received 17 December 2022 | accepted 04 May 2023 | published 10 May 2023

Doi: 10.31157/an.v28i4.449

EFFECT OF MIRROR THERAPY ON MOTOR AND SENSORY RECOVERY FROM BRACHIAL PLEXUS INJURY: CASE REPORT.

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Abstract

Introduction: A brachial plexus lesion (BPJ) causes muscle weakness and altered sensitivity of the upper limb. Likewise, it generates a reduction of afferents, which alters the cortical representation of the segments involved, causing poor motor and sensory recovery. As a treatment, peripheral nerve transfer surgery generates motor reorganization and cortical displacement, which favors motor recovery. Mirror therapy (MT) contributes to the recovery of peripheral nerve injury by stimulating the somatosensory, primary motor, and premotor cortexes, which increase cortico-muscular excitability and have an impact at the sensory and motor level. **Clinical findings**: 35-year-old male patient presenting total paralysis and anesthesia of the right upper limb after BPJ axonotmesis type with a ten-month evolution time and a history of nerve transfer surgery. **Intervention**: MT was applied twice a week for four weeks. Sensitivity, pain, muscle activation, muscle strength, range of motion, and level of disability of the upper limb were evaluated. **Results**: improvement was observed in neuropathic pain and sensitivity regulation, as well as increased activation of the deltoid, biceps, triceps, extensor carpi radialis longus, and flexor carpi ulnaris muscles. **Conclusion**: favorable results were obtained regarding sensitivity, neuropathic pain, and muscle activation of the upper limb. It can be suggested that nerve transfer surgery, evolution time, and MT together can stimulate the recovery of a patient with BPJ.

Keywords: *mirror therapy, peripheral nerve injury, brachial palsy, brachial plexus injury*

Introduction

The brachial plexus provides motor and somatosensory innervation to the upper limb, so a lesion in this nerve network generates muscle weakness and altered sensation in the upper limb.[1] Nerve injuries of the upper limb affect the functionality and quality of life of the people who suffer them due to the inability to perform their daily activities, which has emotional and economic repercussions.[2]

The severity of the lesion depends on the location, mechanism, and extent of the lesion.[3] When a peripheral nerve injury occurs, a reduction of afferents is generated, which alters the cortical representation of the segments involved, resulting in poor motor and sensory recovery.[2]

Peripheral nerve transfer is a surgery performed after a peripheral nerve injury, in which a healthy nerve is repositioned at the site where the damage occurred, to reinnervate the paralyzed muscles. On a motor level, there are several neuroplastic changes, since, when the donor and recipient cortexes are adjacent to each other, they receive similar corticospinal projections. On the other hand, the phenomenon of cortical displacement occurs when both cortical areas have previous intrinsic connections. If the donor nerve is from the contralateral hemibody, the representation of the motor cortex is displaced to the contralateral hemisphere via subcortical structures. At the sensory level, no functional reorganization has been reported.[4,5]

Mirror therapy (MT) consists in the observation of the movement of the healthy limb in a mirror placed medioagittally, in such a way that its reflection generates the visual illusion of the appropriate movement.[6] Mirror neurons, involved in motor learning, are activated when the movement performed by the healthy limb has a functional purpose.[7,8] This generates stimulation of the cortex corresponding to the affected limb and causes an increase in cortico-muscular excitability, which may lead to a recovery of motor function.6 According to Zink, et al2 MT contributes to the recovery of peripheral nerve lesions by stimulating cortical areas that have lost afferents -such as the somatosensory cortex and the primary motor and premotor cortexes-, preventing the loss of cortical representation, thus helping the recovering nerves to generate organized and functional connections.

MT has been widely used in different conditions, such as hemiparesis, phantom limb syndrome, and complex regional pain syndrome.[7] However, there is little research on its use in peripheral nerve injuries, therefore, the present case report aims to examine its effect on sensation and motor function in a patient with brachial plexus injury (BPJ). This case study has a qualitative descriptive design, subject to the CARE methodological guidelines for case reports.[9,10]

Presentation of the clinical case

The patient is a 35-year-old male patient, a trailer driver, with no relevant pathological personal history, who presented with monoplegia of the right upper limb and neuropathic pain after BPJ of the axonotmesis type, caused by polytrauma on June 2, 2021. The patient also suffered cranioencephalic trauma, fracture of the right clavicle, fracture of the right acetabulum and ischiopubic ramus, and injury to the right peroneal nerve. He was hospitalized for 22 days.

