

Circulation

Photomed Laser Surg. 2005 Jun;23(3):289-94.

Low-level laser therapy accelerates collateral circulation and enhances microcirculation.

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Objective: To evaluate the efficacy of low-level laser therapy (LLLT) on collateral circulation and microcirculation if a blood vessel is occluded. **Background data:** Investigators have attempted prostaglandin and ultrasound therapy to promote improvements in the vascular bed of deprived tissue after an injury, which may lead to occlusion of the blood vessels. **Materials and Methods:** Thirty-four adult rabbits were used in this study, two of them considered 0-h reading group, while the rest were divided into two equal groups, with 16 rabbits each: control and those treated with LLLT. Each rabbit underwent two surgical operations; the medial aspect of each thigh was slit, the skin incised and the femoral artery exposed and ligated. The site of the operation in the treated group was irradiated directly following the operation and for 3 d after, one session daily for 10 min/session. The laser system used was a gallium-aluminum-arsenide (Ga-Al-As) diode laser with a wavelength of 904 nm and power of 10 mW. Blood samples collected from the femoral artery above the site of the ligation were sent for examination with high-performance liquid chromatography (HPLC) to determine the levels of adenosine, growth hormone (GH) and fibroblast growth factor (FGF). Tissue specimens collected from the site of the operation, consisting of the artery and its surrounding muscle fibers, were sent for histopathological examination to determine the fiber/capillary (F/C) ratio and capillary diameter. Blood samples and tissue specimens were collected at 4, 8, 12, 16, 20, 24, 48 and 72 h postoperatively from the animals of both groups, control and treated. **Results:** Rapid increases in the level of adenosine, GH, and FGF occurred. The F/C ratio and capillary diameter peaked at 12-16 h; their levels declined gradually, reaching normal values 72 h after irradiation in the treated group. Numerous collateral blood vessels proliferated the area, with marked increases in the diameters of the original blood vessels. **Conclusions:** The results indicated that LLLT

accelerated collateral circulation and enhanced microcirculation and seemed to be unique in the normalization of the functional features of the injured area, which could lead to occlusion of the regional blood vessels.

Effects of near-infrared low-level laser irradiation on microcirculation.

Maegawa Y, Itoh T, Hosokawa T, Yaegashi K, Nishi M. *Lasers Surg Med.* 2000; 27:427-437.

The present study was conducted to explore the effects of LLLI on microcirculation. We investigated the effects of LLLI on rat mesenteric microcirculation *in vivo*, and on cytosolic calcium concentration ($[Ca^{2+}]_i$) in rat vascular smooth muscle cells (VSMCs) *in vitro*. LLLI caused potent dilation in the laser-irradiated arteriole, which led to marked increases in the arteriolar blood flow. The changes were partly attenuated in the initial phase by the superfusion of 15 μ M L-NAME, but they were not affected by local denervation. Furthermore, LLLI caused a power-dependent decrease in $[Ca^{2+}]_i$ in VSMCs. The circulatory changes observed seemed to be mediated largely by LLLI-induced reduction of $[Ca^{2+}]_i$ in VSMCs, in addition to the involvement of NO in the initial phase.

Effects of 780 nm diode laser irradiation on blood microcirculation - study by time dependent T1-weighted enhanced magnetic resonance imaging (MRI).

Schaffer M et al.

Six healthy volunteers were irradiated on their right plantar pedis with 5J/cm² and a fluence rate of 100 mW/cm². T1-weighted MRI was used to quantify the time-dependent local accumulation of Gadolinium DTPA, which semi-quantitatively reflects local blood flow. Images were obtained before and after laser application. LLLT resulted in an increase of signal to noise ratio of more than 0.34 (range 0.23-0.63) after irradiation according to contrast enhanced MRI. Increased blood flow offers an explanation for the clinical observation of improved wound healing and reduced pain after LLLT. The effect might complete and improve the outcome of other therapeutic modalities such as tumor ionizing radiation therapy and local chemotherapy.

