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PHYSIOLOGY & REHABILITATION | CASE REPORT

Effects of mirror therapy on the reacquisition of motor imagery in patients with a hand orthopaedic injury

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Abstract: Background: On commencing occupational therapy (OT), some patients with hand orthopaedic injury complain of not knowing how to move an affected finger. **Aim/Objective:** We report a patient who did not know how to move his finger on commencing OT after an operation for a metacarpal fracture of the left thumb. **Material and Method:** The patient had a swollen left thumb and moderate limited joint range of motion. Occupational therapy included training for finger joint range of motion and a dynamic splint. Mirror therapy (MT) was initiated on the first day of OT, and both procedures were administered as described in previous studies. **Results/Findings:** After MT, he reacquired motor imagery during the early phase of OT. After OT, the patient's left thumb regained normal range of motion and his complaint of "unsure of how to move fingers" resolved. Cerebral blood flow during MT was measured by using functional near-infrared spectroscopy for the reference. Cerebral blood flow was increased in the primary sensory-motor area on the side opposite the unaffected hand. **Conclusions:** Mirror therapy may help patients regain motor imagery sooner. **Significance:** We will conduct further studies to assess the effect of MT on patients who undergo hand surgery.

Subjects: Rehabilitation Medicine; Occupational Therapy; Hand Surgery

Keywords: motor imagery; mirror therapy; hand orthopaedic injury; functional near-infrared spectroscopy

1. Introduction

On commencing occupational therapy (OT), some patients with a hand orthopaedic injury complain that they do not know how to move the affected finger. Previous studies (Stenekes, Geertzen, Nicolai, De Jong, & Mulder, 2009) indicate that decreased motor imagery, which is caused by lack of feedback by visual input and proprioceptive sensation due to a prolonged time of not moving the finger, is problematic. In this paper, we report our experience with a

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PUBLIC INTEREST STATEMENT

Previous studies indicate that decreased motor imagery, which is caused by lack of feedback by visual input and proprioceptive sensation due to a prolonged time of not moving the finger, is problematic. In this paper, we report our experience with a patient who did not know how to move his finger on commencing occupational therapy postsurgery for fracture of the metacarpal of the left thumb.

patient who did not know how to move his finger on commencing OT postsurgery for fracture of the metacarpal of the left thumb. After undergoing mirror therapy (MT), he reacquired motor imagery during the early phase of OT.

2. Ethical consideration

The content of this study was explained to the patient in writing and orally. He provided written informed consent in advance of this presentation. This article was also presented in a revised form at the First Asia-Pacific Occupational Therapy Symposium, which was held October 20–22, 2017 in Taoyuan, Taiwan

3. Case

A 30-year-old male patient, who worked in the manufacturing business, was injured when an H steel fell onto the dorsal side of his left thumb as he worked on Y Z, X. He underwent surgery (i.e., percutaneous pinning and neurolysis) at 12 days after the injury, removal of plaster cast and application of a short opponens splint at 34 days after the injury, and removal of the short opponens splint and OT at 53 days after the injury.

4. Initial evaluation

The left thumb active range of motion (“passive range of motion”) was as follows: radial abduction, 35 (35); palmar abduction, 25 (35); metacarpophalangeal joint (MPJ) flexion 20 (22)/extension, –12 (–6); and interphalangeal joint (IPJ) flexion/extension, 32 (38)/–22 (–20). On commencing OT, he was instructed to bend and stretch his thumb. However, he had a befuddled expression on his face and said he did not know how to move his thumb.

5. Details of OT

Passive range of motion exercise was commenced. Dynamic splints for palmar abduction and for MPJ/IPJ flexion were prepared. Mirror therapy was administered the same day that OT commenced. Based on previous studies (Dohle et al., 2009; Yavuzer et al., 2008), we determined methods through which the patient could imagine moving the affected thumb by looking in a mirror box at a mirror image of his moving healthy thumb.

6. Mirror therapy

Ramachandran, Rogers-Ramachandran, and Cobb (1995) believed that “learned paralysis” occurs in the brain because a paralyzed extremity does not receive appropriate visual feedback. Thus, to eliminate the phenomenon of a “part with learned paralysis”, MT was developed to provide the brain with visual feedback through illusion.