An electromyography and evoked potentials study was performed with an evolution period of seven weeks after the trauma. The deltoid, biceps, triceps, index extensor, pronator teres, ulnaris anterior, first dorsal interosseous, and abductor pollicis brevis muscles were studied; they presented normal insertion potential, resting potential with the presence of positive waves and fibrillation potentials in middle deltoid, biceps and triceps, and fibrillations in all the muscles evaluated. The recruitment and interference patterns were diminished in all the muscles studied. Regarding motor neuroconduction, the median, ulnar, musculocutaneous, and axillary nerves were studied, and no bioelectrical response was recorded in any of them. Concerning sensory neuroconduction, the aforementioned nerves and the radial nerve were studied, no bioelectric response was evoked in musculocutaneous or axillary nerves, the median nerve showed latency at the lower limit and decreased amplitude, the ulnar nerve showed decreased latency and normal amplitude, and the radial nerve showed latency at the upper limit and decreased amplitude. A diagnosis of right BPJ of the axonotmesis type was made at the level of the upper, middle, and lower trunk with active denervation data.

Three months after the trauma, nerve transfer surgery was performed. The right pectoral nerve was taken as the donor nerve and the right musculocutaneous nerve as the recipient. Subsequently, the patient received intermittent physiotherapy for two months from his medical insurance, which consisted of electrotherapy and passive mobilization exercises.

Physical evaluation

Sensitivity was assessed by dermatomes, superficial sensitivity was evaluated with a soft touch, and deep sensitivity with three firm touches with a metallic object along the nerve pathway. The results were as follows: the right dermatomes C5, C6, C7, and C8, were anesthetic for both types of sensitivity, as well as the T1 dermatome, anesthetic for superficial sensitivity and hypoesthetic for deep sensitivity. As for pain, the patient reported 10/10 on the analogous numerical scale (ENA, abreviation in Spanish for Escala Numérica Musical).

Muscle activation, that is, the ability of the muscle to perform a measurable muscle contraction, was assessed by surface electromyography, which allows quantification of muscle electrical activity in microvolts (uV). The Intelect Advanced Combo Chattanooga equipment was used for the procedure. The muscles evaluated and their level of activation were: deltoid, 40 uV; biceps, 90 uV; triceps, 50 uV; radial extensor carpi radialis longus, 40 uV, and flexor carpi ulnaris, 55 uV. The arcs of motion had a range of 0° in all shoulder, elbow, wrist, and metacarpophalangeal joint movements.

Strength was assessed using the modified Daniels scale, which has values between 0 and 5; 0 indicates the absence of palpable muscle contraction and 5 represents the greatest possible strength. The following shoulder muscles were assessed: flexors (anterior deltoid and biceps fibers), extensors (posterior deltoid, teres major, teres minor and latissimus dorsi fibers), abductors (middle deltoid and supraspinatus fibers), adductors (pectoralis major, latissimus dorsi and rhomboid), internal rotators (teres major, subscapularis and pectoralis major) and external rotators (infraspinatus and teres minor). Shoulder strength was 0/5 in all shoulder muscle groups, except flexors, where it was 1/5. Elbow, wrist, and metacarpal strength were 0/5 in all muscle groups.

Disability of the upper limb was assessed through the Disabilities of the arm, shoulder, and hand (DASH) questionnaire, which has two sections, the first one rating the disability and the second one the work and sports participation. In the first section the patient scored 128 points, that is, 81.6% disability, while in the second section, he scored 40 points, that is, 100% disability in sports and work activities.

