Biological Effects Of Painless Laser Needle Acupuncture

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ABSTRACT
Laser needle acupuncture is a new method to stimulate acupuncture points. We describe the technique, its first use, and its value in acupuncture research. Laser needle publications we included are based on 511 measurements in 231 healthy volunteers (129 female, 102 male), with a mean (SD) age of 25 (3.5) years (range, 18-38 years). One pig experiment is also included.
The results of randomized, double-blind, controlled, crossover studies show that the methods of laser Doppler flowmetry, functional multidirectional transcranial Doppler sonography, functional magnetic resonance imaging, and near infrared spectroscopy are able to objectify and quantify peripheral and cerebral effects of laser needle acupuncture.
For the first time, we were able to investigate scientifically the differences between needle acupuncture, which includes pain stimulation, and laser needle acupuncture, a continuous multichannel method of painless acupuncture stimulation. Laser needle acupuncture can induce specific, reproducible changes in the brain. These can be expressed by shifts in different parameters, such as cerebral blood flow velocity.
KEY WORDS
Laser Needle Acupuncture, Acupuncture, Laser, Laser Doppler Flowmetry, Transcranial Doppler Sonography, Functional Magnetic Resonance Imaging (fMRI), Near Infrared Spectroscopy

INTRODUCTION
The stimulation of acupuncture points with laser light can evoke specific effects in the periphery and in the brain. These effects can be objectified and quantified using modern biomedical engineering techniques. Laser needle acupuncture represents a new, painless method for primary optical stimulation of acupuncture points.1-14 Laser needles are not inserted in the skin; they are simply applied to the acupuncture point. This method allows the simultaneous stimulation of individually combined points.

This study gives a current summary regarding scientific proof and innovative aspects of laser needle acupuncture. We discuss studies of the peripheral effects using registration of temperature and laser Doppler flowmetry8,9,13 as well as publications regarding the objectification of cerebral effects of laser needle acupuncture aided by functional multidirectional transcranial Doppler sonography,1-3,8,9,11,12 functional magnetic resonance imaging (fMRI),11,12 and near infrared spectroscopy.2,4-6,8,9

METHODS
Temperature and Microcirculatory Monitoring
The surface temperature of the skin and the measurement parameter Flux (= product of concentration and velocity of erythrocytes) were measured with the Laser-Doppler-Flowmetry Monitor DRT 4 (Moor Instruments, Millway, Axminster, England). A DPIT-probe (diameter, 8 mm; length, 7 mm) with a power of 1 mW was used. The edge frequencies were 20 Hz and 22.5 kHz.8,9,13

Functional Multidirectional Transcranial Doppler Sonography
The Multi-Dop T System (DWL Electronic Systems GmbH, Sipplin-gen, Germany) was used to measure the mean blood flow velocity in different cerebral arteries. A 4-MHz (ophthalmic artery), as well as 2-MHz probes (posterior cerebral artery, anterior cerebral artery , middle cerebral artery) were applied with a specially developed ultrasound probe-holding construction.
Functional Magnetic Resonance Imaging (fMRI) The fMRI investigations were performed using a 1.5-T total body system (Intera, Philips Medical Systems, Best, Netherlands). The blood oxygen level-dependent contrast sensitive images were acquired with a T2-weighted gradient echo sequence (single shot planar readout, flip angle 90�, TE 50 ms, FOV 250 mm, matrix 96 x 96 interpolated at 128 x 128, layer number 30, layer thickness 4 mm). A total of 144 volume images were registered

continuously in succession, with a repetition time of 5 seconds.

The fMRI-study was based on a block design with alternating resting conditions for 1 minute and 1 minute of laser needle activation. A total of 6 resting and 6 activation intervals were registered. Each fMRI data registration required 12 minutes.11,12

Near Infrared Spectroscopy

Near infrared spectroscopic investigations for monitoring laser needle acupuncture were done with the NIRO 300 Monitor (Hamamatsu Photonics, Japan). Measurement values and changes such as in oxyhemoglobin and desoxyhemoglobin were determined using the Lambert-Beer principle. Alterations in parameters could be measured absolutely with this system, but not the level (absolute concentration) at which these changes (in a positive or negative direction) occur. As long as no change in concentration was given, the measurement value was zero. The fixating of the sensor (emitter and near infrared detectors) on the head was done with a silicone holder.

