Mirror therapy for improving motor functions in patients with leprosy with grade 2 disabilities

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Abstract

Background

Mirror therapy has been used to treat phantom limb pain and to improve motor function after stroke. We evaluated the efficacy of mirror therapy in patients with leprosy with paresis.

Methods

Twenty-four patients with leprosy who presented with unilateral grade 2 disabilities were recruited from July 2016 to November 2016 and randomly assigned. Group A, the mirror group, participated in the mirror therapy, and group B, the control group, were treated with a sham therapy. After the interventions, the paretic muscle/limb function, hand coordination abilities, walking, and abilities to perform activities of daily living were reevaluated with the voluntary muscle testing (VMT) at weeks 3, 6, and 12.

Results

In group A, there was an increase in the VMT score from baseline with a median of 2 (interquartile range 0–6) to 3 (2–5) at 3 weeks after initiation of VMT with a further increase to 5 (4–7) at 6 weeks and to 5 (4–8) at 12 weeks, which remained elevated at a median of 6 (5–8) even after 4 weeks after intervention. By contrast, the control group showed the following trend in response to the sham therapy: 2 (1–3) at baseline, 2 (2–4) at 3 weeks after intervention, 3 (3–6) at 6 weeks, 4.25 (3–5) at 12 weeks, and 4 (4–7) at 16 weeks. In group A, VMT scores increased from baseline by 26.9% ($p < 0.001$), 18.02% ($p < 0.001$), and 15.46% ($p < 0.001$) at 3, 6, and 12 weeks, respectively, compared with group B in which VMT scores increased from baseline by 17.13% ($p < 0.001$), 11.02% ($p < 0.001$), and 3.93% ($p > 0.05$) at 3, 6, and 12 weeks, respectively. The muscle strength in mirror group participants improved markedly compared with the control group (post hoc Bonferroni $p = 0.027$).

Conclusion

Mirror therapy is a safe and cost-effective approach in the treatment of paretic limbs of patients with leprosy.

Classification of evidence

This study provides Class IV evidence that mirror therapy improves muscle strength in patients with leprosy associated with paresis.

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→ Class of Evidence

Criteria for rating therapeutic and diagnostic studies

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Leprosy is an important cause of preventable disability. Even after completion of treatment, a large proportion of patients sustain disability from nerve damage, requiring continued care to limit further secondary damage. Deformities seen in leprosy-affected persons range from

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The target in leprosy rehabilitation is to enable the highest functional independence level possible for the individual and to increase the quality of life despite the current limitations.

a mild degree of anesthesia on the hands and/or feet to a very severe degree such as resorption of the fingers and toes, clawing, trophic ulcers, wrist drop, and foot drop rendering them useless for walking. Functional loss in the upper extremity causes difficulty in performing daily living activities.¹ The target in leprosy rehabilitation is to enable the highest functional independence level possible for the individual and to increase the quality of life despite the current limitations. However, conventional treatment methods used for this purpose are insufficient in enabling functional recovery, whereas reconstructive surgeries that are required for maximum possible correction are expensive and already have a tremendous backlog. Their social and financial rehabilitation further adds economic burden to the country, i.e., India.¹

Mirror therapy is a simple, inexpensive, and patient-oriented treatment. It was described initially as a therapeutic modality for the amputee's phantom limb pain² and later was found to be efficacious in the improvement of motor functions of the extremities of patients with stroke.^{3,4} As muscle paresis secondary to leprosy is a prototype of peripheral nerve injury and others⁵ have found the useful role of mirror therapy in a peripheral nerve injury-induced causalgia, we tried to find the efficacy of mirror therapy among patients with leprosy. To date, no study has been conducted to evaluate the role of mirror therapy in patients with leprosy with disabilities.

Methods

This study was conducted at the Outpatient Department of Dermatology, Gauhati Medical College and Hospital, Guwahati, Assam.

Primary research question: Does mirror therapy help in improving the muscle strength in patients with leprosy with paresis?

Participants

A total of 24 patients with leprosy who presented with grade 2 disabilities (World Health Organization grading of disabilities: table 1) were equally divided into 2 groups (figure 1).

Inclusion criteria

Patients with unilateral paresis; unilateral deformities with mobile claw fingers or paralyzed hand or foot drop; and age <60 years.