Physiotherapeutic intervention

The intervention program was based on the evidence of the neuroplastic changes that MT generates, specifically, the activation of the somatosensory, motor, and premotor cortexes, which generate cortico-muscular connections similar to those produced when true movement is performed.[2,6,7] This neuroplasticity is useful in the treatment of peripheral nerve lesions in which there is no possibility of generating cortical activation through voluntary movement. In previous research on the application of MT in patients with peripheral nerve injury, potential effects were observed in the reduction of pain, sensory reeducation, and muscle activation,[11–14] so we consider that this intervention deserves to be studied more extensively.

The program consisted of four phases, each lasting one week. MT was applied twice per phase, for a total of four weeks. The first stage of treatment began when the patient had an evolution of ten months; the last therapy was applied when he had an evolution of eleven months and one week. Tables 1a and 1b in the supplementary material describe the exercises for each phase.

Response to treatment

A significant change was observed in the sensitivity of the C7 and C8 dermatomes, in which it went from being null to increased; likewise, the T1 dermatome regulated its sensitivity. Significant changes were also found in the decrease of the patient's pain, which started at 10 and ended at 4 points according to the ENA. Regarding the activation of the evaluated muscles, an increase was presented as follows: deltoid, from 45 to 65 uV; biceps, from 90 to 120 uV; triceps, from 50 to 70 uV; extensor carpi radialis longus, from 40 to 50 uV, and flexor carpi ulnaris, from 55 to 80 uV. Concerning upper limb disability according to the DASH questionnaire, the score in the disability section went from 81.6% to 55.83%. However, in the work and sports participation section, it remained at 100%. Regarding the range of motion and muscle strength, the expected quantitative results were not obtained. However, a favorable clinical difference was observed in the activation of the proximal muscles of the upper limb. Table 1 shows a comparison between the variables before and after the intervention.

Discussion

Regarding the prognosis of complete brachial plexus lesions, Entezari et al.[15] reported that only 40% of the lesions in which the nerve is sectioned and receives nerve repair will have partial or total recovery in a period of 25 to 32 weeks. Concerning neuropathic pain, a study by Brito et al.[16] found that it persists even five years after a complete BPJ. Likewise, a systematic review with meta-analysis reported that only 29.3% of patients who underwent nerve transfer surgery for BPJ reported pain relief in a post-surgical period of up to four years.[17]

In the findings of the present study, it could be observed that MT could contribute to changes in sensitivity, as well as to a decrease in pain. This could be because MT provides a visual substitution of the area of the body that lost afferents and thus enhances the reorganization of brain circuits back to how they were before pain was felt. Similarly, the observation of two healthy upper limbs by this therapy could help to reduce the sensation of pain.[11]

The results of this clinical case are similar to those reported by Mayara et al.[12] In this work, MT applied early was found to be an effective therapeutic measure for sensory recovery after nerve repair surgery, similar to classical sensory reeducation applied months later.

Table 1. Comparison of variables before and after the MT intervention.

Variable	Before	After
Sensibilidad (dermatomas)	**Superficial sensitivity:** C5, C6, C7, C8, T1 anesthetics **Deep sensitivity:** C5, C6, C7, C8 anesthetic, T1 hypoesthetic	**Surface sensitivity:** C5, C6 anesthetic, C7, C8 hyperaesthetic, T1 normoesthetic **Deep sensitivity:** C5, C6 anesthetic, C7, C8 hyperaesthetic, T1 normoesthetic
Dolor (ENA)	10/10	4/10
Muscle activation (surface electromyography)	Deltoid: 40 uV Biceps: 90 uV Triceps: 50 uV Radial extensor carpi radialis longus: 40 uV Ulnar flexor carpi ulnaris: 55 uV	Deltoid: 65 Uv Biceps: 120 uV Triceps: 70 Uv Radial extensor carpi radialis longus: 50 uV Ulnar flexor carpi ulnaris: 80 uV
Disability (DASH questionnaire)	Disability section: 81.6%. Labor and sports participation section: 100%	Disability section: 55.83%. Labor and sports participation section: 100%
Strength and range of motion	No detectable movement found	Clinical difference, activation of the proximal muscles of the upper limb

Another significant finding was the increase in muscle activation, which coincides with that described by Chen et al,[13] who applied MT after peripheral nerve repair and found improvement in upper limb function after a 12-week intervention.

