

1. Laserneedles in acupuncture

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1.1 Introduction and motivation

In the past 30 years, acupuncture established itself in Europe and America. Patients perceive acupuncture as an effective, non-medicinal form of treatment which conforms to the increasing desire of living a natural and balanced life. Particularly in case of chronic pain, patients attested the predominantly satisfactory results of acupuncture, especially since side effects of long term drug treatment can be ruled out with this method. In 1998, a great advancement was made leading to the acceptance of acupuncture in Western medicine. After a Consensus Conference, the United States National Institute of Health concluded that acupuncture was proven effective in cases of post operative nausea and vomiting, nausea and vomiting accompanying chemotherapy, as well as post operative tooth pain [1]. Acupuncture was also rated for the following indications: addictive illnesses, menstrual pain, headaches, tennis elbow, fibromyalgia, back pain, carpal tunnel syndrome, bronchial asthma as well as for alternative or complementary treatment after stroke. At this conference, it was emphasized that side effects of competently performed acupuncture are rare and compared with conventional therapies seem to be much more favourable [2].

Even today, the acceptance of acupuncture in some fields of western medicine is problematic particularly because no objectified proof regarding the effects of acupuncture is available. Critics fail to see, that many excellent scientific studies exist, particularly regarding acupoint-analgesia, which provide a detailed picture of physiological pain reduction achieved by acupuncture treatments. Currently, over 200 scientific publications dealing with the elementary mechanisms of acupoint-analgesia exist. Especially the leading studies by Pomeranz and Chiu [3], as well as those by Mayer et al. [4] which deal with the analgesic effect of acupuncture resulting from an increased release of β -endorphin, establish the complex picture of neurobiological basics of acupoint-analgesia [5]. A systematic overview and critical rating of the current level of knowledge regarding neurobiological mechanisms in acupoint-analgesia were recently documented by Irnich and Beyer [6].

In the meantime, the acupuncture-endorphin-hypothesis could be proven in a number of different independent animal experiments. The ability to block the analgesic effect of acupuncture by injecting an opiate antagonist in the

acupoint is a strong indication that the afferent nervous system plays a role in transmitting the effects of acupuncture. All of these scientific results conform to the knowledge of modern pain research regarding the role of endorphins and are described to such an extent, desirable for other well-established western medical methods. The fact that these scientific results are mainly obtained from animal studies, underlines their objectivity. On the clinical level, the situation is fundamentally different. Numerous single-case and controlled studies have been documented, however definite evidence for the effects could not be proven up to this day. Of course we must note that classic needle acupuncture cannot be investigated using randomised, double-blind study designs. Neither the patient, nor therapist can be blinded, since the patient always feels the insertion or stimulation of the applied needle and the therapist always must control the position, puncture depth and angle of insertion. *There is no doubt that acupuncture has to be proved in the future by objectivized, double-blind clinical trials.*

However, this is only possible, when an adequate placebo method for classic needle acupuncture is available. Such a method does not exist up to this date; the placebo needle used by Streitberger et al. [7] does not fulfil the requirements of a double-blind study design.

The development of a real placebo method for classic needle acupuncture is definitely of initial importance for further acupuncture research and establishing acupuncture as a medical treatment method.

The goal of recent extensive field studies (GERAC-Study, Model study by German private insurance companies) was to prove or refute the efficacy of acupuncture treatment in selected indications using clinically controlled methods on a statistically significant level. Objectified, clinical evidence of effects could not be obtained in these studies for the named reasons.

The initial idea of laserneedles resulted from analysis of laser acupuncture, developed and spread throughout Europe in the 1990's. It was obvious, that the century-old technique of classic acupuncture or simultaneous stimulation of therapy specific acupoint combinations began to leave its natural course. Acupoints are stimulated one after the other, even though no evidence in classic or modern literature is given, that identical effects occur. Suddenly, the puncturing of acupoints according to the basic schemes of Chinese acupuncture was no longer important in Western "Laserpuncture". With the development of laserneedles, we tried to maintain the fascinating aspects of acupuncture: the complex diagnostic system on the one hand, the simple therapeutic procedure and the effects on the other. The simultaneous procedure, simple handling adapted to needle acupuncture, needle equivalent stimulation effects and stimulating characteristics, were the most important goals of laserneedle acupuncture. Thus, laserneedles should be applied non-invasively by direct contact between the light emitting source and the skin. It was always clear, that quantitative documented proof of the postulated equivalence between laserneedle and classical metal needles is necessary.

An important, but not yet investigated question concerns the connection between stimulation strength and the effects of acupuncture.

We know that an inserted acupuncture needle must be moved and repositioned by the therapist to increase stimulation intensity resulting in the De-Qi sensation. This effect is not easy to quantify since the intensity of stimulation triggered by needle puncture is also not quantifiable. How the stimulation intensity at the acupoint influences the effect of acupuncture still remains an unanswered question in this context. If we assume that acupuncture is not more than a specific kind of nerve stimulation, the question arises, whether this form of acupoint stimulation correlates with the dose-effects known from the field of bio-physiology, and underlies the Weber-Fechner-Law. With laserneedles, the light dose applied at any desired acupoint combination can be measured exactly. Compared to other classic metal needles, the stimulus strength can be quantified so that determination of dosis-effect relationships is possible. A basic assumption regarding stimulation characteristics i.e. the timing factor of stimulus intensity has to be made for experimental investigation of dose-effect relationships in acupuncture. In our first approach we assumed that the nocizeptive stimulus triggered by the classic metal needle is a continuous constant stimulation which lasts as long as the needle is inserted. In order to be equivalent to this stimulation mode, the laserneedles should act in the so-called continuous wave modus. Equivalence between both needle types can only be assumed under these circumstances. Frequency-modulated laser light is generally not equivalent to the application procedure of the classic needle acupuncture.

