Violet Laser Acupuncture—Part 3: Pilot Study of Potential Effects on Temperature Distribution

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Abstract
Infrared thermography for temperature distribution monitoring was performed in ten healthy volunteers (M/F, 5/5; mean age ± SD, 24.9 ± 3.3 years) before, during, and after stimulation by noninvasive violet (405 nm) laser needle at the Dazhui (GV14) acupoint. Significant (p < 0.001) increases of temperature at a region of interest around the acupoint were observed. Furthermore, temperature also increased significantly (p < 0.05) at a so-called “far field” area Zhiyang (GV9). In two persons, however, needle acupuncture and placebo (deactivated laser) did not have the same temperature effects. Violet laser induces changes in skin surface temperature distributions.

1. Introduction
Violet laser acupuncture is a new method that was first described by our research group [1–5]. In the first two parts of the study, reproducible effects on brain circulation (multidirectional transcranial ultrasound Doppler sonography) and peripheral microcirculation (laser Doppler flowmetry) were presented in the Journal of Acupuncture and Meridian Studies [1,2].

The goal of this third part of the series was to investigate temperature distribution in the skin of the same volunteers using infrared thermal imaging.

2. Materials and Methods
2.1. Violet laser acupuncture

The method of laser needle acupuncture has been described in detail in the first and second parts of the study [1,2] and in previous work [3–8]. Noninvasive violet optical needles (wavelength, 405 nm; output power, 110 mW; laser needle spot diameter, 500 μm; time, 10 min) were fixed onto but not inserted into the skin. The same research system from Laserneedle EG GmbH (Wehrden, Germany) as mentioned in parts 1 and 2 of the study [1,2] was used for
the measurements (compare Fig. 1). This equipment consists of ten semiconductor injection laser diodes. Each single needle can emit at a different wavelength. In the present study, a continuous wave (CW) mode was used. Due to coupling losses, the output at the tip of the laser needle is approximately 100 mW. Irradiation lasted 10 min (600 seconds), and therefore optical power energy density was very high (in kJ/cm² range) [1,2,6,7].

2.2. Monitoring of temperature distribution by infrared thermography

The change in local skin temperature in biological systems is determined by the difference in the thermal energies received and lost by conduction transfer and advection, as well as by that released by chemical reaction processes such as metabolism [9]. Thermal imaging involves measurements of surface temperature using an array of infrared sensors installed in an infrared camera. This imaging allows for simultaneous measurement of temperatures of multiple points on the skin and is also a reference for the surrounding temperature. For this study, a FLIR i5 infrared camera (Flir Systems Inc., Portland, USA) with a wavelength range 7.5–13 μm was used (Fig. 1). Temperature distribution measurements were possible in the range 0–250°C. Data were transferred to notebook computer using ThermaCAM Researchers Pro 2.8 software (Flir Systems Inc., Portland, USA).

2.3. Healthy volunteers and procedures

The same ten healthy volunteers (M/F, 5/5; mean age ± SD, 24.9 ± 3.3 [range 20–31] years; mean height ± SD, 173.4 ± 9.7 cm; mean weight ± SD, 68.3 ± 16.3 kg) as investigated in parts 1 and 2 of the study [1,2] were evaluated. None of the volunteers was taking any medication. All persons were informed about the nature of the investigation, as far as the study design allowed. The study was approved by the local ethics committee (Medical University of Graz, No. 13-048, valid until Jan 25, 2011; “laserneedle stimulation”), and all volunteers gave their written informed consent.

The persons lay face down on a bed in our lab (constant room temperature, 25°C), some with their faces in a sponge rubber mask similar to those used for the positioning of patients undergoing neurosurgery, so that respiration was unhindered.

Four 5-minute periods of averaged data before (a), during (b, c), and after (d) the violet laser stimulation were compared (see also Fig. 3, bottom). Therefore, irradiation lasted for 10 min.

Similar to the study design described in parts 1 and 2 [1,2], all persons received active laser stimulation (n = 10; Fig. 3), and in addition, 2 of 10 subjects (randomly chosen) were investigated using metal needle and placebo (deactivated laser) stimulation as control. Not all of our European volunteers had a high acceptance of manual needle acupuncture, especially because of the point location, which is hidden from direct view.

