

Use of an 800 nm High-power Diode Laser for the Treatment of Leg Vein Telangiectasia

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Summary provided by Lumenis Inc.

The study summarized below was presented to the FDA as part of the regulatory review of the LightSheer™ Diode Laser System for leg vein treatments. This product was cleared for hair removal in December 1997, for leg veins in January 1998, and for permanent hair reduction in April 1999. This summary is intended to help practitioners better inform their patients. This review is provided by Lumenis Inc. for informational purposes only and is not a substitute for clinical observation of laser-tissue interaction and training.

ABSTRACT

Lasers have been used for hair removal since 1995, but few have had properties that are also effective in treating leg veins. This dose-response study at Wellman Laboratories on 25 patients with 200 treatment sites has determined parameters for an 800 nm high-powered diode laser. It has also resulted in recommendations for patient selection and a treatment protocol. Patients presenting with leg vessels between 0.4 and 1 mm have been shown to respond to laser treatment, with results improving with the number of treatments and with time after treatment.

BACKGROUND

Sclerotherapy and surgical intervention are the most common techniques for eliminating leg veins. Sclerotherapy is typically considered the first line of treatment. However, some patients have aversions to this invasive procedure. In addition, fine caliber vessels may be difficult to cannulate with a needle. The treatment of spider veins around the ankles may best be treated by alternative treatment methods such as lasers. Various lasers/light sources, including KTP lasers (532 nm), pulsed dye lasers (585-600nm), alexandrite lasers (755 nm) Nd:YAG lasers (1064 nm), and filtered xenon flashlamps have been used to treat leg veins.¹

Semiconductor diode lasers are considered the most efficient light sources available and are particularly well suited for clinical applications. The pulsed diode laser used in the study delivers high-energy laser pulses, in combination with a proprietary skin cooling system, to target leg veins. Treatment operates on the principle of

selective photothermolysis, which combines selective absorption of light energy by the oxyhemoglobin in the leg veins with suitable pulse energies and pulse widths (pulse durations) that correspond to the thermal relaxation time of the target.

An 800 nm wavelength laser (a prototype of the LightSheer Diode Laser System, Lumenis Inc., Santa Clara, CA) was studied to determine its effectiveness in clearing leg veins. The delivery of the laser energy is through a handpiece that contains high-power diode arrays, eliminating the need for an articulated arm or fiber-optic beam delivery system. The handpiece integrates a condenser that mixes light to produce a fluence of 10-40 J/cm² over a uniform 9x9 mm area². The handpiece contains an actively cooled convex sapphire lens that, when pressed against the patient's skin slightly before and during each laser pulse, provides thermal protection for the epidermis. The cooling lens allows higher doses of laser energy to safely and effectively target leg veins.

Diode lasers generate a wavelength that is absorbed by oxyhemoglobin, the target chromophore for leg vein treatment. During leg vein treatment, oxyhemoglobin absorbs the laser energy, transferring heat to the vascular epithelium, and denaturing the vessel wall. At this wavelength there is less energy absorbed by the competing chromophore (melanin) than when shorter wavelengths are used. This can reduce side effects caused by interaction with the melanin in the epidermis. Also the longer 800 nm wavelength penetrates deeper into the skin than most other systems and thus may be more effective at reaching the target area. While this diode system was designed for hair removal and its effectiveness was shown in a previous Wellman study,³ our goal was to understand its effect on leg veins.

CLINICAL STUDY

Objective

The Wellman Laboratories of Photomedicine's primary objective was to investigate safety and effectiveness of a pulsed 800 nm diode laser for leg vein clearance. The study addressed two groups of leg veins: those with a diameter of less than 0.4 mm and those with 0.4-1.0 mm. It was designed as a dose-response study with the primary response measurement a clinical assessment of vessel clearing and side-effects obtained by direct visual inspection as well by standardized polarized photography. Objective measurement of vessel diameter was obtained from standardized digital photography. The dose parameters were laser fluence, laser pulse width, number of pulses per treatment, and number of treatments.

Protocol

All prospective study subjects were examined with doppler ultrasound to ensure their veins were competent. By detecting the blood flow when a compressed vein is relaxed, doppler ultrasound clearly indicates when veins are refluxing and are not suitable for laser treatment. Patients with refluxing reticular veins by this exam were excluded from the study (this is the present standard of care).