The physical characteristics of laserneedles determine their physiological influence in tissue. We have been performing theoretical studies for some time dealing with the elementary interaction between photons and complex, biological molecules. Using molecular-dynamical methods of theoretical physics, we are able to calculate and predict the interaction of electrons or photons with complex molecules, as well as the effects of molecular excitation and basic relaxation on molecular surroundings. However, this is only possible when quasi elastic scattering processes between the photons and biological molecules are the predominant interactive processes. If we assume that elementary stimulation in acupuncture is generated on a molecular level, molecular-dynamic calculation shows [8], that electrical and optical stimulation show physiologically identical results and also generate and maintain a rhythmic cascade of action potentials at the nocizeptive structures as those produced when chemical transmitters such as substance P and bradykinine are released after needle puncture. These results can define the most important physical marginal requirements for the emission characteristics of the laserneedles: the emission wave lengths should be selected in a such a way, that quasi elastic scattering processes are dominant and emission intensity at the distal output of the laserneedle should be so

high, that responses relevant for acupuncture can be triggered by optical stimulation.

1.2 Dose-effect relationships in acupuncture

One of the fundamental biophysiological laws, the Weber-Fechner's Law, describes the relationship between strength of perception E of a sensory stimulus and intensity of the stimulus S . As a result, the stimulus effect and stimulus response correlate and can be described with the following logarithm:

$$E \sim \ln S$$

This proportionality does not imply more than that the doubling of stimulus strength not automatically leads to doubling of perception or effects of the stimulus.

If we illustrate this simple relationship graphically, two important characteristics become visible and are shown in Figure 1.1.

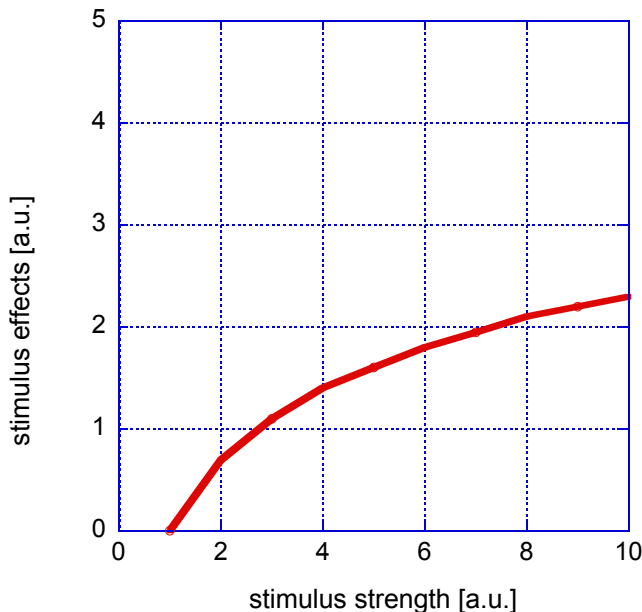


Fig. 1.1: Relationship between stimulus strength and stimulus effects according to Weber-Fechner's Law.

The curve illustrates threshold characteristics of physiological stimulation. Sensory stimuli do not lead to any effects when stimulus intensity lies under

a critical threshold value. Weak external influences are filtered out by the organism. Moreover, the curve shows the saturation characteristics of physiological stimuli. Thus, a doubling of stimulus strength does not lead to the doubling of effects within the organism. Finally, this is an expression for the adaptability of the organism to external stimulation, whose intensities can vary over many orders of magnitude.

Validity of Weber-Fechner's Law has been proven for acoustic, thermal, chemical and mechanical stimuli.

In our experiments, we investigated if this physiological law is also applicable to acupuncture, e.g. if stimulus strength at the acupoint and the resulting induced specific effects are correlated. For this purpose, laserneedles with different optical power density were used. Power densities which are effective on the skin were varied from 1.5 – 5 W/cm². In order to compare the effect of laserneedles under identical circumstances, parallel experiments using classic metal needles were also performed. The blood flow velocity in the ophthalmic artery (OA) and its changes during stimulation of an eye specific acupuncture scheme were studied in this experiments. Preliminary studies showed that the simultaneous stimulation of acupoints Zanzhu and Yuyao, the acupoints eye and liver on the ear, as well acupoints E2 from Korean hand acupuncture and Yan Dian from Chinese Hand acupuncture led to significant and specific increases in blood flow velocity (OA) when using metal needles or laserneedles [9] (compare chapter 2). The specific effect on the visual system could be proven by the parallel measurement of blood flow velocity in the middle cerebral artery, which remained constant i.e. did not show any changes in measurement results when using this acupuncture scheme. Measurement of blood flow velocity was performed with transorbital and transtemporal Doppler sonography. Blood pressure was registered before, during and after measurement. Treatment time was 10 minutes and blood flow velocity data was monitored continuously. A randomised, cross-over study design was used and each volunteer underwent acupuncture with laserneedles, as well as with metal needles. The study protocol was approved by the ethics commission of the Medical University of Graz, reasons for exclusion of volunteers (n = 27) were treatment with medication, visual disorders, as well as neurological and psychological deficits.

Figure 1.2 shows the detected dependency of blood flow velocity in the OA as a function of power density from the laserneedles.

