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Laser and vacuum therapy for treatment of facial nerve palsies

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ABSTRACT

Facial nerve (FN) palsies consist of paralysis of unknown origin potentially caused by metabolic disorders, trauma, and infectious diseases. Currently, FN injuries diagnosed as Bell's Palsy (BP) are characterized by total involvement of the affected hemiface, leading to multiple consequences including lack of eye lubrication. Our study employed low-level laser therapy (LLLT) for recovery of FN palsies by patient 1 with BP and patient 2 with trauma. Our LLLT protocol used gallium aluminum arsenide (GaAlAs) laser (wavelength 780 nm and power 70mW) during 60 seconds per 0.04 cm² of illuminated area for BP treatment (patient 1), and lasers emitting at 660 and 808 nm (power 600 mW) during 3 minutes per 2-3 cm² of illuminated area used synergistically with vacuum therapy equipment for trauma-based FN-palsy treatment (patient 2). Patient 1 received 2 sessions per week over 2 months and patient 2 over 3 months. LTTT treatments resulted in complete recovery of patients 1 and 2. No medication was administered during vacuum therapy and laser treatment. Normal facial expression was achieved including facial symmetry at rest and enhanced facial movement. Our results indicated that LLLT can enable nerve regeneration, as facial muscles recovered their normal functions. Based on these results, we believe laser therapy may be a viable approach to nerve regeneration and may have clinical relevance to be confirmed upon increasing patient numbers in future studies. Also, the combination between LLLT and vacuum therapy may arise as an alternative treatment to accelerate the recovery of the facial expression of FN-palsies and BP patients.

Keywords: Low-Level Laser Therapy; Photobiomodulation; Phototherapy; Cupping Therapy; Facial nerve palsy; Bell's palsy, facial nerve injury.

1. INTRODUCTION

In cases of fracture of the temporal bone, facial nerve (FN) injuries may develop as a result of trauma on the peripheral FN. Fractures are diagnosed by using computed tomography (CT), but diagnosing FN palsies are typically more complex due to many possible causes such as neurological diseases. The diagnosis of FN palsies defines the appropriate treatment to be administered as early as possible to prevent the development of potential complications resulting from lesions associated with the trauma on the peripheral FN. These complications include hematotympanum, changes in the temporomandibular joint, rupture of the ossicular chain, and leakage of cerebrospinal fluid in otorhinoliquorrhea patients.

One of the most common FN injuries among adults is Bell's Palsy (BP), also known as idiopathic peripheral facial palsy. BP is diagnosed when the FN injury involves the affected hemiface completely (instead of affecting only the lower portion of the individual's face such as in central facial paralysis). However, BP is still an acute peripheral paralysis of FN of unknown origin and sudden occurrence. Previous studies have suggested BP could be caused by primary infection or reactivation of the Herpes simplex virus (HSV) due to its presence in patients' urine samples. Currently, BP diagnosis still

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requires exclusion of all other causes such as other neurological diseases and schwannomas. Light-based treatments which work for BP and other FN palsies are highly attractive to patients seeking for relief of their symptoms without having their FN injury diagnosed. The treatment approach shown in this work could potentially work for BP and other FN palsies.

In terms of complications to be overcome by treatments, BP complications include restrictions in the movement of the eye and eyelid, dry eyeball due lack of lubrication by the eyelid, and any control associated with the FN VII cranial nerve.[1] Complications result in poor patient prognosis, as taste perception in the anterior two thirds of the tongue, release of tears and saliva, facial mimicry and facial muscles are controlled by the motor of the VII cranial nerve.

