Laser acupuncture - innovative basic research: visual and laser-induced evoked potentials

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Background and aims: Laser acupuncture is a therapeutic medical method. Innovative basic research is necessary within this fascinating area of research. This publication focuses on visual evoked potentials (VEP) elucidated by non-invasive and partially non-perceptible laser stimulation.

Materials (Subjects) and Methods: The first part of this study presents systematic VEP-monitoring in connection with laser acupuncture and manual needle acupuncture in 40 healthy volunteers. The second part deals with bilateral non-perceptible laser needle (638 nm, 40 mW, 500 µm, 1 Hz) irradiation of the Neiguan acupoint (PC6) in a 26-year-old female healthy volunteer using a new 32-channel evoked potential analysis technique.

Results: We were not able to find significant changes in latency or amplitudes of VEPs during laser acupuncture within the first part of the study. However in the second part we report about human cerebral evoked potentials after non-perceptible laser stimulation.

Conclusions: The findings indicate that exposure to laser needle stimulation with a frequency of 1 Hz can modulate the ascending reticular activating system. Further studies are necessary to confirm or refute the very interesting findings.

Key words: Laser acupuncture, laser needle, neuromonitoring, neuroscience, VEP, acupuncture, laser, evoked potential.

INTRODUCTION

Laser acupuncture offers a safe and therapeutic medical modality that is nearly free from side effects. There have been many progresses within the last years; however ongoing innovative basic research is still necessary within this fascinating area of research. Our European research team has published more than 150 peer reviewed papers on this topic (www.pubmed.gov; www.litscher.info). This publication focuses on visual evoked potentials elucidated by non-invasive and non perceptible laser stimulation. The results open new insights not only in laser acupuncture research but also in general laser medicine.

Visual evoked potentials (VEP) are of particular importance for the quantification of organic and functional defects in the visual system. 1) For this reason the function of the primary visual pathway, which is not directly influenced by the brain stem, has to be examined. For example, in connection with pathologic states of consciousness, especially somatosensory 2) and auditory 3) evoked potentials (EPs) are described; in both cases, the primary pathway passes through the brain stem and the EPs are altered characteristically during comatose states. 1,3,4,5)

The first part of this publication 6) presents the use of systematic VEP-monitoring in connection with laser and manual acupuncture in 40 healthy volunteers. The irradiation of the skin overlying the median
nerve of the wrist in humans using a helium-neon laser stimulation with a wavelength of 632.5 nm, an output power of 1 mW and a frequency of 3.1 Hz can produce a somatosensory evoked potential obtained at the Erb’s point on the shoulder. This evidence of photosensitivity in peripheral nerves was found by Walker and Akhanjee already in 1984.\(^7\)

The laser needle technology was first investigated scientifically at our Medical University of Graz.\(^8\) The method does not puncture the skin; the needles are only applied at the surface of the skin. Future oriented studies performed by our research group in cooperation with many other groups worldwide and published in high-level journals\(^9-17\) have shown that laser needle stimulation with different wavelengths can induce effects similar to those evoked by needle acupuncture.

The aim of the second part of this report\(^18\) was to investigate if there is any measurable evoked potential in the brain after ‘laser needle’ stimulation at the Neiguan acupoint (PC 6), which is also located at the wrist, near the median nerve.

**MATERIALS AND METHODS**

**Volunteers**

Forty healthy volunteers aged between 20 and 45 years (mean age ± SD: 24.8 ± 4.7 years), 27 female and 13 male, took part in this study. None of the volunteers had striking ophthalmologic findings or were taking central nervous system effective medication at the time of examination. All test persons had an inconspicuous psychological and neurologic status and anamnesis. This part of the study was approved by the ethics committee at the University of Graz (11-017, 00/01).

The subject for the second part of our investigations was a 26-year-old female who was sitting in a special sound booth. The box is located at the Department of Psychology, Neurophysiology at the University of Graz (Fig. 1a,b).

**Stimulation, registration and evaluation parameters**

Registration of VEPs was done with equipment from Axon Systems Inc., Hauppauge, N.Y., USA. Recording of bioelectrical evoked brain activity was performed from Oz to Fz using a grounding electrode GND between Oz and Fz in accordance with the international 10:20 system (Fig. 2).