Acupuncture stimulation was performed again at the point Dazhui (GV14) located below the spinal process of the 7th cervical vertebra [1,2]. As mentioned in the previously published parts of the study, this is an important point for treating common cold, occipital headache, cervical spondylosis, and torticollis. This point is also commonly used for moxibustion, and is therefore suitable for violet laser stimulation, which to some extent also produces heat effects that are described in this paper.

Heart rate (Medilog AR12; Huntleigh Healthcare, Cardiff, UK) and blood pressure (Cardiocap, Datex, Hoevelaken, Netherlands) were recorded in addition to the temperature parameters (compare also [1,2]).

2.4. Statistical analysis

Data were analyzed by Friedman’s repeated measures ANOVA on ranks (SigmaPlot 11.0; Systat Software Inc., Chicago, USA); Tukey’s test was used for post hoc analysis. The level of significance was defined as p < 0.05.

3. Results

A typical example of the temperature distribution registered by infrared thermography before, during, and after violet laser acupuncture at acupoint Dazhui (GV14) is shown in Fig. 2. Temperature increases at the stimulation area (+0.7°C), as well as at a “far field” area (+0.2°C) Zhiyang (GV9) were noted.

Fig. 3 summarizes the results of temperature analysis of the ten healthy volunteers. Skin temperature measured by infrared thermography changed significantly (p < 0.001) at a distance of 3 cm from acupoint Dazhui (red columns in Fig. 3). It was interesting that temperature also changed significantly (p < 0.05) at a so-called “far field” location (area below the spinous process of the 7th thoracic vertebra, parallel to the inferior angle of the scapula; Zhiyang [GV9]; blue columns in Fig. 3).

Nonsignificant changes were found during stimulation by needle acupuncture (Fig. 3; circles); moreover, the placebo procedure with deactivated laser did not lead to any significant change (Fig. 3; squares).
which temperature changes can be measured has improved significantly over the last several years. The accuracy in nonsignificant changes in standard monitoring parameters such as heart rate and mean arterial blood pressure has been documented in the literature. A review article on examining temperature in connection with acupuncture and at a "far field" area (Zhiyang) has been published by our research group in 2006 [10]. Li et al. [11] performed a prospective, randomized, controlled experiment in 40 Chinese healthy volunteers during simulated driving. Magnitopuncture was applied at Dazhui and Neiguan (PC6); the main outcome parameter was heart rate variability. The test group that received verum acupuncture showed significantly reduced sympathetic and significantly increased parasympathetic activity [11].

The effects of an application of 10% cantharides extract on Dazhui and Neiguan was studied by Tang et al. [12] in 50 cases of perennial allergic rhinitis. The efficacy rate was 88%; after the treatment, allergic nasal mucosa-provocative test of the treatment group was significantly improved [12].

Cupping on Dazhui and three points on the bladder meridian, aided by auricular pressing, was shown to yield a curative effect in cases of hormone-dependent bronchial asthma, which enabled the patients to reduce the use of cortisone in a study by Hu [13].

This study suggests that violet laser acupuncture (405 nm) can lead to a significant increase in temperature in an area surrounding the stimulation point (in this case Dazhui). A similar observation was also found in a previous investigation [3]. In addition, we found that the temperature also increased in a so-called "far field" area (Zhiyang) located proximal at the same meridian (governing vessel). However, there are limitations in our study design. In a future controlled study, it would make sense to stimulate a non-acupuncture point with the same technical equipment and also to record skin temperature at a distance of 3 cm. Despite the small number of subjects (n = 10) in the present study, it is interesting to note that there were significant results at the acupoint and distinct differences between violet laser stimulation, manual needle stimulation, and deactivated laser stimulation (placebo), similar to the changes in the microcirculation as described in part 2 [2].

Because the energy level of violet laser stimulation was relatively high (in kJ/cm² range), tissue heating was induced, as was previously described by our group [3]. In that report thermal imaging demonstrated that at a distance of 1 mm from the tip of the violet laser needle tissue temperature increased by 2.6°C [2,3]. The present study results are relevant insofar as a generally accepted proof for the existence of meridians using thermal imaging cannot be assumed to exist. Whether thermal imaging can contribute to this still open-ended question is controversial [14–17].
5. Conclusion

After violet laser acupuncture stimulation on the Dazhui (GV14) acupuncture point, there was a significant increase in the skin temperature surrounding the stimulated point, and interestingly, there was a significant increase in the skin temperature surrounding the acupuncture point described as “far field” (GV9).

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