Altschuler, Wisdom, and Stone et al. (1999) conducted a study of MT in patients with central nervous system disease and applied MT to nine patients with hemiparesis following a stroke; the patients had improvement in upper limb paralysis. Sutbeyaz, Yavuzer, and Sezer et al. (2007) administered a conventional stroke rehabilitation program (i.e., 5 days a week at 2–5 h daily for 4 weeks) to 40 patients with hemiparesis, consisting of 20 patients in the mirror group and 20 patients in the control group (mean time after stroke, 3.7 months). In the mirror group, the MT program added an additional 30 min a day to their therapy. The mirror group had improvement in leg paresis and functional independence measures. Dohle et al. (2009) demonstrated the effect of MT on digital function injury and surface sensibility within 1 month after the onset of hemiparesis. In Japan, Hirayama, Inoue, and Sato et al. (2012) found that finger motor activity improved significantly in 14 stroke patients in the MT group, compared to patients in the control group. To examine the effect of MT in patients with orthopaedic disorders, Ramachandran et al. (1995) used MT in patients with phantom pain caused by hand amputation. Other investigators have used MT for patients with complex regional pain syndrome and noted improved pain relief (Moseley, 2005). Occupational therapists administered MT for orthopaedic patients and confirmed a significant effect on enhancing joint range of motion in automatism (Rostami, Arefi, & Tabatabaei, 2013).

The mechanisms of MT effect include remodelling of physical images by building motion perception by using visual illusion, providing afferent information to the brain (Yavuzer et al., 2008), and improving function by motor image-evoking brain activities that resemble actual motor actions (Amimoto, 2009). Studies (Nojima, Mima, & Kawamata, 2012) using recent neurophysiological tests have been conducted and reveal activation of the corticospinal tracts, such as the primary motor cortex, on the same side as the motion (Nojima et al., 2012). However, practical validation needs to be conducted (Hirayama et al., 2012).

7. Additional validation

Cerebral blood flow (CBF) during MT and the relation of CBF with motor imagery were investigated. CBF was measured using topography for cerebral function with near-infrared spectroscopy (NIRS), which is based on Beer-Lambert's law; NIRS measures CBF on the surface of the cerebrum (i.e., cerebral cortex) and presents this information as optical decay curves and changes in the concentrations of substances, based on their absorbance in a solution. The haemoglobin (Hb) concentration of sites with cerebral activity is measured by using NIRS, which is based on the blood oxygenation level-dependent (BOLD) effect (i.e., local CBF changes with cerebral neural activity) (2002).

7.1. Method

The CBF was measured using topography for cerebral function with NIRS (ETG-7100 Optical Topography System; Hitachi Medical Corp., Tokyo, Japan). The measuring sites were around the right central sulcus (i.e., the right primary motor cortex (C4) in the 10–20 system).

7.2. Mirror therapy tasks

Task A involved exercising the right hand + watching the unmoved left hand. Task B involved exercising the right hand + watching the mirrored right hand. Task C involved watching the unmoved left hand and imaging of the left hand moving. One set consisted of 20 s performing the task and 40 s of rest. Five sets were continuously performed.

7.3. Results processing

The arithmetic means of oxyhaemoglobin, deoxyhaemoglobin, and total haemoglobin during the continuous five sets were calculated.

8. Results

The CBF was highest in Task B (i.e., MT), followed by CBF in Task C (i.e., motor image only) and Task A (Table 1).

9. Final evaluation

The left thumb range of motion was as follows: radial abduction, 55 (60); palmar abduction, 50 (65); MPJ flexion/extension 40 (50)/–4 (0); and IPJ flexion/extension, 66 (70)/0 (0). The symptom of the patient not knowing how to move his finger was eliminated after undergoing three sessions of OT.

Table 1. Average value of oxy-Hb, deoxy-Hb, total in the task (Unit: mM · mm)

Task	oxy-Hb	deoxy-Hb	total
A	0.011	–0.01	0.001
B	0.027	–0.011	0.016
C	0.017	–0.01	0.007

Oxy-Hb: Oxidized haemoglobin, Deoxy-Hb: Deoxidizedhaemoglobin, Total: Total haemoglobin

Task A: Involved exercising the right hand + watching the unmoved left hand.

Task B: Involved exercising the right hand + watching the mirrored right hand.

Task C: Involved watching the unmoved left hand and imaging of the left hand moving.

10. Discussion

Some research has confirmed that motor imagery alone increases muscle strength (Yue & Cole, 1992). However, the outcome depends on a patient's imagery capability. Other research also shows that MT enhances activation in the area of the primary motor cortex (Giroux and Sirigu, 2003). As a consequence, the illusion induced by MT is useful for changing cerebral representation. Therefore, MT may help patients who complain of being unsure of how to move their hand regain motor imagery sooner, based on cerebral function. Rehabilitation will be easier when training patients with MT during the postsurgery fixation period to prevent the loss of motor imagery after removing the fixation.