Table 1 Leprosy: World Health Organization grading system

Hands and feet	
Grade 0	No anesthesia, no visible deformity or damage
Grade 1	Anesthesia present, but no visible deformity or damage
Grade 2	Visible deformity or damage present
Eyes	
Grade 0	No eye problem due to leprosy; no evidence of visual loss
Grade 1	Eye problems due to leprosy present, but vision not severely affected as a result (vision: 6/60 or better; can count fingers at 6 m)
Grade 2	Severe visual impairment (vision worse than 6/60; inability to count fingers at 6 m); also includes lagophthalmos, iridocyclitis, and corneal opacities

Exclusion criteria

Patients with leprosy in reaction (episodes of acute or sub-acute inflammation); patients with bilateral paresis, stiff finger joints or fixed deformities or with joint movement limitations in the healthy upper/lower extremity, or a visual field defect or neglect syndrome; patients who had previously undergone a rehabilitation program; patients on steroids and thalidomide; patients who presented with disabilities resulting from other than reaction or leprosy disease process; patients with diabetes mellitus or any other concomitant immunocompromised states such as HIV or tuberculosis; patients with any disorders affecting the musculoskeletal system; and patients with a history of stroke or any other central neuropathies.

Standard protocol approvals, registrations, and patient consents

The study was approved by the Gauhati Medical College and Hospital Institutional Ethical Committee (No. :MC/217/2016/Pt-I/14). Written informed consent was obtained from all patients (or guardians of patients) who participated in the study (consent for research).

BIAS control and randomization

The following measures were taken to control bias:

1. Single-blinded block randomization using a block size of 2 was performed with the purpose to eliminate bias. For block randomization, the online site randomization.com was used.
2. For matching, 1:1 ratio was used for nearest neighbor propensity score matching, where for each treated individual, we selected the comparison individual with the most similar propensity score, and this was done without replacement, which means that each comparison individual was used as a match only once, and used a greedy algorithm.

The subjects were age, sex matched with identical or comparable to affected site (example for paresis of unilateral lower

Figure 1 Patient flow diagram

limb matched with either side paresis of lower limb) and as far as possible similar duration of paresis and subtype of leprosy.

Statistics

Voluntary muscle test (VMT) improvements were analyzed within the groups using appropriate statistical methods: χ^2 and Kruskal-Wallis one-way analysis of variance (ANOVA) for nonparametric scales and one-way repeated-measures ANOVA for percent changes. When a significant difference was found, post hoc comparisons were performed using a Bonferroni correction. All statistical analyses were performed using SPSS 21. Statistical significance was defined as $p < 0.05$. Data are presented as mean $\pm$ SD or median (interquartile range).

Interventions

Group A

Patients in the mirror group were asked to place their intact limb in front of a vertically placed mirror in the mid-sagittal line and to perform a series of hand movements consisting of wrist and finger/knee/ankle and toe flexion, extension, abduction, and adduction movements (conventional exercise drills delineated by the National Leprosy Eradication Programme, India, followed routinely in Leprosy clinics, table 2)⁶ while viewing the reflected image of their normal limb. Thirty minutes of mirror therapy program a day, in addition to conventional leprosy rehabilitation training circuit, 5 days a week, for 4 weeks was performed.

Group B

The control group was treated with a sham therapy program for the exact duration as that of group A, in addition to the conventional occupational therapy. The sham therapy consisted of the same exercise circuits as delineated for the mirror therapy but was conducted without the mirror so that the timing and muscle loading were similar to those in the mirror group.

After the interventions, the paretic upper and lower extremity function, hand coordination abilities, walking, and abilities to perform activities of daily living were reevaluated with the VMT.

Table 2 Conventional exercise drills delineated by the National Leprosy Eradication Programme (NLEP), India, followed routinely in leprosy clinics

Exercise drill	Targeted nerve/joint
Little finger abduction	Ulnar nerve
Thumb up (pen test)	Median nerve
Wrist up	Radial nerve
Foot up	Lateral popliteal nerve
Spreading of toes	Post tibial nerve
Range of movement: active/passive/flexed	Proximal joints

Voluntary muscle test

The integrity of peripheral motor nerves was examined using a manual muscle strength test according to a standard protocol (Brandsma 1981). Individual scores were recorded for each muscle tested (0–5; 0 = paralyzed and 5 = normal strength): first dorsal interosseus, abductor digiti minimi, abductor pollicis brevis, opponens pollicis, extensor hallucis longus, and peroneus longus and brevis. In the routine examination, at least 2 muscles were tested for each nerve: either 2 distal or 1 distal and 1 proximal, except for tibial nerve distally, medial and lateral plantar branches where evaluation of the muscle may be difficult or impossible; thus making the VMT score from 0 to $5 \times 2 = 0–10$ (in the case of tibial nerve, VMT range 0–5). Individual muscle groups in each patient were subdivided into 3 categories at entry: those initially paralyzed (a motor score of 0), those initially paretic (a motor score of 1–4), and those functioning normally (a motor score of 5).

