

Cerebral effects of noninvasive laserneedles measured by transorbital and transtemporal Doppler sonography

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Abstract

Laserneedles represent a new noninvasive optical stimulation method which is described for the first time in this paper. We investigated 27 healthy volunteers (mean age \pm SD: 25.15 \pm 4.12 years; range: 21 - 38 years; 14 female, 13 male) in randomized cross-over trial to study differences between laserneedle acupuncture and manual needle acupuncture in specific cerebral parameters. Mean blood flow velocity (v_m) showed specific and significant increases in the ophthalmic artery during laserneedle stimulation ($p=0.01$) and during manual needle stimulation ($p<0.001$) at vision-related acupoints. At the same time insignificant alterations in v_m were found in the middle cerebral artery for both acupuncture methods. Optical stimulation using properly adjusted laserneedles has the advantage that the stimulation can hardly be felt by the patient and the operator may also be unaware of whether the laserneedle system is active, and therefore true double blind studies can be performed. Further studies using different laser stimulus intensities and wavelengths are in progress to optimize the adjustment of the new noninvasive laserneedles and to clarify further the elementary acupoint-excitations.

Keywords: Computer-controlled laserpuncture (CCL); LASERneedle ; acupuncture; transcranial Doppler sonography (TCD); blood flow velocity; ophthalmic artery; middle cerebral artery

Introduction

The term "acupuncture" is used to refer to the insertion of needles into the body, at special chosen sites, for the treatment or prevention of symptoms and conditions.

“Laserpuncture” is known as a method to stimulate sequentially acupoints by low level laser radiation. In contrast to that "laserneedles" allow to stimulate appropriate acupoint combinations simultaneously and with higher radiation doses and therefore, represent a new noninvasive **optical** stimulation which is described for the first time in the present report in scientific literature. The aim of this study was to provide the first selective evidence of specific effects of laserneedle acupuncture and needle acupuncture on brain and eye using a combination of vision related acupoints of traditional Chinese medicine, Korean hand acupuncture and ear acupuncture. Quantification of differences in cerebral effects [1] between laserneedle acupuncture and needle acupuncture was performed using a randomized cross-over study design.

Methods

Noninvasive Laserneedles

The noninvasive laserneedles were constructed to fulfil two essential requirements of acupuncture [2]:

- i. They allow the *simultaneous* stimulation of different combinations of acupuncture points.

- ii. The emitted laser intensity is so adjusted that a vegetative stimulus, most probably by alteration of the protein channels of the cell membranes, can be induced without destroying the surrounding tissue.

The laser radiation is coupled into eight optical fibres and the laserneedles are arranged at the distal ends of the optical fibres. To maintain the fundamental advantage of noninvasiveness, the laserneedles were fixed onto the skin but not pricked into the skin. Figure 1 depicts the measured intensity profile across the optical fibre output. The insert shows a photograph of the distal laserneedle end. Due to the direct contact of the laserneedles and the skin, no loss of intensity occurs and the laser power, which affects the acupuncture points, can be exactly determined by integration of the intensity curve shown in Figure 1. Actually, the output intensity of each laserneedle was determined in such a way, resulting in an average light intensity at the contact area on the acupoint of about 4 W/cm^2 .

Fig. 1

Furthermore, the contact application allows to attribute the cerebral effects of laserneedle acupuncture unambiguous and exactly to the laser radiation dose exposed to the acupuncture points. The diagram in Figure 2 illustrates the linear dependence of the laser energy density on the treatment time. Due to the fact that the area exposed to laser rays is constant and the beam divergence can be neglected, the effective laser radiation dose at the acupoints was determined directly from the output intensity of the laserneedles and the treatment duration.