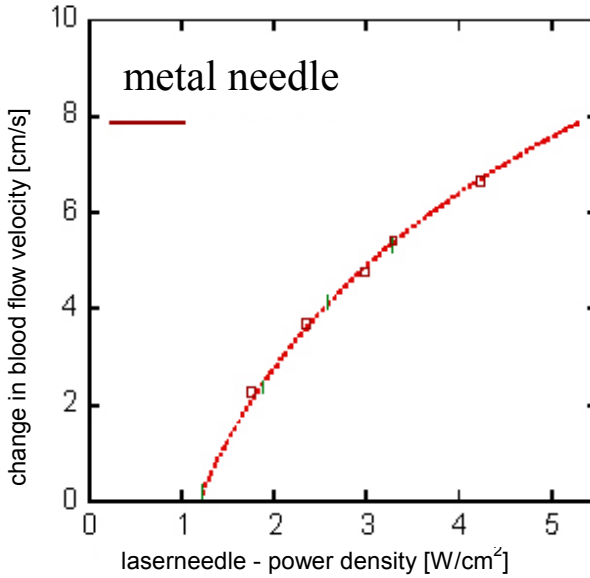


Fig.1.2: Change in blood flow velocity in the OA in dependence on the power density of the laserneedles during stimulation of an eye-specific acupuncture scheme. The mean changes measured in metal needle acupuncture are marked with a line.

Figure 1.2 clearly shows that acupuncture of the seven eye-specific acupoints leads to a significant increase in blood flow velocity in the OA. Metal needles yield an increase from 10 cm/s to 18 cm/s.

It is obvious that changes in blood flow velocity are dependent upon the optical power densities applied when using laserneedle acupuncture. The curve conveys the best analytical adaptation of measurement values. This curve satisfies the mathematical function $f(x) = c \times \ln(x + 0.5)$.

This indicates that blood flow velocity in the OA is an effective parameter for acupuncture treatment and is logarithmically dependent on the stimulus intensity of the laserneedles. Thus, we can conclude, that Weber-Fechner's Law is valid for the dose-effect relationship examined here. The threshold value I^* for optical power density can be calculated from the registered and analytically determined effect curve; $I^* = 1.3 \text{ W/cm}^2$. This indicates that the optical power density of the laserneedles must be greater than 1.3 W/cm^2 in order to activate the physiological effects of acupuncture. In addition, we can see that the needle equivalence in optical power densities of the laserneedles reach $I \geq 5 \text{ W/cm}^2$. We can assume that an increase in blood flow velocity in the OA is based on a complex cerebral reaction resulting from acupoint

stimulation, preceded by multi-synaptic switching of optically induced acupuncture stimulation potentials.

It is noteworthy, that despite the physiological complexity, the logarithmic relationship between stimulus strength I and stimulus effect is maintained. We interpret this as obvious proof, that specific effects of acupuncture underlie these logarithmic dose-effect relationships. *The existence and validity of dose-effect relationships in acupuncture could be proven for the first time using the methods described here.* This statement is strictly valid only when using laserneedles which trigger continuous permanent stimulation, thus allowing exact quantification of stimulus strength. To what extent low or high frequency modulation of laserneedle light can modify proven dose-effect relationships is unclear and must be investigated in further studies. Since the postulated equivalence between metal needles and laserneedles could be clearly shown in the examined context, we can conclude that classical acupuncture and its effects also should be functionally dependent on stimulus strength according to a potency rule.

1.3 Laserneedle acupuncture as a placebo method

The requirements of an adequate placebo needle and an adequate placebo method for classical needle acupuncture are clearly to define:

The requirements of a placebo needle are:

1. The placebo needle should not generate any acupuncture effect
2. The placebo needle should be of identical shape and size compared to the verum needle and therefore should not be distinguishable from a verum acupuncture needle
3. The application procedure of the verum needle and the placebo needle should be identical
4. The application procedure of the verum needle and the placebo needle should not depend on the individual experiences of the treating physician
5. The perception of the placebo needle and the verum needle at the acupoint by the patient should be identical

The requirements of an acupuncture placebo method are:

1. The fundamental rules of the classic acupuncture have to be preserved, in particular the simultaneous needling of any acupoint combination should be possible with the placebo method

2. The direct contact between the treating physician and the patient has to be minimized by the placebo method, to exclude any healing effect by the aura of the physician

If the placebo needle and the placebo method meets all these requirements, a double blind clinical study can be performed.

We know that needle puncture at desired skin points also leads to effects that are similar to those resulting from stimulation of acupoints. For that reason, this type of acupuncture is called sham-acupuncture. A further demand on the placebo method would be to establish a clear definition between the categories of verum-acupuncture, placebo-acupuncture and sham-acupuncture.

Based on these criteria the applicability of laserneedle acupuncture as a placebo method for classic needle acupuncture can be analyzed precisely. We already mentioned that laserneedles are not inserted into the skin, but applied to the skin at the acupoint. This non-invasive method of application is an important characteristic of laserneedle acupuncture. Our studies with more than 250,000 practical applications of laserneedles show that laserneedle stimulation with distal optical power densities of about 5 W/cm² are not perceived as a stimulus sensation by the majority of patients and volunteers. Of course the threshold of laser light stimulation is different and variable from person to person, however, laserneedle stimulation with a primary emission wavelength of 685 nm at acupoints on the body is not perceivable for most patients. The cerebral effects generated by laserneedle acupuncture were investigated systematically using multi-directional functional Doppler sonography, near-infrared spectroscopy (NIRS) and functional magnetic resonance imaging [10].

In other chapters of this book we show that laserneedles with power ≥ 5 W/cm² lead to specific changes in cerebral blood flow velocity during stimulation of visual acupoints nearly identical to those in needle acupuncture.

In addition to these experimental studies, the effects of acupuncture regarding changes in cerebral oxyhaemoglobin concentrations were investigated. Here, a visual acupuncture scheme was used and in this case, non-specific cerebral parameters could be analysed. This was done using a randomized, cross-over design with direct comparison between metal needle and laserneedle stimulation. Details from these experiments are described in [11].