Written informed consent was obtained by the subject, and the investigations were also approved by the ethics committee of the Medical University of Graz (13-048, Laserneedle-Stimulation). The subject was not taking medications and had no neurological or psychological impairments. The volunteer was informed about the nature of the investigation, as far as the study design allowed, and the measurements were performed in accordance with the Declaration of Helsinki.

**Fig. 1:** (a) Healthy volunteer during ‘laser needle’-EEG (electroencephalography) experiment in Graz, Austria (with written permission of the subject). (b) Bilateral stimulation of the Neiguan acupoint (PC 6).

**Fig. 2:** Schematic illustration of the recording and stimulation method of VEP (above) and measurement procedure (below).
For electroencephalographic recordings (EEG) we used new EEG-cable electrodes \(^ {19} \) and adhered them with conductive paste (Grass EC2). Electrode impedance was always below 5 kOhm. In order to examine the visual system, light stimulation with a stimulus frequency of 1.8 Hz was applied at 3 second intervals by special spectacles having 6 integrated “high-intensity-lamps”.

Filters were set at 1.0 to 100 Hz and \( n = 130 \) stimuli were averaged. The analysis window comprised 0 to 400 ms and the stimulus was presented binocularly with closed eyes.

The absolute latency of components N75 (L1), P100 (L2) and N140 (L3) as well as the amplitudes N75/P100 (A1) and P100/N140 (A2) were used as evaluation parameters in the study of the 40 volunteers. \(^ {6} \)

Laser needle stimulation (Laserneedle GmbH, Berlin, Germany) allows the continuous stimulation of one or more acupuncture points on the body, the head, hands or ears. \(^ {8, 20-31} \) In the second part of this investigation, laser irradiation of 658 nm and 55 mW laser diodes was coupled into an optical fiber and the laser needle was arranged at the distal end of this fiber. Due to coupling losses, the output power of the laser needles was reduced to 40 mW. The fiber core used in this study was 500 \( \mu \)m in diameter. Stimulation frequency was 1 Hz. The method is described in detail in previous publications. \(^ {8, 20-31} \)

In order to have the laser pulses act as the sole stimulus to the average with the EEG recording system, each flash of the laser was accompanied by a 5 V pulse signal that triggered the average.

As in further studies, \(^ {7} \) control experiments were performed to eliminate the possibility that the evoked potential obtained after laser irradiation was influenced by timed artifacts arising from the interface between the laser instrument and the signal averaging system.

For the EEG investigations in this female volunteer we used two USB biosignal amplifiers (g®, USBamp generation 3.0) with 16 input channels each. For all channels, the simultaneous sample rate was set to 512 Hz (24-bit resolution) with a high-pass filter at 0.1 Hz, a low-pass filter at 100 Hz, and a notch filter at 50 Hz. \(^ {18, 32} \)

In the present investigation, we recorded 32 EEG-channels. The electrodes were positioned on the cap according to the 10-20-system; the reference electrode was placed on the nose, and the grounding electrode was placed behind the ear above the mastoid process (compare Fig. 1a). Electrode impedance was again less than 5 kOhm in each position. \(^ {18, 32} \)

The software package MATLAB® was used for the analysis of the evoked potentials. After a visual inspection of the raw EEG data, trials containing artifacts were marked and omitted from further analysis. Afterwards the raw EEG was band pass filtered between 0.8 and 10 Hz. Finally, altogether about 600 trials were averaged from the processed EEG.

In a control measurement, the optical stimulation of the laser needle was visible for the healthy volunteer. To avoid a direct stimulation of the eye, the subject wore eye protection glasses, and the light source was located behind a screen.

**Acupuncture**

**Guangming (GB37):**
- **Localisation:** 2 cun under the middle connecting line to point GB34 and the most prominent point of the lateral malleolus.
- **Depth:** 1 - 2 cun vertically
- **Indication:** Pain in the left lateral side of the lower leg, visual impairment.

**Taichong (LR3)**
- **Localisation:** At the proximal angle between os metatarsale I and II, where the corpus and base regions of both bones approach one another.
- **Depth:** 0.5 - 1 cun vertically
- **Indication:** Lateral head pain – migraine headaches, muscular overstraining, muscle cramps, spasmolytic effect, opens eyes.

**Zhiyin (UB67)**
- **Localisation:** Lateral corner of the nail of the 5th toe
- **Depth:** 0.1 cun vertically
- **Indication:** Headache, rotation of child in breech or lateral presentation, clears eyes and vision.

