LOW REACTIVE-LEVEL 830 NM GaAlAs DIODE LASER THERAPY (LLLT) SUCCESSFULLY ACCELERATES REGENERATION OF PERIPHERAL NERVES IN HUMAN

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Forty patients with short and long-term neurosensory impairment following perioral nerve injuries are presented in this study. Assessment of their sensory level was undertaken using a variety of nerve tests, one of them was a visual analogue scale (VAS) for registration of sensitivity level prior to and after 10 treatment sessions and additionally for 21 of the 40 patients after 20 treatment sessions. Low level laser therapy (LLLT) was applied using GaAlAs 830 nm, 70 mW continuous wave. Dose of 6.0 J/cm^2 was standardized for all patients.

Improvement of the eight patients with clinical symptoms of less than 1 year after 10 treatments, was between 40–90% (average 51.9%) and after 20 treatments between 60–80% (average 66.7%) for the three patients who continued with the treatment. In 32 of the 40 patients with clinical symptoms of more than 1 year duration, their improvement was estimated at between 40 and 80% (average 54.8%), 21 patients completed 20 treatment sessions and the end results were between 60–90% (average 71.1%). This was an uncontrolled clinical study of LLLT on perioral nerve injuries and demonstrated the effectiveness of GaAlAs laser on the nerve involved when applied to the nerve trunk and terminal endings. Although controlled research into actual mechanisms and pathways is needed, the preliminary findings are very promising.

KEY WORDS Perioral nerve injury LLLT Neural regeneration

Introduction

Since the first laser was developed by Maiman[1] in 1960, there have been many investigations of its use in a wide variety of medical and biological fields. This has been reported from different parts of the world[2–4] but its use is still highly controversial.[5] Its remarkable therapeutic success in the treatment of various nerve injuries was first reported in 1978[6], and the possible mechanisms governing its effects have been explored by many authors.[6] One group[7] found that LLLT on the bare nerve affected the nerve directly and its effects were both preventive and therapeutic. Other studies suggested that direct neural action may be responsible for the therapeutic effect.[8–10] Walker and Akhanjee[11] reported that application of LLLT over the skin overlying the medial nerve at the wrist in humans with 1-mW He-Ne laser was capable of producing somatosensory evoked potentials identical in latency with electrical stimulation of the same nerve. Nerve conduction in rats has shown that transcutaneous He-Ne laser irradiation doses in the range 4–10 J/cm^2 cause a significant increase in action potentials in the sciatic nerve and that this effect is considered to be consistent and long-lasting.[12] In another study, scar formation following nerve crush was reduced and again action potential magnitude increased due to He-Ne laser therapy compared to untreated contralateral controls.[13]

Other areas have been suggested as being suitable for LLLT: inflammatory diseases; wound or ulcers; pain condition of any kind; and regression of strawberry haemangioma.[14–18]

The management of patients with maxillofacial neurosensory impairment is one of the complicated aspects of dentistry. Several methods for surgical repair of injured nerves have been used over the years with valuable results, but they are often difficult to perform. Since the output power of low level laser therapy is non-distinctive, its use to stimulate injured nerves without surgical intervention would be highly desirable. In this uncontrolled study we report on the significant effects of LLLT on perioral nerve injuries particularly the inferior alveolar, mental and lingual nerves.

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Patients and Methods

The Laser

The laser system used was a biophoton (Ronving Dental Denmark) GaAlAs diode laser, consisting of a control console and a hand-held delivery probe, connected to the console by a flexible cable. The system delivers 70 mW output in continuous wave at 830 nm in the near infrared, and is used in contact pressure technique. The laser gives a spot size of approximately 0.16 cm^2, with a probe diameter of 18 mm and an incident power density of around 437.5 mW/cm^2. The laser beam was applied at the nerve trunk (i.e. mandibular foramen), third molar, mental foramen and lower lip areas for inferior alveolar nerve therapy. The internal oblique ridge and then worked along the lateral border of the tongue from posterior to anterior for the lingual nerve treatment. When the mental nerve was treated, the mental foramen, lower lip and chin areas were irradiated. Treatment time per point was around 90-s mark, giving an incident energy density of 6.0 J/cm^2. Patients were treated three times per week until a satisfactory degree of sensation was achieved.

