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Use of Robotic Assisted Mirror Therapy for Hand Rehabilitation in Post-stroke Patients: A Narrative Review of Literature

Hemanshi N. Vekariya[1], Vivek H. Ramanandi[2], Rumana Khatun A. Pathan [3], Roshni G. Kachhadiya [4]

[1,3,4]Post graduate Student, SPB Physiotherapy College, Veer Narmad South Gujarat University, Surat, India.
[2]Associate Professor, SPB Physiotherapy College, Veer Narmad South Gujarat University, Surat, India.

Corresponding Author: Dr. Vivek H. Ramanandi

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ABSTRACT

Background: Recovery of hand function is very important for the independence of patients with stroke. Standard mirror therapy is a well-established therapy regime for severe arm paresis after acquired brain injury. Soft robotic glove along with mirror therapy (i.e., robotic assisted mirror therapy) have been employed recently to assist the recovery of hand function during activities of daily living (ADLs) in stroke patients. This study aims to review available literature related to use of robotic assisted mirror therapy for hand rehabilitation in post stroke patients.
Methodology: Full texts of scientific literature published in English language between 2011 to 2022 were searched on various online databases. Total 3 publications related to use of robotic assisted mirror therapy for hand rehabilitation were found. Based upon the selection criteria, 2 full texts were included for review. Randomized control trials (RCTs), pre-test/post-test, pilot & non-RCTs were included.
Result: Both articles reported that combining effect of mirror therapy with robotic glove therapy was more beneficial when compared to the conventional mirror therapy alone to improve glove functions.
Conclusion: It can be concluded that clinically combination of mirror therapy with robotic glove will be promoted for better outcomes related to hand rehabilitation in post-stroke patients.

Keywords: Hand Rehabilitation, mirror therapy, robot glove, robotic hand, stroke.

INTRODUCTION

Current definition of stroke was declared in 2013 by American Stroke Association and it is describes as, "Stroke is an episode of neurological dysfunction caused by focal cerebral, spinal, or retinal infarction".[1] Stroke is one of the leading causes of disability and handicap worldwide and in most countries, it is the second most common reason of death.[2] According to Global Burden of Disease Study (GBD), stroke continues to be second only to ischemic heart disease in contributing to the global share of deaths since 1990 to 2016.[3] According to census data from 2011 population of Surat metropolitan region is approximately 45.91 lakhs and is estimated to be approximately 77.84 lakhs in year 2022.[4] Recent study suggest that crude incidence of stroke in

India ranged from 108 to 172/100,000 people per year, crude prevalence from 26 to 757/100,000 people per year, and one month case fatality rates from 18% to 42%.[5] Feigin et al. (2015) reported that in 2013 globally there were nearly 25.7 million stroke survivors, 6.5 million deaths due to stroke, 113 million disability adjusted life years (DALYs) lost because of stroke and 10.3 million new cases of stroke.[6]

Loss of motor function in the upper extremity, particularly that of the hand, is most often seen after stroke.[2] Impairments in hand function have a large impact on health- related quality of life (HRQoL) and this impairments often lead to difficulties in performing daily hand activities, especially those that require the use of both hands, i.e., bi-manual activities.[7] The ability to perform bi-manual activities is therefore an important goal in stroke rehabilitation.[8] Upper limb motor impairment occurs in approximately 50–80% of individuals in the acute stage of stroke and continues in 40- 50% in the chronic stage.[9] Which renders the rehabilitation of the upper limb after stroke challenging. It is imperative that upper limb rehabilitation must be intensive, repetitive, and task-oriented.[10]

Ramachandran and Rogers-Ramachandran (1996) were the first to introduce the use of these visual illusions created by a mirror for treatment of phantom limb pain.[11] Mirror therapy (MT) is one method utilized to create a reflective illusion to help affected limbs move more efficiently.[12] The Wen Zeng et. al. (2018) meta-analysis provides some evidence that mirror therapy may significantly improve motor function of the upper limb in patients with stroke.[13]

It has been suggested in literature that the benefits of a robotic device for rehabilitation purposes include: more intense and longer therapy sessions, feedback mechanisms to amplify movements, automated sessions to reduce therapy hours, automation of patient-specific therapy based on degree of motor impairment, and more precise measurements of motor function.[14] In a previous study, Stroke patients with impaired hand function gave positive feedback for a soft robotic glove system in functional tasks.[15] Soft robotic gloves work on air pressurization and they are able to support finger range of motion (ROM), generate the desired actuation of the finger joints and enhanced grip strength and motor function of hand in stroke patients.[14,16] Robotic glove can provide an effective means for assisted or passive movement simulation, while mirror therapy work on mechanism of motor imagery. Based on previous research, it can be concluded that combination of both interventions may provide a better outcome.[17,18]

This study aims to review available literature related to use of robotic assisted mirror therapy for hand rehabilitation in post stroke patients.

