



Review Article

Systematic review of the effects of mirror therapy in children with cerebral palsy

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Abstract. [Purpose] To provide data for systematic intervention plans in occupational therapy practice by objectivity showing the value of mirror therapy interventions in children with cerebral palsy. [Subjects and Methods] Medline and EMBASE databases were searched for the key words “cerebral palsy,” “mirror movement,” “mirror therapy,” and “mirror visual feedback.” Nine studies that met the inclusion and exclusion criteria were identified. The qualitatively determined level of evidence, period of research, comparisons and interventions, tools used to measure the intervention, and the effects were analyzed. [Results] According to the results analyzed, one (1/9, 11.1%) study showed the same result as the control group, one (1/9, 11.1%) showed a negative effect, and seven (7/9, 77.8%) showed positive effects of mirror-mediated therapy, with meaningful improvement in function, such as hand strength, movement speed, muscle activity, and accuracy of hand matching. [Conclusion] Through this study, the value of mirror-mediated therapeutic interventions in occupational therapy practice targeting cerebral palsy was confirmed. It is expected that this result will be useful in establishing mirror therapy as an interventional program.

Key words: Cerebral palsy, Mirror therapy, Systematic review

(This article was submitted May 16, 2016, and was accepted Jul. 29, 2016)

INTRODUCTION

Cerebral palsy (CP) is a non-progressive disorder that damages the immature brain during and after delivery. It is a complex syndrome with seizures and accompanying sensory-motor, cognitive, and behavioral disorders, characterized by defects in movement and posture¹⁾. CP can be classified into spastic, athetoid, and ataxic types based on a neurological classification²⁾. Generally, CP exerts more adverse effects on upper limbs than lower limbs in children with CP, and activity restrictions in the arms and hands make effective use of the upper limbs in daily life difficult³⁾. Functional disability in the upper limbs of children with CP is a result of motor cortex and corticospinal tract damage that affects delicate and refined movements⁴⁾.

Therapeutic interventions for children with CP include diverse methods such as neuro-developmental treatments, bilateral therapeutic exercises, constraint-induced movement therapy, sensory integration therapy, and mirror-mediated therapy^{5–7)}. Among these, mirror-mediated therapy is based on activation of the mirror neuron system⁸⁾. Mirror neurons are present in the premotor cortex and inferior parietal cortex; they are nerve cells that are activated when an individual performs a specific movement or a specific movement of another person is observed⁹⁾.

In mirror-mediated therapy, mirror neurons are activated by the patient’s observing movement of his or her own upper limb (empty hand), reflected in a mirror^{10, 11)}. This method was first introduced by Rogers-Ramachandran and Ramachandran in the treatment of phantom pain in an amputee patient in 1996¹²⁾, but since then, therapeutic effects have been confirmed in various disorders including complex regional pain syndrome (CRPS), cerebral vascular accident (CVA, stroke), and CP^{13–16)}. In a study by You¹⁷⁾, the experimental group that received mirror-mediated therapy showed significant improvement in upper limb function and activities of daily living (ADL) compared with the control group. Gu¹⁸⁾ reported a study with a

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patient with stroke-concomitant hemiplegia in which 6 months of mirror-mediated therapy using a folding mirror resulted in significant improvements in unilateral neglect and ADL performance. In the study by Kim and Lim¹⁹, mirror-mediated therapy administered for 4 weeks (60 min/time, 5 days/week) had a significant effect on upper limb function, sensory, and ADL in a patient with chronic stroke-concomitant hemiplegia. Additionally, in the study by Woo et al.²⁰, the experimental group showed significant recovery of hand function in more areas than the control group did.

Mirror-mediated therapy is effective in inducing activation of the motor cortex. To date, it has been applied mostly in adult patients with stroke in South Korean studies, and most studies have involved upper limb exercises. As a result, research supporting the use of this therapeutic intervention in children with CP is so far inadequate. Thus, the purpose of this study was to objectively assess the value of mirror-mediated therapeutic interventions applied to children with CP. This work should provide useful data for establishing more systematic intervention plans in clinical occupational therapy.