Measurement of cerebral concentrations of oxyhaemoglobin and desoxyhaemoglobin were done using NIRS: Figure 1.3 shows the results of these measurements dependent on the optical power of the laserneedles.

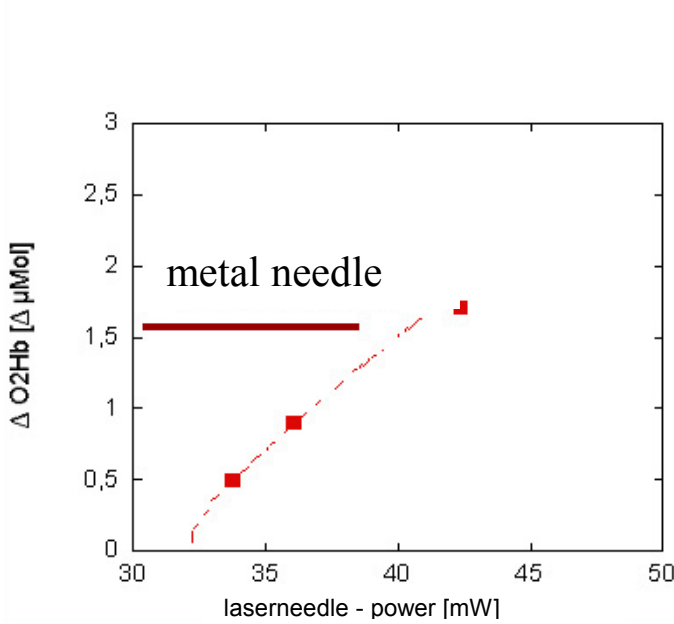


Fig. 1.3: Changes in cerebral oxyhaemoglobin concentration when using a visual acupuncture scheme with metal needles and laserneedles of different optical power. The curve shows the best analytical adaptation to the measurement values of laserneedle stimulation.

The experimental data in Figure 1.3 show that laserneedle stimulation with an optical power of about 40 mW leads to changes in oxyhaemoglobin concentration, similar to the effects when using metal needles. The equivalency between metal needle stimulation and laserneedle stimulation can also be proven with these cerebral effects. These experiments also yield the best analytical adaptation of the measurement results in a logarithmic function, i.e. cerebral oxyhaemoglobin concentration parameters also underlie a physiological dose-effect relationship.

The definition of verum-acupuncture, placebo-acupuncture and sham-acupuncture presents a fundamentally unsolved and principally unsolvable problem for classic acupuncture with metal needles. We examined the possibilities to differentiate and define these three modalities experimentally for laserneedle acupuncture. Hereby, acupoint combinations were stimulated with laserneedles, which according to traditional Chinese medicine are coherent with the visual or olfactory system. Figure 1.4 shows the scheme of visual distant points used.

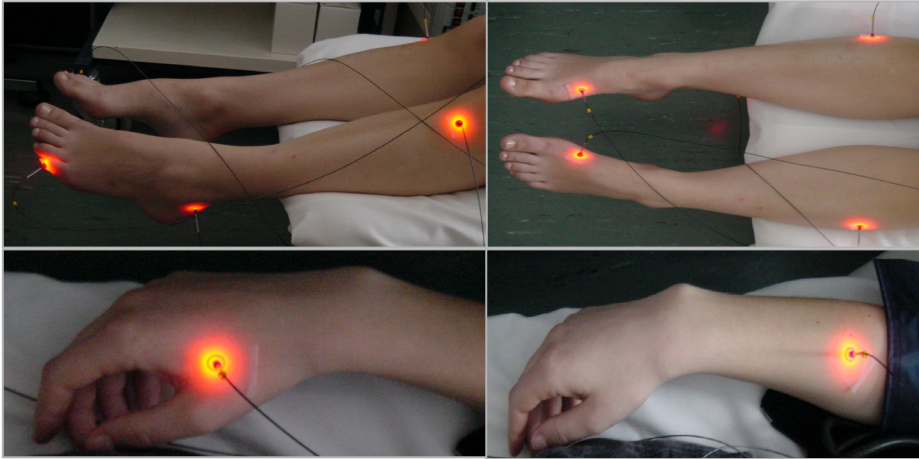


Fig. 1.4: Distant acupuncture points Hegu, Zusanli, Kunlun and Zhiyin of the visual system (left) and the selected sham-points (right).

Stimulation of the olfactory system was done with acupoints Yinxiang, Pianli and Hegu. Changes in blood flow velocity in the posterior cerebral artery (PCA) and anterior cerebral artery (ACA) were used for determining the effects of acupuncture stimulation and registered with functional Doppler sonography. In addition, changes in activity in the frontal area and olfactory cortex were detected using functional MR-imaging. Detailed information regarding these measurements [10] are described in chapter 8.

A randomised, controlled cross-over study design was used and can be divided in the following test situations:

The verum situation, characterized by activated laserneedles at the selected acupoint, the placebo-situation characterized by non-activated laserneedles at the acupoints and the sham-situation, characterized by activated laserneedles at the selected sham-points.

The verum-situation showed a specific, significant increase in blood flow velocity in the PCA and ACA in our volunteers ($n = 41$), resulting in specific, significant activity in the occipital and olfactory cortex visible in MR-imaging. No significant changes in functional Doppler sonography and in functional MR-imaging were registered in the placebo-situation or sham-situation.