Patient Population

There were 29 female and 11 male patients, a male/female ratio of 2.6:1, giving a total of 40 patients. The ages ranged from 26 to 90 years (mean: 44.9 years). Duration of clinical symptoms varied from 2 to 132 months (mean: 42.9 months). Ten treatment sessions with LLLT were given for all the 40 patients. The patients graded the effectiveness of their therapy after two weeks from the day we completed the treatment. Twenty-four of the 40 patients continued with 10 more sessions, and again they graded the effectiveness of their therapy after two weeks. It was noted that all of the patients were receiving laser therapy only, without any other concomitant therapy or medications.

Trauma Entities

Patients were divided into groups according to their duration of clinical symptoms. Tables 1 and 2 show the possible causes of nerve injuries and the distribution of nerve involved and sex in the total patient population. It can be seen that surgical removal of lower right and left molars were the most common causes in the group, at 45% ($n = 18$) and 15% ($n = 6$) respectively. Those patients who went through sagittal split osteotomy accounted for 15% ($n = 5$). Other factors which might be responsible for nerve damage include fracture, inflammation, excision of hyperplastic tissue, tumour, needle injury which might cause intraneural haematoma and incision at the retromolar pad because of the variations in the course of the lingual nerve in this area.[19–20]

Table 1. Possible causes of trauma on peripheral nerves in 40 patients

Surgical procedure	Tooth no.	No. of patients
Surgical removal of lower	48	18
wisdom teeth	38	6
Extraction	48	2
Apicoectomy	35	3
	45	2
Osteotomy (SSO)		5
Implant region	46	1
	35	1
Endodontic	46	1
Needle injection region	35	1
Total		40

Table 2. Distribution of nerve involved and sex in 40 patients

Nerve	Male	Female	Total
Inferior alveolar	7	17	24
Mental	3	3	6
Lingual	1	9	10
Total	11	29	40

All patients with long- and short-term neurosensory impairment after traumatic nerve injuries were evaluated. Each patient was asked subjective questions such as the degree of numbness, tingling, burning or indeed any change. In addition objective tests were carried out for response to light touch and pin-prick stimuli. A two-point discrimination test and visual analogue scale (VAS) were also monitored. The visual analogue scale was used for registration of the grade of sensitivity level prior to and after the treatment. Two-point discrimination was measured in the traditional fashion using a vernier calipers. It was used by stroking the dorsal surface of the tongue or mucosa from behind forward, applications being made to each side in turn. Patients were asked to discriminate one-point with the calipers closed, from two-point at varying distances between the points. Normal measure of sensation vary from 7 to 14 mm, they are considered diminished at from 15 to 20 mm and absent above 20 mm.[21] A visual analogue scale was subjectively measured by means of a scale line marked '0' at one end representing lowest sensitivity level of '100' at the extreme end-point representing maximal sensitivity level. Patients were asked to estimate the effectiveness of LLLT on the scale.

Table 3. Clinical condition of 40 patients pretherapy and after 10 treatment sessions with LLLT

No. of patients	Duration of symptoms	Sensitivity level (%)	Range of improvement	Average
8	Less than 1 year	0–20	40–90	51.9
32	More than 1 year	0–50	40–80	54.8

Table 4. Result of patients who completed 20 treatment sessions with LLLT

No. of patients	Duration of symptoms	Range of improvement	Average
3	Less than 1 year	60–80	66.7
21	More than 1 year	60–90	71.1

Results

Tables 3 and 4 show the response of patients before, after 10 and 20 treatment sessions. It shows that eight patients with clinical symptoms of less than 1 year's duration, pretherapy sensitivity level ranged between 0 and 20% on the visual analogue scale (VAS). After 10 treatment sessions, improvement of sensation ranged between 40 and 90% (average 51.9%) and final end results of the three patients who completed 20 treatment sessions between 60 and 80% (average 66.7%). In 32 patients with clinical symptoms of more than 1 year's duration, pretherapy sensitivity level ranged between 0 and 50%. After 10 treatment sessions improvement of sensation was estimated between 40 and 80% (average 54.8%) and final results of the 21 patients who completed 20 treatment sessions was between 60 and 90% (average 71.1%) as estimated by the patients on the VAS.

The patients in this study are satisfied with the effectiveness of LLLT. They all feel they have benefited from the treatment and are feeling more comfortable than before the laser therapy.