Fig. 2

Multidirectional transorbital and transtemporal Doppler sonography

Transorbital and transtemporal Doppler sonographic examinations were performed with a Multi-Dop T unit (DWL Electronic Systems GmbH, Sipplingen, Germany). A 4 MHz and a 2 MHz probe were used in a multidirectional ultrasound probe holder construction. The monitoring arrangement for simultaneous recording of Doppler sonographic signals in the ophthalmic artery (OA) and the middle cerebral artery (MCA) was stationary at the circumference of the head. Blood flow profiles in the OA were measured transorbitally with the smallest power value able to detect signals (max. 20 mW/cm²). Under acoustic control, the angle and position of the probes were adjusted until the greatest possible signal amplitude was reached. Alterations in the blood flow velocities of both arteries were registered continuously and simultaneously. In addition blood pressure was measured noninvasively before, during and after stimulation (Cardiocap® CC-104, Datex Medical Electronics, Hoewelaken, The Netherlands).

Participants

The study protocol was approved by the institutional ethics committee of the University of Graz (11-017ex00/01) and all 27 participants gave written informed consent. Fourteen female and 13 male aged 21 - 38 years (mean age 25.15 ± 4.12 ($\bar{x} \pm SD$) years) were examined. None of the subjects was under the influence of centrally active medication and had visual deficits. All persons were free of neurological or psychological disorders. They were paid for their participation.

Acupuncture and Procedure

Seven vision related acupoints were tested in two sessions (laserneedle acupuncture and needle acupuncture) in the same persons. The acupuncture scheme consisted of two traditional Chinese acupoints: UB.2 Zanzhu (Location: In the depression of the medial end of the eyebrow. Needling method: Puncture transversely 0.5 - 0.8 cun) and Ex.3 Yuyao (Location: At the midpoint of the eyebrow. Needling method: Puncture transversely 0.3 - 0.5 cun). In addition two ear acupoints (liver and eye; compare Fig. 3) and two vision-related acupoints from Korean hand acupuncture (E2) and one from Chinese hand acupuncture (Yan Dian) were used [3-5].

The acupoints were punctured with sterile, single-use needles after local disinfection of the skin. We used three different types of needles (body: 0.25 x 25 mm, Huan Qiu, Suzhou, China; ear: 0.2 x 13 mm, European Marco Polo Comp., Albi, France; hand: 0.1 x 8 mm, Sooji-Chim, Korea). Needle stimulation was achieved by rotating with lifting and thrusting of the needles.

In case of laserneedle acupuncture the acupoints were cleaned with alcohol, the laserneedles were put in contact to the skin and stable fixed by plaster stripes. The acupoint scheme was the same as described above.

During the experiments the subjects were in a relaxed and comfortable position on a bed in our laboratory. Then the monitoring equipment was positioned. After a 10-minute resting period the laserneedles or acupuncture needles were applied. The choice for the initial stimulation was randomized.

The mean blood flow velocity (v_m) in the OA and the MCA were evaluated simultaneously and continuously [1]. Each person was studied with laserneedle acupuncture and needle acupuncture. The choice of the measuring procedure was randomized and the interval between the experiments was 20 to 30 minutes.

Statistical Analysis

The data were tested with Kruskal-Wallis ANOVA on ranks using the computer program SigmaStat (Jandel Scientific Corp., Erkrath, Germany). The results of the conditions before (a), during (b) and after (c) acupuncture were given as means (\bar{x}) \pm standard deviation (SD) or standard error (SE). The criterion for significance was defined as $p < 0.05$.

Results

The demographic data, the laser- and acupuncture schemes and the measurements of mean blood flow velocity in the OA and MCA are summarized in Figure 3.

Fig. 3

The results showed significant increases of v_m in the OA during (b) laserneedle acupuncture ($p=0.01$) and needle acupuncture ($p<0.001$). At the same time only minor, insignificant changes in v_m were seen in the MCA. The mean arterial blood pressure (before laserneedle acupuncture: 79.2 ± 6.6 (SD) mmHg; before needle acupuncture: 77.5 ± 6.6 mmHg) was not significantly changed during laserneedle acupuncture (78.4 ± 6.4 mmHg) or needle acupuncture (79.1 ± 6.5 mmHg).

The maximum amplitude of v_m in the OA was detected with a delay of 10-30 sec after the initial stimulus by the needles and with a delay of 20-60 sec after the initial stimulus by the laserneedles.