From these experimental studies, we conclude that a clear differentiation between verum-acupuncture and placebo- or sham-acupuncture is possible in regard to laserneedle acupuncture. In this context, the basic difference between acupuncture with laserneedles and with metal needles becomes obvious and fulfils and important criterion for an adequate placebo-acupuncture method. Since the reproducible De-Qi sensations can be

triggered with laserneedle acupuncture and the proven cerebral effects do not pose special demands regarding the positioning of the laserneedles, we conclude that acupuncture with laserneedles fulfils all requirements of a complete placebo experiment. We want to emphasize that the proven physiological equivalence between metal needles and laserneedles applies to all of the reports and scientific results achieved with laserneedles and in turn is also valid for classic needle acupuncture. Therefore, the use of laserneedle acupuncture, performed in randomised, double-blind studies, can be of great advantage for clinically objectifying the effects of acupuncture.

1.4 Physical characteristics of laserneedles

The laserneedles were developed at the University of Paderborn to provide a therapeutically and methodically equivalent, non-invasive instrument to the classic metal needle.

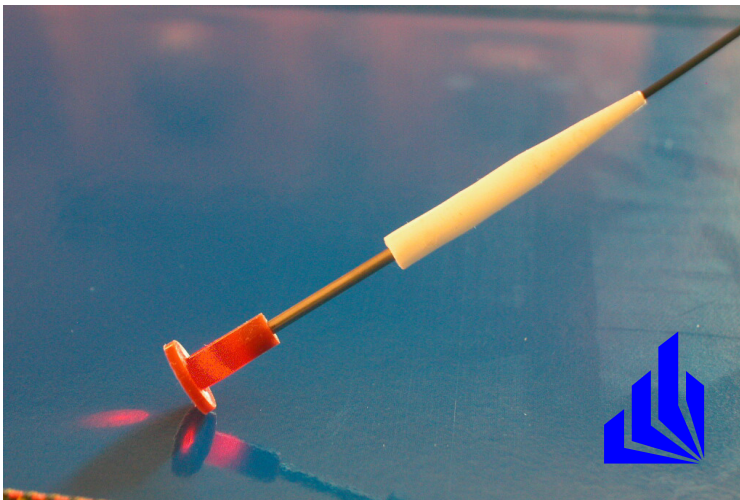


Fig. 1.5: Laserneedle for acupuncture.

Figure 1.5 shows a laserneedle. You can see that laserneedles are acupuncture needles with optical fibres that can be applied to the skin in such a way that the distal light emitting region of optical fibre is in contact with the surface of the skin. A major goal of these scientific studies was to develop photonic acupuncture needles for simultaneous stimulation of selected acupoint combinations on the body and ear which can be used in the exact same way as metal needles. The optical power densities at the distal laserneedle exit were set in such a way, that metal needle equivalent stimulation effects are guaranteed.

Physical foundation of stimulation effects in the numerous experimental studies is the emission of laser light with a wavelength of 685 nm (red light) as well as the complementary emission of infrared laser light with wavelengths of 880 – 950 nm. Hence, laserneedles emit “bi-chromatic“ light with a power density of 5 - 10 W/cm² at the exit of the laserneedle. Complementary, bi-chromatic emission is based on light conversion, i.e. red laser light also activates the infra-red photons in the light wave conductor. Laser light leaving the laserneedle is coherent and is routinely examined with Michelson-Interferrometry regarding its characteristics of coherence. Chronological and spatial coherence of emitted photons is immediately lost when entering the skin and diffuse scattering becomes a determining factor. The physiologically determinant power density range of 5 - 10 W/cm² is achieved by a specially developed method of optical tailoring of the fibre core.

In Table 1.1 we can see that this method is very effective, when we want to reach a maximum of power density with a minimum of laser strength.

Laser power	Laser-spot diameter at the skin	Optical power density
50 mW	5 mm	0.25 W/cm ²
50 mW	0.5 mm	25.5 W/cm ²
50 mW	0.05 mm	2550 W/cm ²

Tab. 1.1: Connection between laser power, laser-spot diameter and optical power densities.

Exemplary calculations show that a power density of 0.25 W/cm² results when laser power of 50 mW and spot-diameter of 5 mm at the skin, commonly used in one-hand, laser-pens is applied. In order to reach the required physiological range of power density for the laserneedles, a 20 W laser must be used! As illustrated in Table 1.1, reduction of the spot-diameter by the factor 10 leads to an increase in optical power densities by a factor of 100.

The emission characteristics of laserneedles described here, in particular regarding the optical power densities affecting the skin from 5 - 10 W/cm², as well as the bichromatic emissions of red and infrared laser light are based on patented technologies only realised in laser-acupuncture needles and are available under the trade name LASERneedle® [12].

Contact application guarantees that the applied light dose can be exactly determined and reproduced. The next figure (Fig. 1.6) graphically illustrates how much light energy is transferred from a laserneedle during acupuncture treatment into the skin.

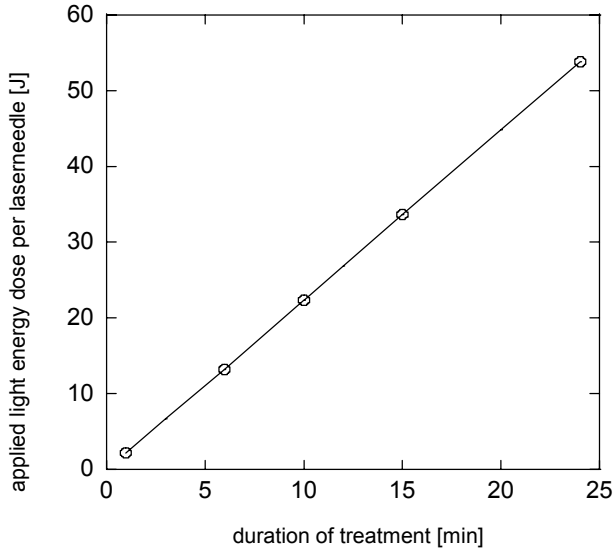


Fig. 1.6: Light dose of a laserneedle dependent on the duration of treatment.