Currently, the most indicated therapy to BP is steroid use, which allows ecovery rates of ~90%. If a patient is diagnosed with BP, antiviral drugs may be beneficial to prevent effects from HSV infection and reactivation.[2] Other types of treatment include physiotherapeutic-based modalities such as facial exercises, massage, thermal shock, electrotherapy, and electrical stimulation. Yet, these modalities exhibit questionable efficacy, [3] since evidence is low that facial exercises can restore facial function and shorten BP recovery times [4], and that successful BP treatment can be achieved by increased muscle and nerve function induced by electrotherapy, or by increased blood flow and oxygenation [5–79], as well as edema reduction induced by sinergic massage and thermal methods. [80] With this in mind, Low-level light therapy (LLLT) can be a promising approach to treat BP and other FN palsies.

Previous studies have demonstrated the success of LLLT in particular FN palsy settings. Anders et al. has shown that rat FN regeneration following crush injury increased upon application of LLLT at specific parameters. [81] Yamada et al. indicated that LLLT could be an alternative treatment for patients with peripheral facial paralysis and not responding to corticosteroids or an adjunctive treatment for peripheral-facial-paralysis patients not manageable by corticosteroid therapy. [82] Also, recent studies demonstrated that LLLT has significantly improved the recovery of BP patients. [3,83] The LLLT-induced accelerated neural regeneration has made LLLT a promising treatment for neural diseases including postherpetic pain, dental hypersensitivity, paraesthesia, and trigeminal neuralgia. [84]

A scarcely explored approach to treat peripheral FN Palsies is combining LLLT and vacuumtherapy (also referred to as vacuum therapy), as vaccumtherapy raises blood oxygenation and circulation in connective tissue which potentially increases muscle tone, promotes anti-inflammatory effects, and stimulates nerve regeneration. Vacuumtherapy consists of a non-invasive mechanical therapy which uses suction (negative pressure) of skin and subcutaneous tissue to stimulate lymphatic drainage and to rise the local blood flow. [85] Since vaccuumtherapy has been successfully used in aesthetic treatments inclusing those of redistribution of the subcutaneous adipose tissue [85] and cellulite [85], we hypothesize that its effects could improve restoring facial movements lost due to BP and other peripheral FN Palsies.

With the above in mind, our study provides a detailed description of clinical cases using either LLLT alone or in combination with vacuumtherapy to treat peripheral FN palsies for future comparison with clinical cases using other treatment modalities.

2. METHODOLOGY

All procedures followed in this study have received approval of the research clinical ethics committee of Irmandade da Santa Casa de Misericordia de São Carlos, protocol number 3.244.307. Clinical cases describes the clinical development of patients with FN palsies. Clinical case 1 encompasses a case of an BP patient, and clinical case 2 involved a post-traumatic injury patient.

2.1 Clinical Case 1

Our BP patient was 50-year-old, male, Caucasian who presented right facial paralysis after a hypertensive peak event. This patient was treated with LLLT alone for 2 sessions per week during 2 months in total. Each session of LLLT involved a 60-seconds application of infrared light at 808 nm wavelength, 100 mW power, 6 J of total energy per location (illuminated area of 0.04 cm^2), and 105 J/cm^2 dose. Figure 1 shows the face locations where application of infrared light took place. Treatment results are shown in figure 2, which emphasizes the restoration of the face symmetry and facial expression by comparing the face symmetry at rest and the extent of movement with face gestures before and after treatment.

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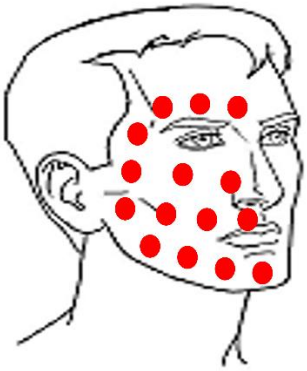


Figure 1: Schematic drawing showing the points where laser treatment was applied by using the active tip of the infrared illumination device in contact with the skin. Points were spaced 1 mm from each other and made linear trajectories in the forehead, maxilla and mandible regions on the patient's face.