In these results, it should be taken into account that other factors could influence the intervention, such as the time of evolution and nerve transfer surgery. It has been observed that these factors considerably improve the patient's prognosis; however, in this case, MT can be considered a coadjuvant for the control of neuropathic pain, since it reduced the time expected for pain relief, and also contributed to muscle activation in a shorter period than previously described.

Conclusion

Favorable results were obtained regarding sensibility, neuropathic pain, and muscle activation of the upper limb when applying MT in a patient with BPJ who received peripheral nerve transfer. It can be suggested that nerve transfer surgery, evolution time, and MT together can stimulate the recovery of a patient with BPJ.

This intervention is novel and shows signs of generating significant changes in pain relief and muscle activation pathways, so it could serve as a reference to assess the usefulness of MT as an adjuvant in the recovery of peripheral nervous system injuries.

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Supplementary material

Table 1a. Mirror therapy exercises, first and second phase

Mirror therapy exercises first phase		
Exercise	**Indication**	**Material**
Cleaning a table and wringing out a sponge	Wipe the table from one side to the other and then from front to back, squeeze the sponge.	Sponge
Tending paper on a clothesline	Take a piece of paper and hang it on the clothesline, then put a clothespin on it, and remove the clothespin afterwards.	Paper, clothesline, and clothespins
Open a bottle, drink it, pour water into glasses at different distances, and close the bottle.	Open the bottle, take it, and pour water into the glasses slowly, then close it.	Bottle and glasses
Knead plasticine and flatten it with a rolling pin.	Take the plasticine out of the container, knead it, roll it into a ball, and then flatten it with a rolling pin.	Plasticine and roller
Typing with a keyboard	Type the sentences indicated on the keyboard	Computer keyboard
Assemble a tower of cubes	Reach the cubes that are far away and build a tower with them.	Six cubes
Mirror therapy exercises second phase		
Folding clothes	Fold the clothes and then stack them	Clothing
Shoe lacing	Put the shoelace on the shoe	Shoe with shoelace
Serve seeds in a bowl with a spoon and with a glass	Pour a cup of seeds into the container, scoop seeds with the spoon.	Seeds, glass and spoon
Winding a rope on a stick	Wind the rope around the pole and then unwind it.	Rope and pole
Roll up a towel, unroll it and fold it.	Handle the towel as indicated, roll it up, spread it out and fold it.	Towel
Crush the indicated color with the hand	Crush the color indicated	Plasticine or colored cards

Supplementary material

Tabla 1b. Mirror therapy exercises, third and fourth phase

Third phase mirror therapy exercises		
Exercise	**Indication**	**Material**
Forming figures with a towel	Make the figure you are asked to make	Towel
Cut a sheet of paper with scissors	Cut the sheet linearly, diagonally, etc.	Sheet of paper, scissors
Forming figures with buckets	Make a tower, a pyramid, a square, etc.	Cubes
Moving balls with a spoon	Take the balls to the indicated glasses	Balls, roller and cups
Simulate washing dishes	Wash the glass, wash the spoon, etc.	Plates, glasses and cutlery
Simulate using a hammer for nailing	Sink a plasticine nail	Plasticine and toy hammer
Mirror therapy exercises fourth phase		
Making figures with plasticine	Make a circle, a star, a triangle, etc.	Plasticine
Moving a ball from one container to another	Take the ball and move it to the other container slowly	Balls and containers
Putting chips through a slit	Take the chips out of the container and then put them one by one through the slit	Chips and container with slit
Cutting plasticine with a knife pretending to be food.	Make a cylinder with the plasticine and then cut it into pieces. Make different shapes as indicated	Disposable knife and plasticine
Open a magazine and turn the pages	Open the magazine, turn the pages, and follow the figures you find with your finger.	Magazine
Using cutlery and pretending to put them in the mouth	Take the spoon, grab food from the plate, put it in your mouth, etc.	Cutlery, plate, and glass