Laser Needle Stimulation

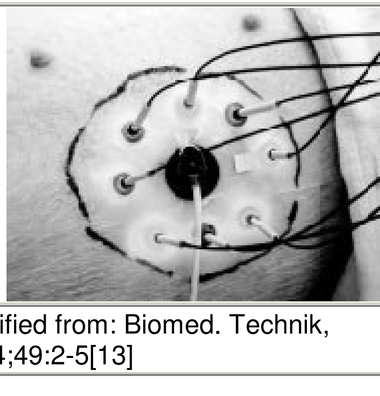
As mentioned, laser needle acupuncture (D. Schikora: European Patent PCT/EP 01/08504) allows the simultaneous stimulation of individual point combinations. Variation and combination of acupuncture points on the body are possible according to Traditional Chinese Medicine (TCM), or at the ear and hand using Korean (KHA) or Chinese(CHA) Hand Acupuncture. The laser needle method is based on a multichannel system with 8 separate semiconductor laser diodes and emission wavelengths of 685 and 785 nm. The system consists of flexible optical light fibers, which conduct the laser light without loss to the laser needle. Thus, a high optical density at the distal end of the laser needle is achievable. The intensity of the laser needles is optimized in such a way so that the patient does not feel the activation of the needle (30-40 mW per needle; diameter 500 mm; duration 10 min; power density 2.3 kJ/cm2 per acupuncture point). More details regarding this method are described in previous studies.1,6

Volunteers, Animal Experiments, and Procedures

This summarizing study presents a total of 511 measurements in 231 healthy volunteers (129 females, 102 males) with a mean (SD) age of 25 (3.5) years (range, 18-38 years). Protocols were approved by the local ethics committee, Medical University of Graz, and all volunteers gave their written consent. None of the volunteers had obvious visual, neurological, olfactory, or mental deficits, or were under the influence of drugs acting on the central nervous system. A maximum of 7 acupuncture points were investigated simultaneously in different measurement series.

Figure 1. Pig (top) and human experimental (bottom) studies using laser needle stimulation. Flux (product of concentration and velocity of erythrocytes), surface skin temperature, and room (R) temperature before (a), during (b-d), and after (e) laser needle activation.

Animal Experiment (sus scrofa domesticus), n=1



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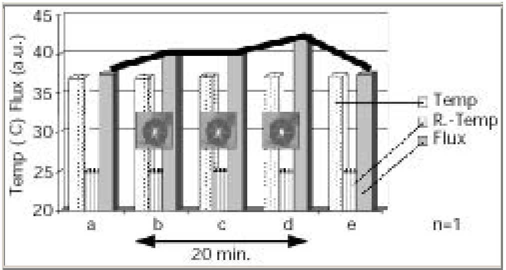
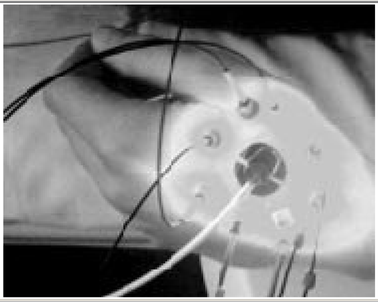


Healthy volunteers: mean age 6 SD: 24.4 6 2.6 yrs; 12f, 10 male, n=22



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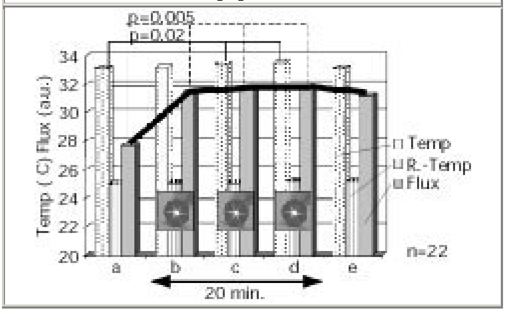


In addition, an animal study (pig) was included in this report. The pigs were put under general anesthesia in the animal surgical suite of the Department of Surgical Research at the Medical University of Graz. This study was performed in accordance with the rules defined by the ethics committee (animal study approval number GZ 66.010/10-BRGT/2003).

Statistical Analysis
Data were analyzed with 1-way repeated measure analysis of variance using the computer program SigmaStat (Jandel Scientific Corp, Erkrath, Germany). The tests described in single publications were used for post hoc analyses. The level of significance was defined as P<.05 when no other value was explicitly given.