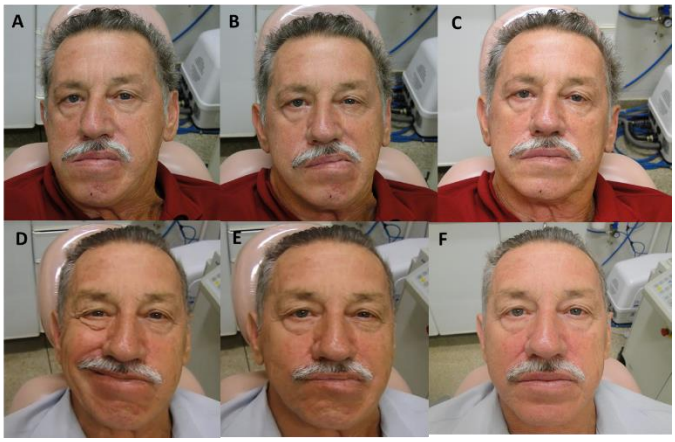


Figure 2: Patient's face A), B), C) before treatment and D), E), F) after the treatment. A) and D) illustrate the patient's face when pouting to the right side, B) and E) when pouting to the left side, and C) and F) when the patient's face is at rest. Movement with greater lateral excursion and a more symmetrical face could be observed after treatment.

2.2 Clinical Case 2

Our post-traumatic injury patient was 22-year-old, female, Caucasian, who had left-sided facial paralysis caused by herpes at 3 days before facial paralysis, and reported unilateral deafness. This patient was diagnosed with FN injury and cochlear vestibular nerve. This patient was treated with LLLT combined with vaccuumtherapy for a total of 3 months. Vaccuumtherapy was applied by using a Vacumlaser instrument (MMOptics, São Carlos, SP, Brazil) figure 3. by using circular suction cups of 60-mm and 40 mm of diameter size and and pressure of ~150 mbar in MP9 for 3 minutes. LLLT was applied by using 660-nm and 808-nm illumination for 3 minutes and ≤108 J per location. Simultaneous LLLT and vaccuumtherapy were applied throughout the facial nerve path (frontal, maxillary and mandibular region).

Figure 4 shows the restoration of smile symmetry and facial expression when comparing the facial symmetry and extent of facial movement before and after treatment .

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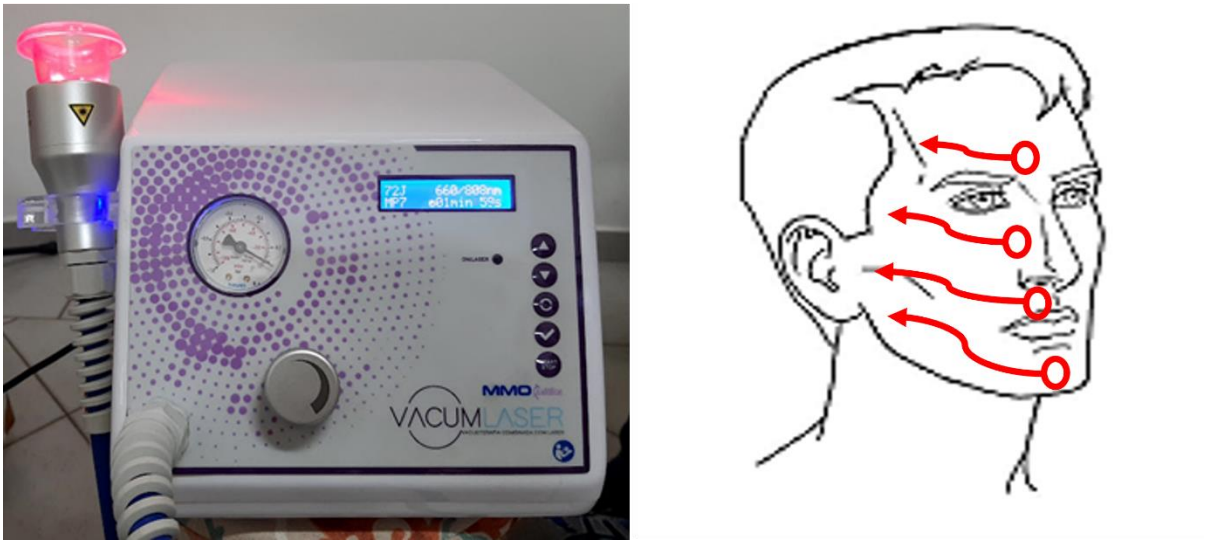