In order to determine the entire optical power transferred into tissue during stimulation of acupoints, the value in the graph needs only to be multiplied with the number of laserneedles applied.

Transmitted light energy of about 320 J, equivalent to about 80 cal or that contained in less than a half teaspoon of yogurt, resulted after a treatment time of 20 minutes, using 8 laserneedles.

In this chapter, we have already noted, that the emission wave length of laserneedle light should be selected in such a way, that quasi elastic scattering processes in tissues are dominant and the adsorption of photons can be neglected.

Figure 1.7 shows the absorption behaviour of the most important tissue structures, dependent on the emission wave length of laser light.

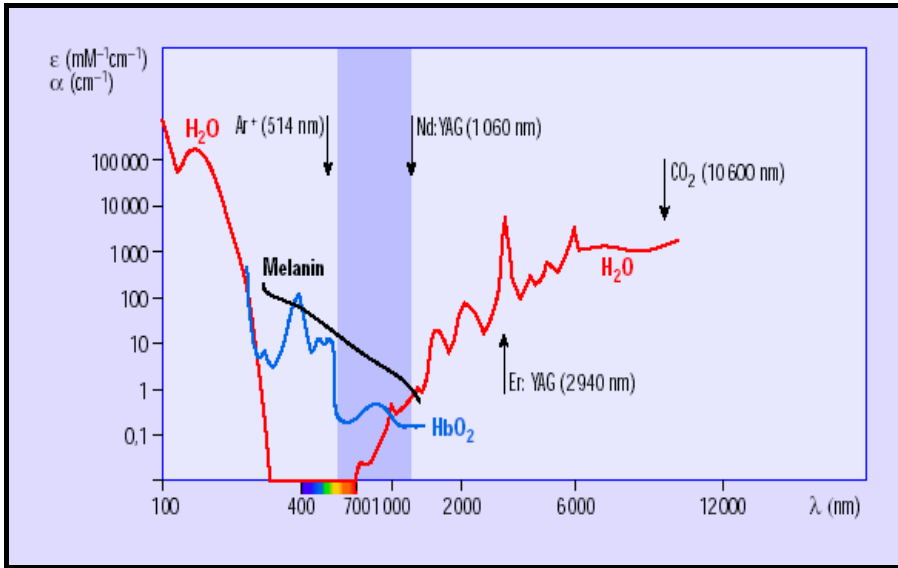


Fig. 1.7: Absorption behaviour of important tissue structures dependent on the emission wave length of laser light.

Figure 1.7 shows that all important tissue structures from the skin yield a minimum in absorption coefficients ranging from 550 -1100 nm within the electromagnetic spectrum. This is particularly true for water, oxyhaemoglobin and melanin. In this “window”, the absorption of photons and production of heat can be neglected since the scattering of photons on tissue molecules is the dominant interactive process. Therefore, this range is very suitable for optical stimulation at the surface of the skin. The depth which photons can reach with diffuse, elastic scattering processes is once again dependent on the wave length. Simple estimates show that even at a depth of 2 - 3 cm, photon densities exist, which can trigger molecular activity at nociceptive structures.

Light wave conductors available today are made of plastic (PMMA), quartz or sapphire and have comparably little absorption in the „window“ area, so that conduction losses in the optical fiber are practically neglectable.

Laserneedles use semi-conductor laser diodes as a light source. Figure 1.8 shows a semi-conductor laser diode schematically.

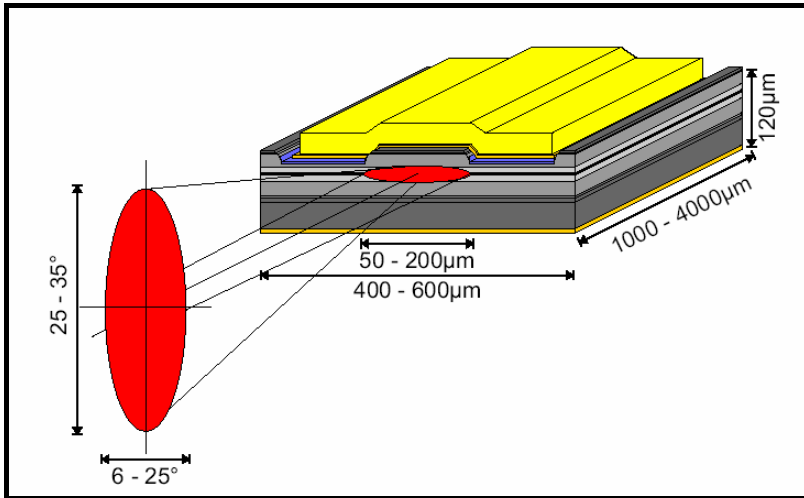


Fig. 1.8: Schematic illustration of a semi-conductor laser diode.

We can see that lasers consisting of mono-crystalline (Ga, Al, In) As are about 1 x 0.5 x 0.1 mm in size, and are about as big as a salt grain. The optically active area of a semi-conductor laser diode is once again smaller by a factor of 1000 and is comprised of layers that are only a few nanometres thick. The fact that the light field emitted by a laser diode doesn't have a circular, but rather an elliptical diameter, is of decisive importance for optical fibre laserneedles. Since the standard light wave conductors available today have a circular diameter they lead to optical losses when an elliptical light field is fenced in a round fibre core. These losses are relatively low and according to technical standings, losses in a fiber are less than 10 %.