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

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Laserneedles represent a new non-invasive 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 a randomised 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. The eight laserneedles used in this study were arranged at the end of the optical fibres. Each fibre was connected to a semiconductor laser diode emitting at 685 nm with a primary output power of about 55 mW.

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 in acupuncture research can be performed.

In an animal study by Kobayashi the effect of GaAlAs laser on the blood flow in flaps was studied through laser speckle flowgraphy (LSF).

40 rats were divided into four groups. Two groups had random pattern flaps, two had axillary pattern flaps with the dominant vessels intact. Flaps were raised and peripheral blood flow assessed through LSF. Laser irradiation was performed in two groups, either directly on the dominant vessel or at one point on the distal part of the flap. The blood flow directly after irradiation was higher than before irradiation. At day 5 there was a clear difference between the irradiated and the non-irradiated flaps. The flaps irradiated at the dominant vessels had a slightly better outcome than those irradiated at the Kobayashi M et al. Studies of the diode laser therapy on blood supply in the rat model. Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 70-71.

Specific Effects of Laserpuncture on the Cerebral Circulation

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Abstract . Acupuncture is a form of traditional Chinese medicine that has developed over thousands of years. We studied the effects of laser puncture, needle acupuncture, and light stimulation on cerebral blood flow in 15 healthy volunteers (mean age 25.0 ± 1.9 years, 5 female, 10 male) with non-invasive transcranial Doppler sonography. In addition 40-Hz stimulus-induced brain oscillations, heart rate, blood pressure, peripheral and cerebral oxygen saturation, and the bispectral index of the EEG were recorded. Stimulation with light significantly increased blood flow velocity in the posterior cerebral artery ($p < 0.01$, ANOVA). Similar but less pronounced effects were seen after needle acupuncture ($p < 0.05$, ANOVA) and laserpuncture (n.s.) of vision-related acupuncture points. Furthermore both, laserpuncture and needle acupuncture, led to a significant increase in the amplitudes of 40-Hz cerebral oscillations. Stimulation of vision-related acupuncture points with laser light or needle acupuncture elicits specific effects in specific areas of the brain. The results indicate that the brain plays a key intermediate role in acupuncture. However, brain activity of itself does not explain anything about the healing power of acupuncture.

HeNe laser effects on blood microcirculation - An in vivo study through laser doppler flowmetry. 2002. 77f.

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Dissertation (Professional Master's Degree "Lasers in Dentistry") - Nuclear and Energy Research Institute / School of Dentistry, University of São Paulo, São Paulo. Advisor: José Luiz Lage-Marques, DDS, PhD, Gessé Eduardo Calvo Nogueira, DDS, PhD

Blood microcirculation performs an important function in tissue repair process, as well as in pain control, allowing for greater oxygenation of the tissues and the accelerated expulsion of metabolic products, that may be contributing to pain. Low Intensity Laser Therapy (LILT) is widely used to promote healing, and there is an assumption that it's mechanism of action may be due to an enhancement of blood supply. The purpose of this study was to evaluate, using laser Doppler flowmetry (LDF), the stated effects caused by radiation emitted by a HeNe laser ($\lambda = 632.8\text{nm}$) on blood microcirculation during tissue repair. To this end, 15 male mice were selected and received a liquid nitrogen provoked lesion, above the dorsal region, and

blood flow was measured periodically, during 21 days. Due to radiation emission by the LDF equipment, a control group was established to evaluate possible effects caused by this radiation on microcirculation. To evaluate the HeNe laser effects, a 1.15J/cm² dose was utilized, with an intensity of 6mW/cm². The results obtained demonstrate flow alterations, provoked by the lesion, and subsequent inflammatory response. There was no statistical difference between the studied groups. As per the analysis of the results there is no immediate effect due to the radiation emitted by a HeNe laser on microcirculation, although a percentage increase was observed in day 7 on medium blood flow rate in irradiated specimens. New studies are necessary to validate the use of this wavelength, in order to promote beneficial alterations in blood supply in radiated areas.