MATERIALS & METHODS

Search strategy:

A systematic search of papers in English, published in peer-reviewed journals between January 2011 and December 2022, was carried out using MEDLINE, CINAHL, EMBASE, Google Scholar, and PubMed electronic databases. Key words and abstracts were searched, using the following descriptors: “stroke,” “hand rehabilitation,” “mirror therapy,” “robot glove,” and “robotic hand.” The idea was to focus on the most recent and relevant research accessible in digital format.

Selection criteria:

✓ **Inclusion criteria:**

i. Study design: pre-test/ post-test study, randomized controlled trial, pilot study, non- randomized trial.

ii. Full text articles are available

iii. The device used for intervention was a soft robot

✓ **Exclusion criteria:**

i. Any other languages than English
ii. Any study conducted prior to 2011
iii. Study including rigid components on the robot-human interface
iv. Study including device which focused on other joints without including the fingers
v. Study including device was intended for use as a prosthetic

- **Screening and data extraction:**

The full texts of articles considered relevant by both the reviewers were obtained and analysed. In addition, the reference lists of included papers were examined to identify any additional articles that might have been missed by the search strategy. Out of total 5 search results, 2 full texts were selected for review based on selection criteria (Figure-1).

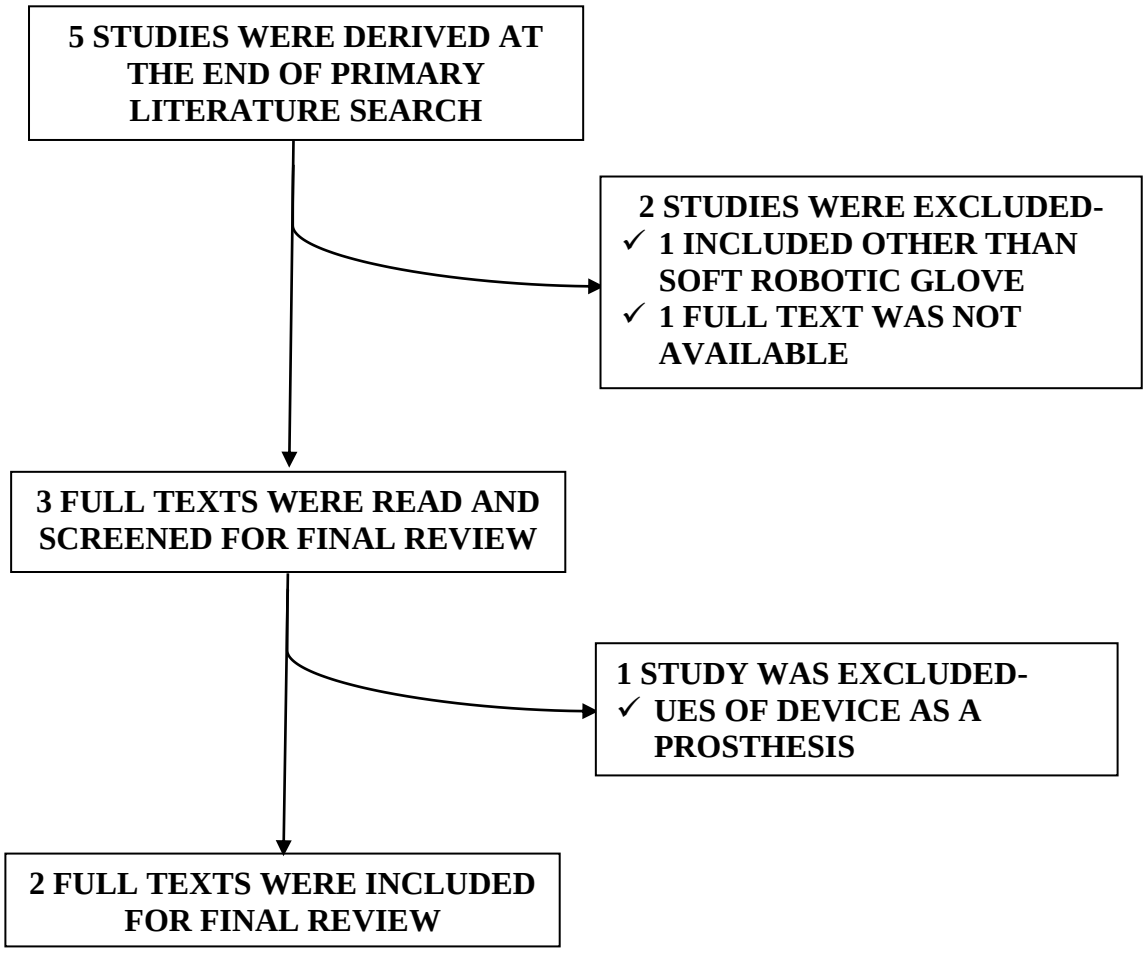

Figure 1: Process of Screening & Selection of Articles

It was considered more appropriate to conduct a descriptive analysis rather than a critical appraisal of the work. The information was tabulated after being properly cross-checked by two authors independently.

RESULT

Table-1 presents an overview of the 2 articles that were analysed. It highlights the type of study, purpose, population, grouping and intervention, total duration of intervention and follow up, the variables and measures of the studies, and the main findings.

Table: 1 Summary Characteristics of the Reviewed Studies (n=2)

Author name, year	No. of participant, Age (years)	Type of study	Groups	Intervention and Total intervention time	Outcome measures	Conclusion
Chong L et al 2022[17]	60, 30 - 80 years	RCT	CG: Conventional treatment + Mirror therapy GG: Conventional treatment + soft robotic glove CoG: Conventional treatment + (Mirror therapy + soft robotic glove)	4 weeks (30 minutes, 5 days per week)	FMA-UE, FIM and Brunnstrom classification of upper limbs and hand	Soft robotic glove and Mirror therapy combined or alone are more effective than conventional therapy in the treatment of post-stroke upper- limb dysfunction.