Discussion

Important factors have led to the expanding use of laser technology in medicine. These factors are the increasing understanding of the wave-length selective interaction and associated effects of ultraviolet-infrared radiation with biologic tissues, including those of acute damage and long-term healing, the rapidly increasing availability of lasers emitting at those wavelengths that are strongly absorbed by molecular species within tissues, and the availability of both optical fiber and lens technologies [6]. Fusion of these factors has led to the development of the new laserneedle system which is described for the first time in scientific literature within this study.

Acupuncture using laserneedles has the advantage that the stimulation can hardly be felt by the patient. The operator may also be unaware of whether the laserneedle system is active, and therefore true double-blind studies can be performed, which was almost impossible up to now in acupuncture research. The new system has the added advantage that it can be used at all standard acupuncture points.

The effectiveness of unconventional complementary medical methods, such as laserpuncture, have previously been documented mainly as single cases. There are only few theoretical and clinical studies concerning laserpuncture in scientific literature [7-16].

Recent scientific and technological progress has truly revolutionized acupuncture. The usage of advanced exploratory tools, such as laser Doppler flowmetry [17], laser Doppler imaging [18], ultrasound [1,5,19,20] or magnetic resonance imaging [1,21], provides revealing insights and attempt to shine scientific light upon the most spectacular of the eastern medical procedures.

Similar like in animal studies [22,23] we have found recently that the brain is the key to acupuncture's and laserpuncture's effects. New experimental constructions to measure ultrasound, light and bioelectrical processes can reproducibly demonstrate effects of stimulation of acupoints in the brain [1,5,19,20,24-28].

Studies with biosensors and probes in a specially designed helmet showed that acupuncture can increase significantly and specifically the blood flow velocity in different cerebral arteries and increase the oxygen supply to the brain [1,5,19,20,24,25,27,28]. Laserpuncture and manual needle acupuncture can also lead to an increase in oxygenated hemoglobin in the tissue oxygen index [20,29]. However, laserpuncture and needling at placebo points did not produce the same effects on cerebral oxygenation.

Laserpuncture is established since many years and was reviewed by Pöntinen et al. [30]. Nonetheless, the changes of cerebral function elicited with commercially available low level lasers were in average one magnitude of order less pronounced than those elicited with conventional needle acupuncture [1,19,20,29].

Streitberger et al. [31] have reported that the stimulus strength at the acupuncture points are of decisive importance for the therapeutic efficiency of acupuncture treatments. Using placebo-

needles in comparison with metal needles, it was found that the efficiency of acupuncture treatments decreases significantly, if placebo needles were used.

Our present study shows that the new high optical stimulation with laserneedles can elicit reproducible cerebral effects which are in the same order (half dimension) with respect to the maximum amplitude of the mean blood flow velocity (v_m) as compared to needle acupuncture. As it is shown in Fig.3 the maximum blood flow velocity rate ratio $\Delta v_m(\text{needle}) / \Delta v_m(\text{laserneedle})$ for the acupuncture scheme selected is of about 2. Regarding the stimulus dynamics we found that the delay time between the initial stimulus and the occurrence of the maximum amplitude of v_m is in the order of 10-60 sec for both methods. This allows to conclude that obviously the basic mechanism of signal activation and transmission are comparable for both acupuncture methods. Interestingly, the maximum flow rate for laserneedles was obtained after exposing a laser ray dose of just 10 J/cm^2 , as it can be estimated from Fig.2.

Conclusion

In conclusion, the results of the laserneedle applications for acupuncture demonstrate specific, significant alterations in blood flow velocity of the ophthalmic artery after stimulating vision-related acupoints on the body, ear and hand. At the same time blood flow velocity in the middle cerebral artery did not change significantly. For needle acupuncture qualitatively the same behavior was observed. The cerebral effects of the laserneedles were comparable to the alterations of the needle acupuncture, they differ absolutely by a factor of ~ 2 . Further studies using different laser stimulus intensities and wavelengths are in progress, to optimize the

adjustment of the new noninvasive laserneedles and to clarify the elementary excitations at the acupoints.