SUBJECTS AND METHODS

To find recent studies on the effects of mirror-mediated therapy, a search was performed in the Medline and EMBASE databases. As search terms, “mirror therapy” OR “mirror movement” OR “visual feedback” AND “cerebral palsy” were used. Based on the titles and abstracts of 187 reports, 17 were initially selected; after reading the studies in full, 9 were finally chosen based on the exclusion criteria.

Selected target studies (1) focused on cerebral palsy; (2) enabled full-text viewing; and (3) included mirror-mediated therapeutic intervention as a method under study. Any study in which the result was not reached based on data was excluded from the analysis.

Data were extracted and organized based on patient, intervention, type of comparison, and outcome (PICO) (Table 4). Data regarding the test used to assess the results, the level of evidence, comparative interventions, and results of the intervention and the intervention effect status were included.

RESULTS

To qualitatively evaluate the level of analysis in the studies, the method of Arbesman, Scheer, and Lieberman²¹ was used. Of the nine studies seven (77.8%) reported level II evidence (Table 1). Regarding the comparative intervention for mirror-mediated therapy, across the nine studies, 14 comparative interventions were used. Mirror-mediated therapy was compared with a no-mirror case in five (35.7%) studies, with an opaque membrane (phase therapy) in four (28.6%) studies, and with a glass membrane in two (14.3%) (Table 2).

Regarding the test used to measure the results of mirror-mediated therapy, 13 methods were used. Evoked electromyograms (EMG) were most frequent (4 cases, 21.1%; Table 3). Given the intervention effects, it was not possible to perform a

Table 1. Level of evidence: analysed experiment

Level of evidence	Frequency (%)
I Randomized control trial, systematic review, meta-analysis	0 (0.0)
II Two groups nonrandomized studies	7 (77.8)
III One group nonrandomized studies	1 (11.1)
IV Single-subject design, surveys	1 (11.1)
V Case reports, narrative literature reviews, qualitative research	0 (0.0)
Total	9 (100.0)

Table 2. Frequency analysis of contents of comparative intervention

Comparative intervention	Frequency (%)
No-mirror	5 (35.7)
Opaque screen	4 (28.6)
Glass	2 (14.3)
Bimanual activity	1 (7.1)
Pre-post comparison	1 (7.1)
No comparative intervention	1 (7.1)
Total	14 (100.0)

Table 3. Evaluation analysis to measure of effects of interventions

Test tool	Frequency (%)
EMG	4 (21.1)
MRD	2 (10.5)
Tardieu scale	2 (10.5)
WeeFIM	2 (10.5)
AHA	1 (5.3)
JTHFT	1 (5.3)
MACS	1 (5.3)
MRI	1 (5.3)
fMRI	1 (5.3)
QUEST	1 (5.3)
Strength (grip, pinch)	1 (5.3)
Time to start, Time to complete	1 (5.3)
TMS	1 (5.3)
Total	19 (100)

EMG: evoked electromyograms, MRD: maximum reaching distance, WeeFIM: Wee Functional Independence Measure, AHA: Assisting Hand Assessment, JTHFT: Jebsen-Taylor Hand Function Test, MACS: Manual Ability Classification System, MRI: magnetic resonance imaging, fMRI: functioning magnetic resonance imaging, QUEST: Quality of Upper Extremity Skills Test, TMS: transcranial magnetic stimulation

meta-analysis, so the studies were summarized by systematic considerations. In terms of intervention effect status, positive effects of interventions using mirror-mediated therapy were seen in seven (77.8%) studies.

DISCUSSION

Cerebral palsy is a major issue in occupational therapy for children. Children with CP of the spastic hemiplegia type show unilaterally involved upper more often than lower limbs²²). CP is characterized by defects in posture and motor skills. Interventions to improve motor skills have used various approaches⁵⁻⁷). Among them, mirror-mediated therapy is based on activation of mirror neurons in a relevant area of the motor cortex. In South Korea, most reported studies have focused on visual perception ability, upper limb function, ADL, and unilateral neglect in adult patients after stroke^{18, 19, 23-25}). A study by Ryu²⁶) applied mirror-mediated therapy in children with CP. In that study, children were assigned to a 4-week program entailing either mirror therapy or a sham therapy. The mirror therapy resulted in enhanced gait ability by increasing physical perceptual and balance ability.