A patient was diagnosed as having motor impairment if the VMT score for any muscle is less than 4 on the 0–5 modified Medical Research Council scale.

Data availability

Any data not published within the article will be shared by request from any qualified investigator.

Results

The demographics of both groups are depicted in table 3. Total nerves involved were 16 (total number of muscles = 27) in the mirror group and 17 (total number of muscles = 30) in the control group ($p = 0.81$ for quanta of nerves involved and $p = 0.58$ for the number of muscles involved).

The median VMT score at the start of the study was 2 (1–3) in the control group and 2 (0–6) in the mirror therapy group ($p = 0.054$). An average improvement of 5.03% per week was noted in the mirror group compared with 2.67% per week in the control group ($p = 0.64$). There were more patients

without recovery in the control group (5/12, 41.67%) than in the mirror group (2/12, 16.67%) with $p = 0.18$.

Mirror group

There was a significant increase in the VMT score from baseline with a median of 2 (0–6) to 3 (2–5) at 3 weeks after initiation of VMT with a further increase to 5 (4–7) at 6 weeks and to 5 (4–8) at 12 weeks, which remained elevated at a median of 6 (5–8) even after 4 weeks after intervention (table 4 and figure 2). The VMT scores increased from baseline by 26.9% ($p < 0.001$) at 3 weeks. These values further increased by 18.02% ($p < 0.001$) and 15.46% ($p = 0.005$) at 6 weeks (midpoint) and at 12 weeks (end of training), respectively, and remained elevated above their baseline values at follow-up 4 weeks later (ANOVA, $p < 0.001$).

Control group

The following trend in response to the sham therapy was observed: 2 (1–3) at baseline, 2 (2–4) at 3 weeks after intervention, 3 (3–6) at 6 weeks, 4.25 (3–5) at 12 weeks, and 4 (4–7) at 16 weeks (table 4). The VMT scores increased from baseline by 17.13% ($p < 0.001$) at 3 weeks. These values further increased by 11.02% ($p < 0.001$) and 3.93% ($p = 0.30$) at 6 weeks (midpoint) and at 12 weeks (end of training), respectively, and remained elevated above their baseline values at follow-up 4 weeks later but were not statistically significant (ANOVA, $p = 0.42$).

Comparative analysis between the 2 groups

Following the trend of improvement in the 2 limbs of the study, it was found that the VMT scores, according to the Kruskal-Wallis H test, were higher in the mirror group with a p value of 0.043, $\chi^2 = 6.17$, at 3 weeks after intervention; $p = 0.019$, $\chi^2 = 7.91$, at 6 weeks; $p = 0.014$, $\chi^2 = 8.52$, at 12 weeks after intervention, and finally $p = 0.0003$, $\chi^2 = 16.17$, at 16 weeks. The percent increment in VMT scores in the mirror group was considerably higher than that in the control group (post hoc Bonferroni $p = 0.027$, 95% confidence interval of this difference: from –0.9994 to –0.5406).

Table 3 Demographic profile

	Mirror group (patient number = 12)	Control group (patient number = 12)	<i>p</i> Value
Male/female	8/4	9/3	0.65
Age (y)	40.23 ± 12.97	39.11 ± 12.53	0.83
Disability duration (wk)	78.62 ± 36.79	83.25 ± 34.91	0.75
No. of nerves involved (clinically with gross impairment/paralysis/clawing)	16 (1.33 ± 0.49)	17 (1.42 ± 0.67)	0.81
No. of muscles examined/involved (motor score)	27 (2.25 ± 1.06)	30 (2.5 ± 1.09)	0.58
Tuberculoid (TT) leprosy	9	10	0.62
Borderline tuberculoid (BT) leprosy	6	7	0.68
Mid-borderline (BB) leprosy	1	0	0.30