The fMRI data were analyzed and evaluated with statistical parametric mapping software (SPM 99, Department of Imaging Neuroscience, Lon-don, England). All images of the volunteers were newly organized and the 1st picture was used as reference, whereby "sinc-interpolation" was used.

Functional data were spatially smoothed with a 6-mm full width at half maximum isotropic kernel. A boxcar waveform convolved with a synthetic hemodynamic response function was used as the reference waveform. A t test was performed to identify regions showing significantly higher activation during the activation condition vs the resting condition. For significantly activated regions, a statistical threshold of P<.05, corrected at the cluster level for multiple comparisons, was used. The activated regions were located using the Tailairach space.

Evaluation Parameters
Temperature (surface skin temperature and room temperature), flux, partially simultaneous and continuous measurement of mean blood flow velocity (vm) in the ophthalmic artery, middle cerebral artery, posterior cerebral artery, and anterior cerebral artery at different measurement times were determined. A number of volunteers underwent testing using different acupuncture schemes. The interval between the single experiments was 30 minutes to 1 day, and the volunteers were instructed to keep their eyes closed during the entire active examination phase. In a similar manner to fMRI examination, the volunteers were unable to determine whether the laser needles had been activated or deactivated.

RESULTS
Figure 1 shows in summary the results of an animal study13 and a non-therapeutic biomedical engineering study with volunteers8,9 regarding the periphery effects of laser needle acupuncture. The flux, hand, and room temperature parameters were summarized at different measurement points. There was a significant (P = .005) increase of flux in the volunteers during 20 minutes of laser needle stimulation. The results of the animal study showed that laser needle stimulation (wavelength, 685 nm; power density, 4.6 kJ/cm2 per point; duration, 20 minutes) can cause alterations in microcirculatory parameters of the skin, in the sense of increased circulation; however, the laser quality and intensity did not induce any micromorphological changes in the skin.13

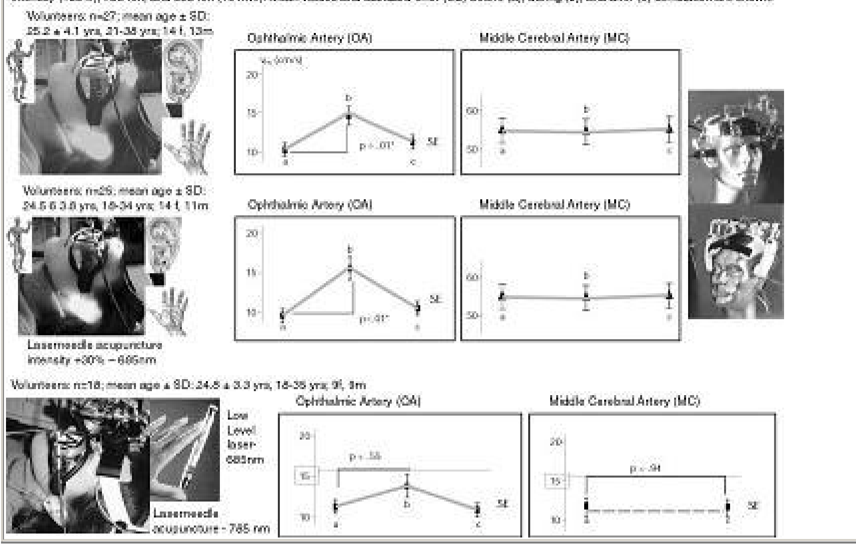


Figure 2. Specific changes in mean blood flow velocity (vm) under laser needle acupuncture (from top to bottom: 685 nm, 685 nm with increased intensity (+30%), 785 nm, and 685 nm (19 mW). Mean values and standard error (SE) before (a), during (b), and after (c) stimulation are shown.

Figures 2 and 3 document specific changes in cerebral blood flow velocities in different arteries. Using the laser acupuncture scheme (TCM: Zanzhu and Yuyao; ear: eye and liver; KHA: E2; CHA: Yan Dian), the blood flow velocity in the ophthalmic artery using a wavelength of 685 nm increased significantly (P = .01). However, a 30% increase in stimulation intensity only increased vm in the ophthalmic artery to a mean value of 11%. Simultaneously, no significant changes in vm occurred in the middle cerebral artery. Using laser needle acupuncture with a wavelength of 785 nm, a marked but nonsignificant (P = .55) increase in vm in the ophthalmic artery during stimulus application occurred. Brief stimulation (20 seconds each) of the single points with a hand-held low-level laser (19 mW) did not reveal any significant (P = .94) differences in vm in the ophthalmic artery concerning the conditions before and after stimulation.

