mental imagery group were instructed to concentrate on sensations from each area of the body, including the phantom arm and hand. After attaining a state pf relaxation, patients were encouraged to imagine comfortable, thorough movement and sensation in their phantom limb. More specifically, they were advised and encouraged to concentrate on sensations from each part of their phantom limb (eg, imagining the sensation of the foot resting against the couch, whether the limb feels warm or cold, and the position of each finger). Next, they were advised to imagine comfortable, thorough movement and sensation in the phantom limb, such that they could "stretch away the pain," and finally to "allow the fingers and limb to rest in a comfortable position." The actual therapy of "moving" and "feeling" the limb lasted for 5 minutes. Patients were asked to perform 40 minutes of meditation and imagery exercises (personalized to take into account whether the right or left limb had been amputated, but otherwise adhering to a script) and were encouraged to practice daily. Patients in this group were also taught a short, 10-minute form of the meditation and imagery exercise to do by themselves.[53]

All patients received daily treatment on a regular basis, first in the rehabilitation care unit, then at home. Phantom pain intensity was assessed by the VAS on a scale of 0 to 10 points in both the groups at baseline, then at 4, 8, and 12 months.

Statistics

The Student *t* test was used for descriptive analysis, and the chi-square and Fisher exact tests were used to compare means. A *P* value of .05 was considered statistically significant at a confidence interval of 95%.

Results

The patients ranged in age between 12 and 75 years (average, 34.79y), with most being between the ages of 31 and years old. Road traffic accident was most common cause of amputation and right handed males were most commonly affected. Most patients had lower limb amputations, with most of those being amputations below the

Table 3 VAS comparison in the mirror therapy and mental imagery groups

VAS Score	Mirror Therapy	Mental Imagery	Total	*P* Value
Results				
0	7.07±1.74	7.85±0.76	7.46±1.39	.241
4	5.87±0.75	7.24±0.90	6.55±1.07	<.001*
8	4.78±1.63	6.63±1.36	5.71±1.76	<.001*
12	2.74±0.77	5.87±1.41	4.30±1.94	<.001*
Difference				
0-4	1.196	0.609	0.902	-
0-8	2.283	1.217	1.750	-
0-12	4.326	1.978	3.152	-
P value				
0-4	<.001*	<.001*	<.001*	-
0-8	<.001*	<.001*	<.001*	-
0-12	<.001*	<.001*	<.001*	-

* In both group there is change in VAS, but mirror therapy is better.

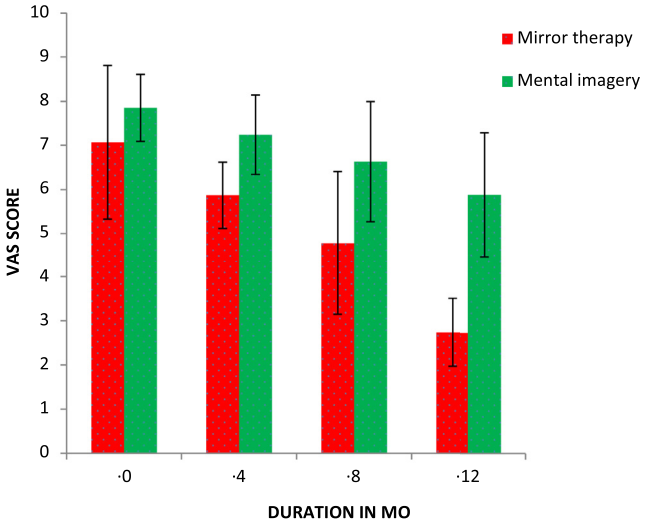

Fig 3 A comparison of VAS in 2 groups of patients studied.

knee (table 1). At baseline, there was no significant difference in VAS score between the groups (table 2, figs 1 and 2), but a significant reduction of pain was observed in both groups at follow-up. When comparing the improvement in both groups, we found that the mirror therapy group demonstrated more improvement (from 7.07±1.74 to 2.74±0.77) (table 3, fig 3).

Discussion

Lower limb amputation was the most common among amputations in this study, and most common cause was trauma. This is similar to the study reported by Sarvestani et al.[60] Ramadugu et al[57] conducted a randomized single crossover trial on 64 amputees and found that there was a significant reduction in PLP in the mirror therapy group at 4 weeks compared with the control group ($P<.0001$). A significant reduction was also observed in the control group also after the switchover. The reduction was sustained for 12 weeks in both groups, and no harm was reported. Similarly, our study also demonstrated that there was significant improvement in PLP in both groups, but crossover was not done owing to long follow-up periods.

In another study, Brunelli et al[61] reported that the mental imagery group showed a significant decrease over time in all of their patients in study population. Between-group analyses showed a significant reduction in intensity (average and worst pain) and interference in activities at the time of the follow-up evaluation. MacIver et al[53] also described that there was reduction in PLP intensity in 13 individuals with upper limb amputation during hand and lip movement after intensive 6-week training in mental imagery. The findings in our current study match those of both of these studies.

Both mirror therapy and mental imagery are inexpensive and effective therapies for amputees. Both therapies are based on cortical reorganization, and both are useful and easily available to patients who are in need of therapy. Both, however, are virtual therapies. Mental imagery depends largely on the patient's mental status; if the patient is calm, it is possible to imagine the necessary things for the therapy to be effective. In this way, mirror therapy may be better, because the patient can feel the limb by visual perception. Mirror therapy works through modulation and excitability of the neural pathway, and by sending the virtual sensation to the cortex, which mimics the normal limb sensation. The effectiveness of mirror therapy has been proven in a study by Foell et al,[62] using functional magnetic resonance imaging.

Study limitations

Limitations of this study included that it was nonblinding, had a small sample size, and did not include a functional component of pain assessment.

Conclusions

Mirror therapy and mental imagery both are good and cost-effective rehabilitation aids for amputee to reduce PLP. However, mirror therapy appeared to be more effective than mental imagery in our study.

Future suggestion

Both mirror therapy and mental imagery can be tried simultaneously. Crossover treatment can also be used to provide better relief to the patients.

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