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Efficacy of Nd:YAG laser treatment (1064 nm) of leg veins depends on the vessel diameter

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Abstract

For many years, leg veins have been successfully treated in clinical practice using long pulsed Nd:YAG lasers at 1064 nm. The concept of selective photothermolysis governs laser parameters such as wavelength, pulse duration and radiant exposure providing high efficacy and low incidence of side effects. It has been frequently reported that efficacy of this laser treatment also depends on the diameter of the leg veins.

To investigate this effect, we conducted a clinical study with 55 consenting patients with leg veins of different vessel diameters. The number and diameter of leg veins were measured prior to, and after the laser treatment, using two different Nd:YAG lasers (1064 nm) with either a short pulse duration (10 ms) or a long pulse duration (60 ms). The patients were treated twice at an interval of 6 weeks, and the results of treatment were assessed 6 and 36 weeks after the second treatment.

The vessel clearance was almost independent of the pulse duration applied. However, the larger the vessel, the better was the result, independent of the pulse duration. A recent mathematical model for laser vessel interaction has revealed that the efficacy of laser treatment should continually improve with increasing vessel diameter. This has now been confirmed by the clinical study.

Keywords: Leg veins; Vessel diameter; Laser therapy

Introduction

In the last 20 years, the use of lasers has significantly improved the treatment of vascular cutaneous disorders. Laser light applied to the surface penetrates the skin and is selectively absorbed by the hemoglobin within the blood vessels. The absorbed energy is converted into heat, leading to an increase in the temperature inside the vessel. If temperatures higher than 70 °C are reached, coagulation of the vessel occurs. By using the appropriate pulse duration, the thermal damage can be restricted to the vessel and the adjacent dermis is spared [1]. This well-known therapeutic approach, selective photothermolysis, was published by Anderson and Parrish more than 20 years ago [2].

The theory has been successfully applied to the treatment of vascular disorders such as port-wine stains (PWS) using flashlamp-pumped dye lasers [3]. The

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treatment of PWS is one of the most investigated applications of lasers in dermatology, ranging from scientific [4–7] to clinical investigations [3,8–11].

However, the diameter of PWS-vessels is small, ranging from 10 to 300 μm [12]. Since pulse duration governs the spatial confinement of laser-induced heating, the ideal pulse duration should be of the order of the thermal relaxation time τ_R or even shorter. The thermal relaxation time is the time required for a peak temperature decrease of 50% inside a vessel following laser impact. Thus, τ_R depends on the size of the vessel leading to optimal pulse durations of about 1–10 ms for these small PWS-vessels [13].

For larger vessels, longer pulse durations seem to be required. Based on a model for laser-induced vessel heating [13,14], a pulse duration of 4.5 ms is suitable for a vessel diameter of 100 μm. For a large vessel diameter of 1.5 mm (e.g. leg veins), the same model would yield a pulse duration of about 1000 ms, which cannot be applied in clinical practice. When using Nd:YAG lasers for the treatment of leg veins (vessel diameter 0.2 up to 4 mm), the applied pulse durations are more or less randomly distributed in the range of 1–100 ms [15–19].

Based on a new mathematical model, we have recently shown that the efficacy of laser treatment (1064 nm) also depends on the vessel diameter of the leg veins. To provide clinical evidence for this theoretical result, we performed a clinical study with 55 consenting adult patients with leg veins of different vessel diameters. In addition, we used two different pulse durations and radiant exposures (J/cm^2).

Material and methods

The clinical study was performed with two different Nd:YAG lasers ($\lambda_{em} = 1064$ nm) for leg veins ranging from 0.2 to 2.0 mm in diameter. The vessel diameter was assessed using a magnifying lens (Dermatoscope, Delta 10, Heine, Germany). In the treatment area, the vessels were counted and graded as small (<0.5 mm in diameter), medium (0.5–1 mm), or large (1.1–2 mm). The treatment area was documented with a digital camera (Canon D30, Germany), before and after treatment, for evaluation of the treatment efficacy and side effects. The patients underwent two laser treatments at an interval of 6 weeks. Clinical evaluation was performed at 6 and 36 weeks after the second laser treatment by counting and grading the vessels. Five categories of improvement, based on the reduction in number of vessels were assigned as follows: 0 = no clearance, 1 = 1–25% clearance, 2 = 26–50% clearance, 3 = 51–75% clearance, and 4 = 76–100% clearance. The pain caused by the laser treatment was assessed by the patients using three graduation levels (mild, moderate, and severe).

Twenty-five consenting female patients of Fitzpatrick skin types I-III (1 type I, 16 type II, and 8 type III), aged 21–62 years, underwent the treatment with a long pulsed (LP) Nd:YAG laser (Lyra, Wavelight, Germany) with a spot size of 2.5 mm, a pulse duration of 60 ms and a radiant exposure of 295 ± 15 J/cm^2. Thirty consenting patients (29 females, one male) of Fitzpatrick skin types II–IV (21 type II, 8 type III, 1 type IV), aged 24–61 years, underwent the treatment with a short pulsed (SP) Nd:YAG laser (Smartepil, DEKA-LMS, Germany) with a spot size of 2.5 mm, a pulse duration of 10 ms and a radiant exposure of 110 ± 10 J/cm^2.

Results

For both lasers, the treated areas showed transient adverse reactions such as purpura, erythema, edema, blistering, and pain during or after laser irradiation.

Using the SP-laser, two patients showed a mild purpura after the first session and one patient after the second session. All 30 patients showed edema, (13 mild and 17 moderate after the first session; 14 mild, 15 moderate, and one severe after the second session) and erythema (three mild, 26 moderate, and one severe after the first session; three mild, 25 moderate, and two severe after the second session).

Using the LP-laser, two patients showed a mild purpura, whereas all 25 patients showed edema (18 mild, seven moderate) and erythema (11 mild, 14 moderate). In one case mild blistering was observed.

All subjects reported pain caused by the laser treatment. With the SP-laser, the pain was mild in 20

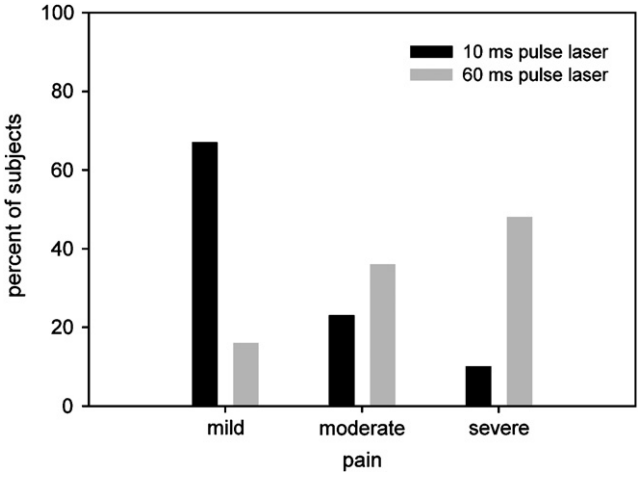

Fig. 1. Registered pain level of the laser treatment in the clinical study using 10 ms (black bars) and 60 ms pulses (gray bars). The long pulse duration obviously caused more pain compared with the short pulse duration but showed comparable clinical results.