The acupuncture points used in the first part of the study, represent corresponding points for vision, according to Traditional Chinese Medicine. \(^ {33} \) These points were needled after local disinfection of the skin, with sterile single-use needles 25 x 0.25 mm (Huan Qiu, Suzhou, China).

Laser acupuncture was performed with a “Profilaser” series PL (Silberbauer, Vienna/Austria; 670 nm, 50 mW). Each point was stimulated by the same person for duration of 20 seconds. This device belongs to the laser class 3b. The appropriate laser protection glasses were used.

“Placebo-needling” was performed at points which according to Traditional Chinese Medicine, were whether located on meridians or were actual acupuncture points (between the proximal approaching area of metatarsal bones 3 and 4).

The following measurement procedure was selected in the first study section (compare Fig. 2):
(A) 2 minutes before to needling, (B) 2 minutes after applying needles and during stimulation, (C) 2 minutes after removing needles, (D) 2 minutes before laser acupuncture, (E) immediately after 20 seconds of laser acupuncture, (F) 2 minutes after completing laser acupuncture, (G) 2 minutes before needling placebo-points, immediately after applying the needle at the placebo points and (I) 2 minutes after removing the needles at the placebo points. Between measurement phases A-B-C (acupuncture), D-E-F (laser acupuncture) and G-H-I (“Placebo”), 5-minute resting periods were made. The modalities (A-B-C, D-E-F and G-H-I) were applied in a randomized manner.

For the second part of the study, the laser needles were placed on the skin at the Neiguan (PC6) acupuncture point bilaterally (Fig. 1b). PC6 is situated between the tendons of the palmaris longus and flexor carpi radialis muscles, 2 cun proximal to the transverse crease of the wrist. The stimulation with red light (658 nm) was not felt by the subject. The volunteer has open eyes, however, the stimulation area was covered, and therefore the subject could not see whether the stimulation was on or off (compare Fig. 1a,b).

Statistical analysis

Data for the 40 volunteers was tested with Kruskal-Wallis one way ANOVA using the statistic program SigmaStat (Jandel Scientific Corp., Erkrath, Germany). The level of significance was $p < 0.05$.

RESULTS

Figure 3 shows a typical example of VEPs from a 22-year-old volunteer. In addition to the absolute latencies (N55, P103 and N127) the amplitudes from N55/P103 and P103/N127 are registered as evaluation parameters.

![Visual evoked potentials from a 22-year-old volunteer. The absolute latencies (L1, L2 and L3) and amplitudes (A1 and A2) are registered as evaluation parameters.](Fig. 3)

Figure 4a graphically documents the results of latency of the P100-component (L2) from all 40 volunteers in a box-plot-illustration. No ($p=1.0$) changes in latency (L1, L2 and L3) during the individual measurement phases occurred. The amplitude values (A1 = N75/P100) from the 40 volunteers investigated in this study are shown in Figure 4b. Only minor and no significant changes ($p=0.948$) during the different measurement phases occurred. Evaluation of the amplitude A2 ($p=0.998$) yielded similar results. However, we note that alterations in latency as well as amplitude during the placebo measurement were the slightest.

![Box-plot-illustration: The horizontal line in the box indicates the position of the median. The ends of the box define the 25th and 75th percentile; the error bars mark the 10th and the 90th percentile.](Fig. 4)
The result of the 32-channel visual evoked potential analysis of the second study part is displayed in Figure 5.\textsuperscript{18)}

Figure 6 shows the same procedure, however the laser light stimulation at the Neiguan acupuncture point was not visible and not perceptible for the subject (compare Fig. 1a,b). Only very small, but reproducible evoked potentials are detectable, mainly over the central and frontal region.\textsuperscript{18)}

To facilitate comparison between the results of the visual evoked potentials and the laser-induced evoked potentials, the two measurements are plotted on top of each other in Fig. 7.\textsuperscript{18)}

**DISCUSSION**

There are currently 595 referenced publications concerning the topic laser acupuncture in the scientific database Pubmed (August 2012). However the basic mechanisms of laser acupuncture are still a hot topic of research and still not solved up to now.