CP occurs in an immature brain and is characterized by non-progressive disorders; effects of mirror-mediated therapy that may activate the motor cortex could reasonably be expected. However, further research is required to elucidate the effects of mirror-mediated therapy with regard to development.

In this analysis of prior research, two-group non-randomized studies (evidence level II) comparing mirror with no-mirror conditions were most frequent. Regarding the tool used to assess the therapeutic interventions, EMG, which measures muscle

Table 4. PICO for analysis

Author (year)	Participants		Interventions	Comparisons	Outcomes
	Dx	Exp/Con			
Jaume-i-Capo et al. 2014 ²⁷)	CP	8/32	CP group: Mirror feedback and no mirror feedback	Normal children: mirror feedback and no mirror feedback	Significant improvements in the experimental group in time between starting time and finishing the mirror program.
Smorenburg et al. 2012 ²⁸)	SHCP	13/10	Unimanual matching task, mirror therapy group	Bimanual matching task, no-mirror therapy group	The group performing bimanual tasks showed significant improvement when conducting mirror movements.
Adler et al. 2015 ²⁹)	SHCP	9/9	Mirror movement: hand flexion and extension thumb-finger opposition, forearm supination/pronation	No-mirror movement	Mirror movement had a negative effect on the activity of both hands and the time to perform activities daily of living.
Gygax et al. 2011 ³⁰)	SHCP	5/5	Group A, 9-week session 3 weeks –mirror therapy 6 weeks –no mirror therapy 9 weeks –wash out	Group B, 9-week session 3 weeks –no mirror therapy 6 weeks –mirror therapy 9 weeks –wash out	Mirror movement could improved muscle strength (grasp, pinch) in children with hemiplegia, as well as functional arm movement.
Smorenburg et al. 2013 ³¹)	SHCP	7/9	Mirror group: bimanual activity with mirror visual feedback	Screen group: Practiced movement with opaque screen between arms	In both groups, improvements in accuracy in matching paralyzed arms.
Feltham et al. 2010 ³²)	SHCP	8/12	CP group: motor performance with glass, opaque screen, mirror; affected and unaffected sides	Normal children group: motor performance with glass, opaque screen, mirror; affected and unaffected side	When measuring myotility with EMG, and comparing the paralyzed and non-paralyzed limbs in CP, muscle activity in the elbows and shoulders was greater.
Feltham et al. 2009 ³³)	SHCP	8/14	CP group: motor performance with glass, opaque screen, mirror; affected and unaffected side	Normal children group: motor performance with glass, opaque screen, mirror; affected and unaffected side	After intervention, the average coordination pattern in the cerebral palsy group showed a similar result to that of children with normal development.
Norton et al. 2008 ³⁴)	SHCP	1/-	TMS, MRI, fMRI, EMG, and force measurements were used to obtain information about the motor pathways responsible for the mirror movements		Mirror movement showed an effect in reorganizing the cerebral cortex in the neonatal period and may be a partial solution to decreased brain tissue mass.
Smorenburg et al. 2011 ³⁵)	SHCP	14/-	All participants performed under three visual conditions: no-vision, screen, mirror visual feedback		Matching accuracy was significantly increased in the mirror visual feedback group.

Dx: diagnosis; Exp: experimental group; Con: control group; SHCP: spasticity hemiplegia cerebral palsy; CP: cerebral palsy; TMS: transcranial magnetic stimulation; MRI: magnetic resonance imaging; fMRI: functional MRI; EMG: evoked electromyograms

activity, was used most frequently. These reports indicate that mirror-mediated therapeutic intervention can be effective in terms of muscle activity in the motor cortex.

Mirror-mediated therapy was generally effective in enhancing muscle strength, motor speed, muscle activity, and the accuracy of both hands. However, it also showed that mirror therapy required more time for performing ADL with both hands than with one hand.

Limitations of this study include that the number of reports analyzed was not sufficient, so no meta-analysis could be performed. In future studies, it is important to confirm the intervention effect systematically based on better study designs targeting children with cerebral palsy. This review also suggests that research assessing qualitative performance of ADLs be performed.

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