Figure 3: Right: LLLT + vacuum therapy device. Left: trajectories where suction cups slid on the patient's face.



Figure 4: Patient's face A), B) before treatment and C), D) after the treatment. A) and C) illustrate the patient's face when pouting and B) and D) when smiling. The photos show that a patient's normal front face and symmetrical smile could be observed after treatment.

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Table 1: Dosimetry parameters used for treatments.

Device	Clinical case number	Wavelength	Power	Time (per location)	Energy (per location)	Application
Twin laser (MMoptics)	Clinical case 1	808 nm	100 mW	60 s	6 J	In touch
Vacumlaser (MMoptics)	Clinical case 2	660 nm (3*) e 808 nm (3*)	600 mW divided into 6 laser spots around the active tip	3 min	≤108 J **	In touch

*(3) active tip – red or infrared **≤108 J after subtracting the lost energy at the spot distance from the tissue surface (dependent on the size of the suction cup).

3. RESULTS AND DISCUSSION

In this study, we have described two clinical cases showing effective LLLT treatment of FN palsies. Our findings corroborate with previous studies demonstrating the success of LLLT to treat morbidities requiring stimulation of nerve regeneration such as BP, paraesthesia, and trigeminal neuralgia. [3,82,86,87] Our study one of the first studies synergistic combining LLLT and vaccuumtherapy for the treatment of FN palsies in which neuromuscular restoration was observed after treatment. Our results indicated that LLLT could promote nerve regeneration for recovery of the normal function of patient facial muscles. Based on the obtained clinical results, we hypothesize that neuromuscular function of the pre-auricular region of the post-traumatic injury patient (clinical case 2) could be restored thanks to the increased blood circulation in the periphery of the inner ear promoted by vaccuumtherapy and LLLT. [88] If our hypothesis is correct, increased blood oxygenation could have favored the repair of the labyrinth tissues responsible for the patient's balance and hearing.

The underlying mechanisms behind photobiomodulation of damaged nervous tissue are still unknown and cannot be fully uncovered by our study. However, we believe our clinical case report can help future research to understand these mechanisms. Particularly for LLLT, one of the most defended hypotheses of photobiomodulation of cutaneous and subcutaneous nervous and muscle tissues is the increased in ATP production in mitochondria promoted by increased enzymatic activity of cytochrome oxidase and adenosine triphosphatase (ATP) involved in the mitochondrial respiratory chain. [89] Other hypotheses include the local production of pro-collagen, collagen and DNA [89], as well as increased nerve function via myelin production. [90]

With our clinical results in mind, we believe laser therapy could be a promising approach to nerve regeneration. The clinical relevance of LLLT should be confirmed by increasing the number of patients involved in the study and statistically monitoring if findings reported in this study are reproducible over a larger population. Nevertheless, it is important to remember that LLLT has potential to non-invasively treat FN palsies in diabetic or hypertensive patients, since these patients cannot be treated with corticosteroids.

4. CONCLUSIONS

As per the clinical cases presented in this study, LLLT alone or the synergistic combination of LLLT and vaccuumtherapy can successfully treat FN palsies by restoring facial symmetry and movement after therapy. Our study can be added to the LLLT literature promoting and clinical relevance of LLLT for nerve regeneration, given that our results agree with other publications in the literature. Our study may also help to unveil the mechanisms behind photobiomodulation of damaged nervous tissue, especially for restoration of facial neuromuscular function.

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