Mareike S et al, 2022[18]	29, 30 - 80 years	RCT	MT: Conventional Mirror therapy (MT) RMT: Robotic + mirror therapy	5 weeks (30 minutes, total 15 sessions)	FMA-UE and MI	RMT achieves greater treatment benefit on motor function than conventional MT. The use of robotics seems to be a good method to implement passive co-movement in clinical practice.

Here,
RCT: Randomized controlled trial
CG: Conventional Treatment Group
GG: Glove Therapy Group
CoG: Combination Therapy Group
MT: Conventional Mirror Therapy Group
RMT: Robotic Assisted Mirror Therapy Group FMA-UE: Fugl-Meyer Assessment Upper Extremity
FIM: Functional independence measure
MI: Motricity Index

DISCUSSION

This narrative review includes studies relevant to a relatively novel treatment intervention, i.e., soft robotic glove therapy that too in combination with an under studied technique, i.e., mirror therapy for sub-acute and chronic stroke patients. As there only sparse literature available on the topics, the discussion about the findings of the reviewed studies will majorly include the empirical evidence.

The combination of visual feedback through MT and the simultaneous somatosensory input on the affected side through robotics probably lead to a positive feedback loop. RMT uses two well-established hand rehabilitation procedures, the mirror illusion, and the sensory input.[17] The mirror illusion has already been proven to activate the contralateral hemisphere.[19]

Apart from the mirror illusion, Synchronized movements of the bilateral hands generated by the robotic glove can reduce the inhibition between the cerebral hemispheres, and proprioceptive feedback on the affected side also facilitates the connection between motor control and the primary motor cortex due to the synchronous movements of the bilateral upper extremities. Promotes sensorimotor integration.

Activation of sensory and motor areas showed a synergistic gain effect18and use of robotics seems to be a good method to implement passive co-movement in clinical practice.[17] The result of the study reviewed were positive indicating that RMT useful for hand rehabilitation in stroke patient.

As the literature available in the topic of interest is very less, the rationale and findings cannot be discussed and future studies on the same topic shall be undertaken.

CONCLUSION

Based on this review, it can be concluded that robotic assisted mirror therapy intervention helpful for rehabilitation of

hand function in patient with stroke and robotic assisted mirror therapy will achieve greater treatment benefit on motor function than conventional mirror therapy.

Declaration by Authors

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