11. Limitation and future approaches of study

A limitation of this study was that it was conducted in a single patient. Therefore, it is difficult to evaluate accurately the effect of MT. Most of the evidence for mirror therapy is from studies with weak methodological quality (Ezendam, Bongers, & Jannink, 2009). Further studies need to be conducted in multiple patients with controls to assess the effect of MT in detail. In addition, definitive motor imagery of patients who complain of being unsure of how to move a hand should be evaluated. Topography for cerebral function with NIRS was used in this study to determine the indices of motor imagery; however, different biometry techniques such as functional MRI and electroencephalography are necessary to investigate effective interventions, based on cerebral function.

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Competing interests

The authors declare no competing interests.

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References

- Altschuler, E. L., Wisdom, S. B., Stone, L., Foster, C., Galasko, D., Llewellyn, D. M., & Ramachandran, V. S. (1999). Rehabilitation of hemiparesis after stroke with a mirror. *Lancet*, 353, 2035–2036. doi:10.1016/S0140-6736(98)09449-5
- Amimoto, K. (2009). Clinical application of mirror therapy and its effect possibility in patients with stroke. *Journal of the Society for the Study of Medical Basis of Physical Therapy*, 12, 5–8.
- Dohle, C., Pullen, J., Nakaten, A., Küst, J., Rietz, C., & Karbe, H. (2009). Mirror therapy promotes recovery from severe hemiparesis: A randomized controlled trial. *Neurorehabilitation Neural Repair*, 23, 209–217. doi:10.1177/1545968308324786
- Ezendam, D., Bongers, R. M., & Jannink, M. J. (2009). Systematic review of the effectiveness of mirror therapy in upper extremity function. *Disability Rehabilitation*, 31(26), 2135–2149. doi:10.3109/09638280902887768
- Giroux, P., & Sirigu, A. (2003). Illusory movements of the paralyzed limb restore motor cortex activity. *Neuroimage*, 20, S107–S111. doi:10.1016/j.neuroimage.2003.09.024
- Hirayama, S., Inoue, Y., Sato, Y., Harada, K., & Kagawa, K. (2012). Effect of mirror therapy on digital motor function injury of patients with hemiparesis following stroke. *Physical Therapeutics Researcher*, 39, 330–337.
- Moseley, G. L. (2005). Is successful rehabilitation of complex regional pain syndrome due to sustained attention to the affected limb? A randomized clinical trial. *Pain*, 114, 54–61. doi:10.1016/j.pain.2004.11.024
- Nojima, I., Mima, T., & Kawamata, T. (2012). Role of human primary motor cortex function in motion exercise for mirror therapy. *Physical Therapeutics Researcher*, 39, 82–89.
- Ramachandran, V. S., Rogers-Ramachandran, D., & Cobb, S. (1995). Touching the phantom limb. *Nature*, 377, 489–490. doi:10.1038/377489a0
- Rostami, H. R., Arefi, A., & Tabatabaei, S. (2013). Effect of mirror therapy on hand function in patients with hand orthopaedic injuries: A randomized controlled trial. *Disability Rehabilitation*, 35(19), 1647–1651. doi:10.3109/09638288.2012.751132
- Stenekes, M. W., Geertzen, J. H., Nicolai, J. P. A., De Jong, B. M., & Mulder, T. (2009). Effects of motor imagery on hand function during immobilization after flexor tendon repair. *Archives Physical Medical Rehabilitation*, 90, 553–559. doi:10.1016/j.apmr.2008.10.029
- Sutbeyaz, S., Yavuzer, G., Sezer, N., & Koseoglu, B. F. (2007). Mirror therapy enhances lower-Extremity motor recovery and motor functioning after stroke: A randomized controlled trial. *Archives Physical Medical Rehabilitation*, 88, 555–559. doi:10.1016/j.apmr.2007.02.034

Japan scientific meeting of brain metabolism monitoring edit: Near-infrared spectroscopy for clinicians (2002) (pp. 1–9). Tokyo: Shinkoh Igaku Shuppansha Co., Ltd.

Yavuzer, G., Selles, R., Sezer, N., Sütbeyaz, S., Bussmann, J. B., Köseoğlu, F., . . . Stam, H. J. (2008). Mirror therapy improves hand function in subacute stroke, a randomized controlled trial. *Archives Physical Medica*

Rehabilitation, 89, 393–398. doi:10.1016/j.apmr.2007.08.162

Yue, G., & Cole, K. J. (1992). Strength increases from the motor program: Comparison of training with maximal voluntary and imagined muscle contractions. *Journal Neurophysiology*, 67, 1114–1123. doi:10.1152/jn.1992.67.5.1114



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