Investigation of visual evoked potentials is primarily performed by neurologic and ophthalmologic problems concerning the substantial and functional integrity of the visual system. It is also used for diagnosis of comatose states, especially in combination with multi-modal techniques.\textsuperscript{1,3-5)}

In an animal study with rabbits, Shen et al.\textsuperscript{35)} investigated VEP as an integral part of a multi-modal series in combination with somatosensory and auditory evoked potentials during acupuncture. The authors of this Chinese article described a significant decrease in amplitude of all components.\textsuperscript{35)}

Scientific studies with humans concerning VEP and acupuncture has only been performed by other research teams on 12 hemianoptic patients.\textsuperscript{36)} In this study Poletti et al.\textsuperscript{36)} describe that the VEP amplitudes located ipsilateral to the occipital lesion after periorbital acupuncture were pronounced. A further publica-
tion 37 describes changes in VEPs in patients suffering from endogenous depression. Duan et al. 38 even attempted to objectivize the connection between the amplitude of the P100 component and different acupuncture points on different meridians. The authors described that a connection between all meridians to the visual system exists, however the needling of placebo points shows no changes in VEP. The extent of these alterations should be variable. Only the acupuncture points located on the bladder meridian indicated activation of VEPs, however the stimulation of acupuncture points on other meridians showed inhibitory effects on VEPs. 38

In the first section of our study including 40 healthy volunteers, we were not able to find significant changes in latency or in the amplitudes of VEPs. The fact that the amplitudes of VEPs can slightly decrease after reduction in concentration but the latencies remain unchanged, must be considered in this part of the study. This mainly applies to latencies > 200 ms, which were not registered or evaluated in our study. In addition, continuous VEP monitoring for more than 3 minutes without pausing could falsify measurement results. This could also be the reason for the different final values among the single measurement phases (A, D and G in Fig. 4a+b). Three different acupuncture points on different meridians were used simultaneously. Thus a correlation with other studies in which blood flow velocity after manual stimulation of acupuncture needles significantly increases in the posterior cerebral artery, is not really possible. On the other hand it is conceivable that at variable time differences, between reproducible and significant changes in cerebral blood flow velocity and alteration in VEPs occur and/or modulation may not be quantifiable due to limitations based on the technical equipment available.

An irradiation, as from a laser, is not a stimulus found in nature. Lasers allow brief pulses (µs to ms) with very fast rise time. 39 The laser needle used for Neiguan acupuncture point stimulation in the second part of the study do not produce high temperatures, however, the penetration depth of the focused red laser light (658 nm) is about 3 – 4 cm. 8 Other experiments have indicated that brief high heating rate diode laser pulses can selectively activate myelinated Aδ fiber nociceptors in rats and produce pricking pain in humans, whereas low heating rate, longer pulses can preferentially activate unmyelinated C fibers in rats and produce burning pain in humans. 39-43 There is no evidence whether these different pulse parameters will differentially activate fibers in humans.

In the second part of our study, the laser needle stimulation (658 nm) was not felt by the subject. It is very interesting that this non-perceptible optical stimulation can lead to cortical responses. This finding appears to be unique in literature. 18 To the best of our knowledge, there are no studies in scientific literature describing this phenomenon. Some reports concerning the effects on human brain EEG caused by manual needle stimulation at the PC6 acupuncture site are available. 34 These authors found that the frequency peaks in alpha-band of 12 channels were more synchronized during and after acupuncture. 34

Conscious perception of stimuli requires two intact systems:

First, the specific input system which results in an evoked potential.

Second, the unspecific system called ARAS, the ascending reticular activating system which was first investigated by Moruzzi and Magoun. 44

There is an example which is similar to the mechanism probably at work in our experiment; for example, during sleep, the ear is also in an activated state; auditory evoked potentials are possible although one does not consciously perceive the stimuli. Therefore it could be possible that laser stimulation modulates functional structures in the ascending reticular activating system.

Further studies with EEG and other neuromonitoring techniques like near infrared spectroscopy 45 and different stimulation methods are in progress and absolutely necessary to confirm or refute the preliminary findings. 18

CONCLUSIONS

Systematic VEP-monitoring in connection with laser acupuncture did not show significant changes in latency or in the amplitudes of VEPs during acupuncture. However we found very interesting small but reproducible human cerebral evoked potentials after bilateral non-perceptible laser needle (658 nm, 40 mW, 500 µm, 1 Hz) irradiation of the Neiguan acupoint (PC6).

Maybe exposure to laser needle stimulation with a frequency of 1 Hz can modulate the ascending reticular activating system.
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