Figure 3

Figure 3. Laser needle acupuncture study in a double-blind, randomized, crossover design. Changes in blood flow vm before (a), during (b-d), and after (e) activation of laser needles according to the specific laser acupuncture scheme (A or B). Volunteers: n=22, 12 female, 10 male; 21-29 years (24.4 ± 2.6 years; x ± SD)

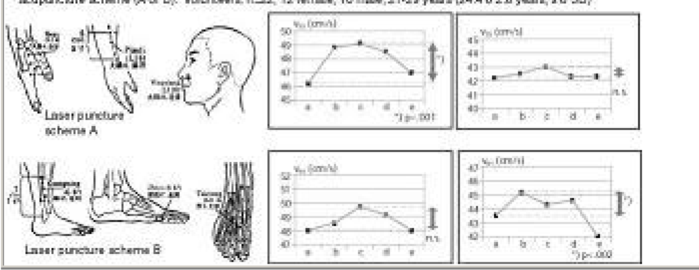
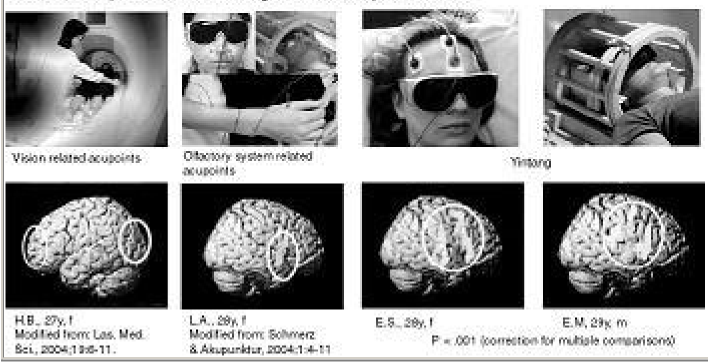


Figure 3 shows the changes in vm in the anterior and posterior cerebral arteries when applying different laser acupuncture schemes. When using laser acupuncture scheme A, vm increased during stimulation significantly in the anterior cerebral artery (P<.001) and was still higher at the end of the experiment than before laser acupuncture. At the same time, insignificant changes in vm occurred in the posterior cerebral artery. During optical stimulation of the acupuncture points in scheme B, a significant increase (P<.002) in vm in the posterior cerebral artery took place, although simultaneously nonsignificant changes in the anterior cerebral artery were observed.

Figure 4

Figure 4. Functional magnetic resonance images illustrating activated cerebral regions after laser needle stimulation. Specific cerebral activation patterns are shown according to the selected acupuncture schemes.



The first fMRI results using laser needle acupuncture are summarized in Figure 4. Significant (P<.05) changes in brain activity were registered in the occipital and frontal regions during stimulation of distant, visual acupuncture points and near the olfactory cortex during the activation of acupuncture points, which, according to TCM, have a connection to the sense of smell. Further, significant (P<.001) activation occurred after stimulating the Yintang point in the fronto-parieto-temporal region, with massive electroencephalographic alterations (appearance of frontal delta activity).10

Figure 5. Cerebral changes in near infrared spectroscopy in mmol of oxyhemoglobin during needling of a placebo point, 3 hand acupuncture points, 2 ear acupuncture points, 2 body acupuncture points according to TCM, a combination of hand, ear, and body acupuncture points, as well as laser needle stimulation, and increased (+30%) laser needle stimulation (from left to right), during and 5 minutes after acupuncture. Modified according to reference 6.