Table 5 shows the percentage and numerical values for the whole patient population. The effectiveness of their therapy is graded into four groups from excellent to poor. No patient complained of any adverse side-effects. In the 40 patients who received 10 treatment sessions, only two patients were in the 'poor' rating, with 5% (n = 2). For the patients who continued for 20 treatment sessions, 30% (n = 12) of the patients rated their result as 'good'. Only 21 (three with less than 1 year and 19 with more than 1 year duration of clinical symptoms) patients completed the 20 treatment sessions.

Table 5. Percentage and numerical values for the whole patient population

Effect	Excellent	Good	Fair	Poor
10 treatment sessions	15% (n = 6)	30% (n = 12)	50% (n = 20)	5% (n = 2)
20 treatment sessions	42.9% (n = 9)	57.1% (n = 12)	—	—

Discussion

Recent clinical and experimental studies on photobiological and photochemical effects of LLLT as a biostimulator device showed that LLLT on injured peripheral nerves improved nerve function.[22,23] Explanation of its therapeutic effects remains equivocal! Reviewing the literature, the effects of LLLT can in general be characterized as antiphlogistic and stimulative on cellular metabolism with a secondary effect on pain.[24] The possibility of triggering nerve cell response and selectively affecting the myelin sheaths, combined with the assumption that LLLT is a non-aggressive therapy, permitted us to use it for treatment purposes. The GaAlAs laser delivered to the skin and oral mucosa penetrates the living tissues, and maybe a significant part of it reaches the nerve lying some 4–8 mm under the oral mucosa and bone.[25]

Regarding the range of all therapeutic lasers (0.1–5 mW) and duration of exposure (20 s–15 min) found in the literature, no major thermal effects have been demonstrated (maximal temperature elevation 0.22°C) at either receptor or neural depths.[26] It has been suggested that when LLLT is applied to the injured peripheral nerve, it prevents a drop in action potential, obviates scar formation, increases vascularization, mitigates degeneration of the surrounding muscle, and accelerates regeneration of the injured nerve.[27,28] These studies are primarily based on positive clinical experiences.

In this an uncontrolled study, we found out that LLLT with a dose of 6.0 J/cm^2 applied directly over the mucosa covering the nerve trunk and terminal endings was suitable in the treatment of nerve injuries after trauma. Using the optic fibre of the laser equipment it is easy to direct the laser beam to the areas around the nerve affected. Inferior alveolar, mental and lingual nerves were selected because they are easily damaged during dento-alveolar surgical procedures.

LLLT on the nerves studied did not demonstrate temperature elevation or other sensations at the first week of treatment. A typical finding at the fourth week was that the patients experienced tingling, burning, prickling, twitching, stretching or crawling-like sensations for the first time. At the fifth and sixth week for those patients who continued for 20 treatment sessions, (particularly the lingual nerve) the nerve became sensitive. This agrees with the findings of Olsen *et al.*[29] that neurons could become sensitive under the influence of LLLT, but this effect diminishes above a certain threshold energy flux.

However, whether laser effect is dependent upon the wavelength of the light, irradiance or dose is still unclear. In our clinical experience, the energy delivered at each point was possibly sufficient enough and this might have resulted in sufficiently deep penetration to the target; i.e. the myelin sheaths of the nerves. In our experience, when the energy delivered to the nerve trunk area and the terminal endings of the nerve involved was less than 3.0 J/cm^2 per point, there was no effect after three treatment sessions.

The significant effects with LLLT in this and other studies performed earlier by the authors,[30] has encouraged us to continue with an aggressive treatment programme for perioral nerve injuries. However, further investigation is required to determine the biostimulative effect of LLLT. Before this method of perioral nerve injuries treatment with LLLT is advocated, controlled prospective studies need to be conducted to rule out probable placebo effect. Such effect is supposed to be determined by several independent factors in the setting of the study, the examiner–patient relationship and the beliefs and expectations of the patients. The significance of applying a new treatment method, which has obtained much public interest should not be overlooked. However, the method is a new and non-invasive procedure, which may be useful in the treatment of peripheral nerve injuries in cases where the nerve has not lost its continuity. It is low cost, not painful, apparently harmless and technically an easy treatment to perform. Peripheral nerve surgery is unpredictable, and LLLT should be tried prior to microsurgical reconstruction of the nerve.

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