The optical power densities alone and not the primary laser strength are responsible for the physiological stimulation effects of laserneedles at the acupoint. The results from our studies show that metal needle equivalent acupuncture can only be performed within a range of 5 - 10 W/cm². Today, we attribute power densities of 10 W/cm² to the field of photodynamic therapies. The question, whether power densities in this range lead to histologic damage is of great importance and was investigated experimentally by our study group [13] (see chapter 5). In an animal study, we could prove that no micromorphologic changes occurred during 20 minute application of laserneedles with about 5 W/cm². Neither microthrombosis or extravasation could be proven, nor changes in endothelial cells of dermal blood vessels could be observed.

Thermic interaction at the acupoint was determined with infrared thermography. As a result, a heating effect of laserneedle light can be neglected. We measure an increase in temperature of about 1 °C at the

immediate contact area during a 20 minute treatment period. If we discuss the conditions during head- and ear acupuncture with laserneedles, we must consider that light intensity in the skin decreases exponentially and is weakened to about 50 % of the initial value when it reaches the skull. Since the stratum corneum, epidermis and dermis have different refractive indexes for optical light, wave transmitting effects occur in the layers of the skin which distribute the laser light laterally over an area of about one to 2 cm². As a result, a proportional reduction in optical power densities up to two magnitudes of order and the power density of laserneedle light is reduced to physiologically unimportant values after transmission through the skin. Transmitted part of the radiation of the laserneedles is completely absorbed by the skull. Using animal experiments, we could also show that no laserneedle-radiation (continuous wave modus) at the surface of the cortex can be observed [14].

Today, the new laserneedles for acupuncture provide instruments which are extensively characterized in medical-scientific studies. About 750,000 acupuncture treatments with laserneedles are performed worldwide in the last two years. In particular, patients appreciate this painless but still effective method of acupuncture.

The medical potential of this new acupuncture method is huge. At the moment, ten University Clinics in Germany, Austria, Switzerland and France are performing scientific studies. The goal of these studies is to study and understand the basics of acupuncture and to get a step closer to the clinical objectification of the effects of acupuncture.

1.5 Acknowledgements

The author would like to thank all of his colleagues who took part in the development of laserneedles.

1.6 References

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2. Cerebral vascular effects of non invasive laserneedles measured by transorbital and transtemporal Doppler sonography

G. Litscher, D. Schikora

2.1 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 non invasive optical stimulation which is described in this book. The laserneedles used in this study emit red light in cw-mode with an output power of 30 - 40 mW per laserneedle, which results in a radiant exposure energy of about 2.3 kJ/cm² at each acupuncture point during a treatment time of about 10 min. Due to the well defined contact application and the possibility to stimulate simultaneously up to eight acupoints, the laserneedles allow to attribute the resulting cerebral vascular effects unambiguous and exactly to the total laser radiation dose exposed at the acupuncture point combination selected. This opens the new scientific possibility to describe the input stimulus strength of complex acupuncture treatments with well established physical parameters. The aim of this study was to provide a possible 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.