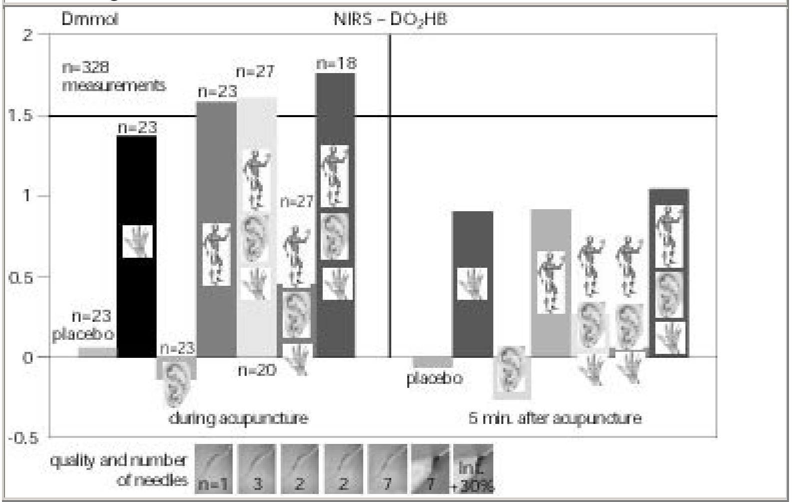


Figure 5 shows, in summary, frontal and non-invasively registered changes in oxyhemoglobin during and after needle or laser needle acupuncture (same scheme as in Figure 2). Whereas nearly no changes during acupuncture of placebo points took place, increases during laser needle acupuncture were obvious.

Figure 6

Figure 6. Stimulus intensity (SI) as a function of time. From left to right: hypothesis, real measured cerebral reactions of near infrared spectroscopy (NIRS) measurement parameters oxyhemoglobin (O2Hb) and desoxyhemoglobin (HHb), as well as the bioelectric response (EEG-BIS). Modified according to references 4, 6, and 10.

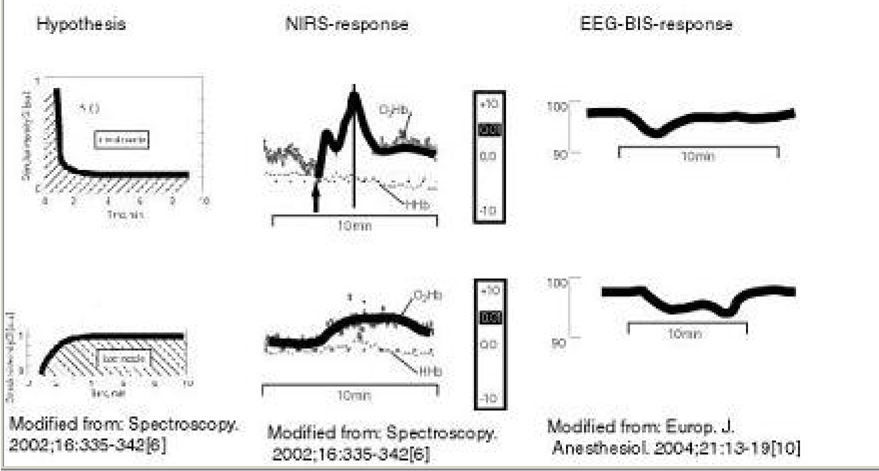


Figure 6 (at the left) shows the hypothetically assumed course of stimulus intensity, in random units of a metal and laser needle, as a function of time. At the right, real time signals registered with near infrared spectroscopy and bioelectric methods are illustrated.

DISCUSSION

Innovation and laser are nearly synonymous. In 1917, Albert Einstein already formulated the physical foundation for so-called light intensification with stimulated emission. In the field of medicine, laser not only allows careful treatment for patients but also, a manifold of selective therapies in nearly all special fields. Laser has become an important instrument in acupuncture for the treatment of small children or patients with needlephobia.

Our goal was to give a summary about previous clinical experimental studies dealing with this new method of optical acupuncture stimulation. Since the volunteer or patient does not feel the intervention, the different acupuncture points can be stimulated continuously and simultaneously. The double-blind, randomized, controlled, crossover studies indicated that cerebral effects of this manner of stimulation are nearly equivalent to that of needles. In addition to complex multidirectional sonography, it was also possible to provide proof regarding cerebral functional changes after laser needle stimulation using fMRI for the first time. At the same time, points "near the head" could be stimulated during fMRI examination, which has not been possible with acupuncture needles and hand-held laser instruments.

These findings may be of great importance, not only for the field of laser medicine but also for acupuncture research in general.

CONCLUSION

We report that laser needle acupuncture allows simultaneous optical stimulation of individual acupuncture point combinations. Variations in acupuncture on the body, ear, or hand, as performed and described in these studies, are also possible. The studies were able to objectify and specify the cerebral effects of laser needle stimulation for the first time. The cerebral effects triggered by this new, painless laser needle technique were of similar dimension to those evoked by manual needle acupuncture.

Painless laser needle acupuncture can induce specific, reproducible changes in the brain. These can be expressed by shifts in different parameters, such as cerebral blood flow velocity.

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