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Figure Legends

Fig. 1: Emission characteristics of a tailored laserneedle used in the present study (a.u. = arbitrary units). The coherence of the laser radiation at the distal output of the optical fibre was examined by Michelson-Interferometry. The inset shows a photograph of the distal end of a laserneedle.

Fig. 2: Energy density in Joule/cm² at the laserneedle contact area in dependence of the time in seconds. Due to the contact application, the laser intensity is constant and the laser radiation dose at the acupuncture point can be determined with high accuracy from time of treatment.

Fig. 3: Subjects, acupoints, and graphical (means \pm standard error (SE)) as well as numerical results of the mean blood flow velocity of the ophthalmic artery (OA) and the middle cerebral artery (MCA) before (a), during (b), and after (c) stimulating with laserneedles or needling vision related acupoints in 27 healthy volunteers in a crossover design.

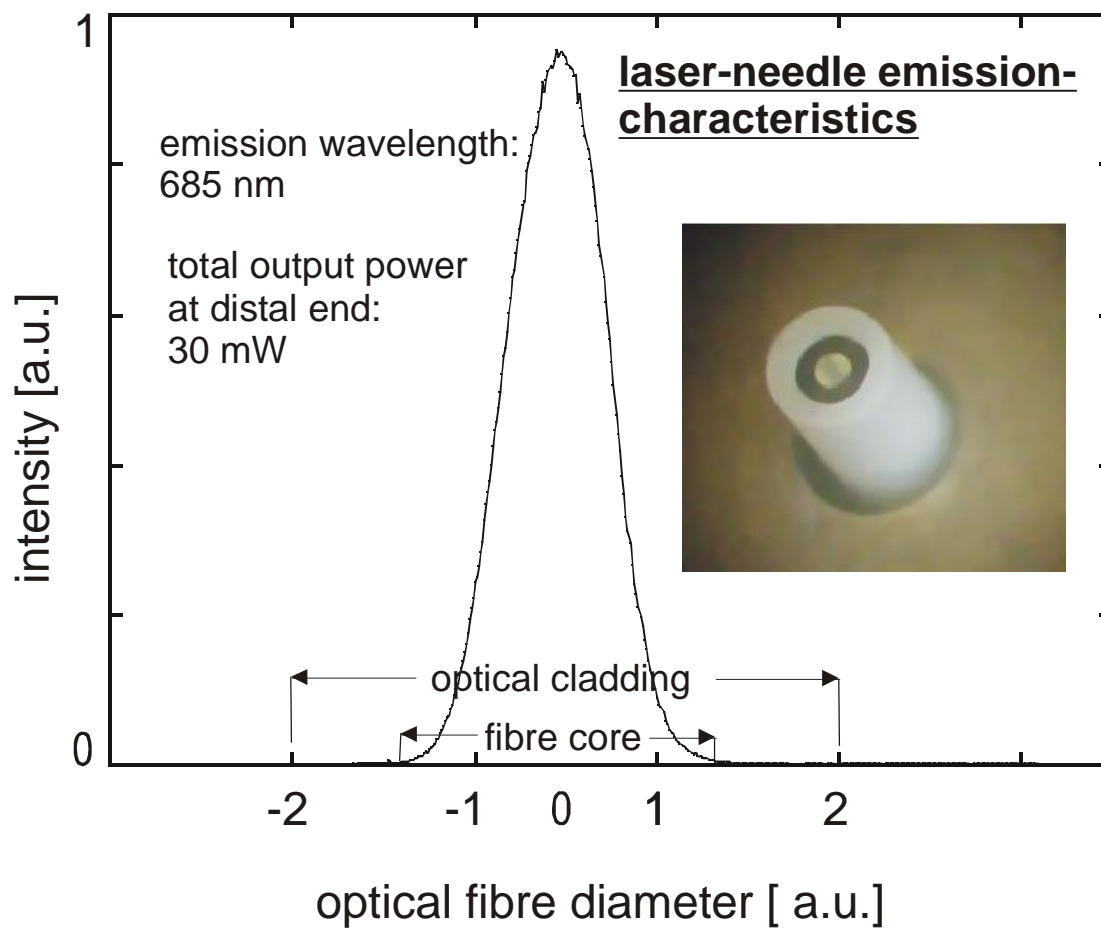


Fig. 1

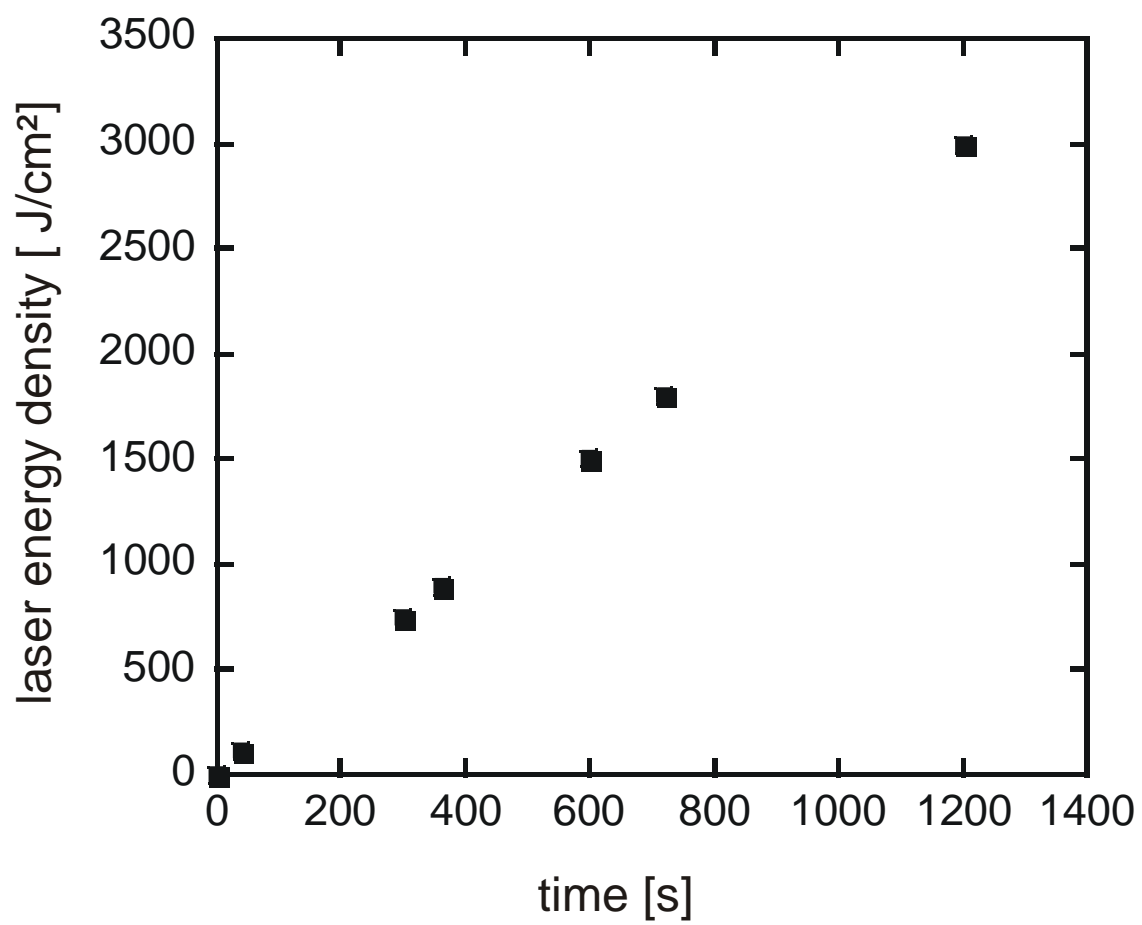


Fig. 2