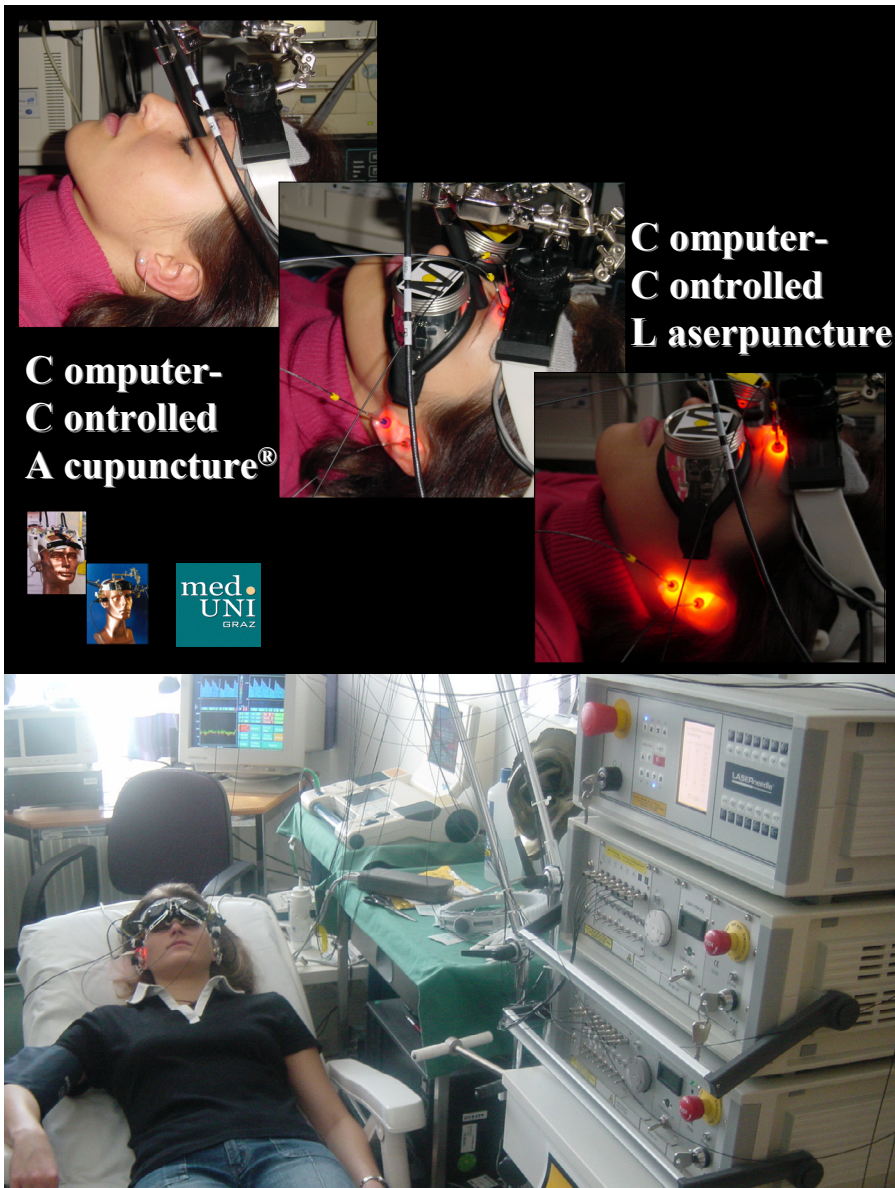


Fig. 2.1: Computer-Controlled Acupuncture® (CCA®) [1] and Computer-Controlled Laserpuncture (CCL) with multidirectional ultrasound probe holder devices in the biomedical engineering lab of the Medical University of Graz. Details concerning the method can be found on the website <http://litscher.info>.

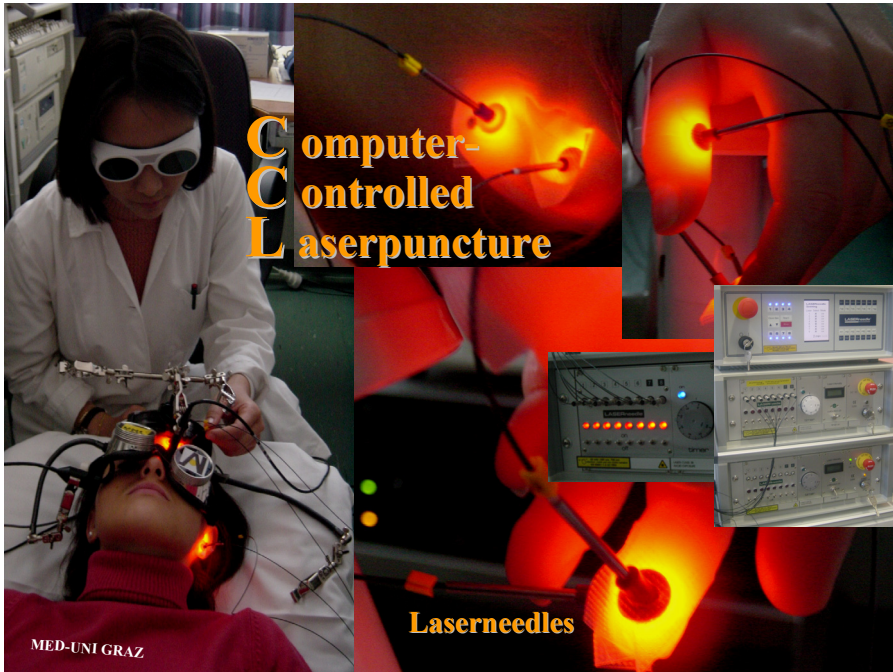


Fig. 2.2: The laserneedle system is a class 3B laser system, therefore it is compulsory to wear specific laser protection glasses.

2.2 Methods

2.2.1 *Non invasive laserneedles*

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

- (i) They allow the *simultaneous* stimulation of up to eight acupuncture points in any different combinations on the body, the head, the hands and the ears.
- (ii) The emitted laser intensity is so adjusted that a stimulus can be induced without destroying the surrounding tissue.

The laser radiation of eight 55 mW - laserdiodes was coupled into eight optical fibres and the laserneedles are arranged at the distal ends of the optical fibres. Due to coupling losses the output power of each laserneedle was reduced to 30 - 40 mW. The fibre core diameter used in the study was of about 500 μm . For our experiments seven vision related acupuncture points were chosen and irradiated simultaneously. The average time of irradiation was of about 10 min resulting in an energy density of about 2.3 kJ/cm² at

each acupoint and a total sum of 16.1 kJ/cm^2 for seven acupoints. To maintain the fundamental advantage of non invasiveness, the laserneedles were fixed onto the skin but not pricked into the skin. Fig. 2.3 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 Fig. 2.3. Actually, the output intensity of each laserneedle was determined in such a way, resulting in an average irradiance intensity at one acupoint of about 3.8 W/cm^2 .

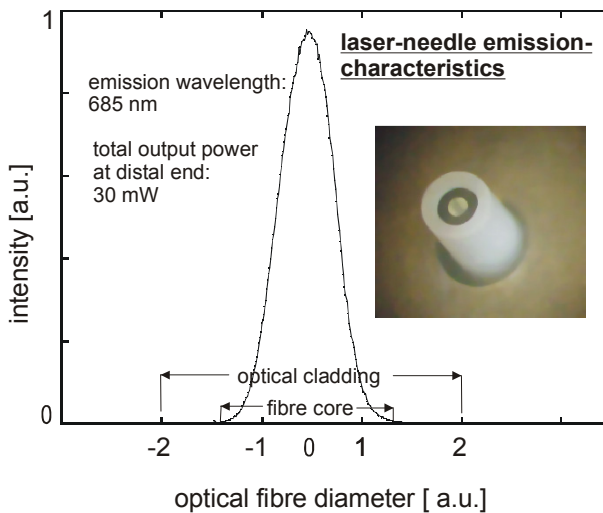


Fig. 2.3: Emission characteristics of a tailored laserneedle used in the present study (a.u. = arbitrary units). The coherence of the laser radiation at the distal output of the optical fibre was examined by Michelson-Interferometry. The inset shows a photograph of the distal end of a laserneedle.

Due to the fact that the contact 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.