Table 4 Improvement in the VMT score over the study duration

	Mirror group	Control group	p Value
VMT score at baseline	2 (0–6)	2 (1–3)	0.054 ^a ($\chi^2 = 5.83$)
VMT score at 3 wk	3 (2–5)	2 (2–4)	0.043 ^a ($\chi^2 = 6.17$)
VMT score at 6 wk	5 (4–7)	3 (3–6)	0.019 ^a ($\chi^2 = 7.91$)
VMT score at 12 wk	5 (4–8)	4.25 (3–5)	0.014 ^a ($\chi^2 = 8.52$)
VMT score at 16 wk (the 4-wk follow-up)	6 (5–8)	4 (4–7)	0.0003 ^a ($\chi^2 = 16.17$)
Percent change in VMT from baseline to 3 wk	26.9 ± 13.8	17.13 ± 12.6	0.007 ^{b,c}
Percent change in VMT from baseline to 6 wk	44.92 ± 18.4	28.15 ± 15.6	0.0001 ^{b,c}
Percent change in VMT from baseline to 12 wk	60.36 ± 20.3	42.08 ± 19.7	0.001 ^{b,c}
Percent change in VMT from baseline to 16 wk	63.80 ± 22.6	48.91 ± 21.8	0.014 ^{b,c}

^a p Value from Kruskal-Wallis (H) one-way analysis of variance (ANOVA).

^b p Value adjusted for 4 multiple comparisons.

^c p Value from ANOVA.

The only observed adverse event was back pain in group A participants (n = 5) and group B participants (n = 4). This was a low-severity adverse event in that it resolved after taking an aceclofenac tablet.

This study showed that mirror therapy combined with conventional rehabilitation in patients with leprosy with disabilities provides additional benefit in terms of motor improvement of extremities.

Discussion

The total number of leprosy new grade 2 disabilities (G2D) is 11363, and India accounts for almost 50% of cases. Future projections of the global leprosy burden show that in 2020, there would be an estimated 1 million people with G2D.⁷ Multiple deformities not only result in biomedical but also psychosocial and financial consequences, which also extend beyond affected persons to influence their families, society, and country as well.⁸

This study showed that mirror therapy combined with conventional rehabilitation in patients with leprosy with disabilities provides additional benefit in terms of motor improvement of extremities. There was statistically significant improvement on VMT of group A.

Figure 2 Comparison of voluntary muscle test (VMT) scores in the control and mirror groups over 16 weeks

TAKE-HOME POINTS

- Mirror therapy is a simple patient-oriented treatment, which has been found useful in treating the amputee's phantom limb pain and in the improvement of motor functions of the extremities of patients with stroke.
- Mirror therapy is a safe and cost-effective rehabilitation approach in the treatment of paretic limbs of patients with leprosy.

We believe that the mirror therapy's successful effects, which have played a role in patients having stroke and phantom limb pain, may also have played a role in the improvement of VMT functions of the patients with leprosy. The mirror illusion may prevent or reverse a learned nonuse of the paretic extremity as the visual image of the paretic limb is perceived similarly to the patient's own moving limb.⁹ Furthermore, mirror therapy may stimulate motor recovery directly by modulating cortical excitability. The movements in front of a mirror are thought to trigger neuronal connections in the relevant motor cortex, and functional MR images have supported this hypothesis.^{9–11} Activation shift, i.e., cerebral activation pattern in the area of the precuneus due to the visual mirror illusion is a determinant for efficacy of mirror therapy.¹² As this study showed significant improvement in VMT of paretic limbs of patients with leprosy with the use of mirror therapy, we believe that patients having limb paresis due to other causes of peripheral neuropathy might be benefited with this simple, inexpensive patient-directed mirror therapy.

Study limitations include the small sample size. In addition, we could not use more sophisticated tools and parameters such as functional MRI, motor and somatosensory evoked potentials, and functional near-infrared spectroscopy of the mirror illusions to study the changes occurring in the brain hemisphere during the therapy because of financial and resources constraint. Further in-depth randomized trials including a large number of patients are needed to clarify whether and to what extent just observation of a mirrored image, and the restoration of the sensorimotor integration and neuronal connections, plays a role in improvement of VMT.

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Disclosure

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Appendix Author contributions

Name	Location	Role	Contribution
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Manoj Pawar, MD	MVP's Dr. Vasantrya Pawar Medical College, Nashik, India	Author	Analysis of data, major part of manuscript writing, and critical revision of the manuscript for important intellectual content.

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