Twenty-five subjects (23 females, 2 males) with Fitzpatrick skin types II to V were enrolled in the study. All the subjects had spider varicosities without underlying refluxing veins in their upper or lower legs. Eight treatment sites on each subject were selected for study. A plastic template was used to map each test site. The vessels in each test site were photographed under standardized conditions using polarized photography and digital imaging. A polarized camera (N6006, Nikon, Tokyo, Japan with CCS-79 Twin Flash, Canfield Systems, Cedar Grove, NJ) was used for polarized photography. Digital images were taken with a charged-coupled-device (CCD) camera (Model 4915-2010, Cohu, Japan) and computer frame-capture board (Scanalytics, Inc., Vienna, VA) at a normal angle of incidence. Analysis of the images was done with IPLAB software imaging package. These images provided a permanent record of vessel size. Cross-sectional diameter was measured at three different locations over the vessel and an average was calculated. The measurements were done by the same investigator to minimize errors. The vessels were classified according to vessel diameter. Size 1 vessels were defined as those having diameters < 0.4 mm and size 2 ranged in diameter from 0.4 to 1 mm. The color (blue versus red) and clinical appearance of each vessel (linear, arborizing, or spider) were also noted.

Treatment parameters were set on the basis of the vessel diameter. Fourteen subjects had Size 1 vessels, while eleven subjects had Size 2 vessels. Size 1 vessels were treated with a combination of fluences (15, 30, and 40 J/cm²), and pulse widths (5, 15, and 20 ms). Size 2 vessels were treated with the same combination of fluences (15, 30, and 40 J/cm²) and, being larger, a higher range of pulse widths (15 and 30 ms). Double and triple pulsing (multiple pulses applied two seconds apart to the same target area) were also investigated at some of the sites. With these laser parameters fixed, half of the treatment sites received one treatment. The other half of the sites were treated three times over three months. These treatment regimes are detailed in Table I.

TABLE I. EXPOSURE SCHEDULE.

| Site | # of treatments | Size 1(less than 0.4 mm) Vessels | | | Size 2(0.4-1 mm) Vessels | | |
|------|-----------------|----------------------------------|------------------|-------------|------------------------------|------------------|-------------|
| | | Fluence (J/cm ²) | Pulse width (ms) | # of pulses | Fluence (J/cm ²) | Pulse width (ms) | # of pulses |
| 1 | 1 | 15 | 5 | 1 | 15 | 15 | 3 |
| 2 | 3 | 15 | 5 | 1 | 15 | 15 | 3 |
| 3 | 1 | 30 | 15 | 1 | 30 | 15 | 2 |
| 4 | 3 | 30 | 15 | 1 | 30 | 15 | 2 |
| 5 | 1 | 30 | 15 | 3 | 30 | 15 | 3 |
| 6 | 3 | 30 | 15 | 3 | 30 | 15 | 3 |
| 7 | 1 | 40 | 20 | 1 | 40 | 30 | 1 |
| 8 | 3 | 40 | 20 | 1 | 40 | 30 | 1 |

All subjects were advised to avoid sun exposure to the treatment areas for six weeks before the laser treatment. After treatment, all subjects were instructed to wear firm pantyhose support for three days after each treatment (this is typical with treatments of sclerotherapy).

Patients were followed at one-month intervals for up to three months after a single treatment and for one month after three treatments. Standardized polarized photographs of the treatment sites were taken before treatment and at each follow-up session. Dermatologists blinded to the study design, but familiar with leg vein treatments, graded leg vein clearance in each digital photograph according to the scale in Table II.

TABLE II. VESSEL CLEARANCE GRADING SCALE.

| Grade | Description | % Clearance |
|-------|--------------------|-------------|
| 0 | No clearing | <5% |
| 1 | Slight clearing | 5-25% |
| 2 | Moderate clearing | 25-50% |
| 3 | Almost cleared | 50-75% |
| 4 | Complete clearance | >75% |

The polarized photographs were also used by the dermatologists to assess complications. Any hypopigmentation, hyperpigmentation, telangiectatic matting, erythema or textural changes were graded from "none," "mild," "moderate" to "severe".

RESULTS

While all patients tolerated the procedure without anesthesia, moderate to severe pain was reported at the highest treatment fluence of 40 J/cm². No textural changes were seen at any time during the study. At one month follow-up after the last treatment on each treated site there was hyperpigmentation in only 4% to 6%, hypopigmentation in 4%, telangiectatic matting in 0 to 1% (a transient vascular reaction more common after sclerotherapy), and no blistering or scarring. Hyperpigmentation occurred in three subjects and hypopigmentation occurred in one subject three months after treatment. (These side effects were transient and were no longer apparent after the completion of the study.) All of these skin reactions were rated as "mild" by the study dermatologists. While pigmentary changes after laser treatment of leg veins are very common, the low incidence in this study can be ascribed to the longer wavelength and the active cooling of the epidermis.

TABLE IIIA. INCIDENCE OF SIDE EFFECTS AFTER SINGLE TREATMENT

| | post | 1 month post Tx I | 2 month post Tx I | 3 month post Tx I |
|------------------------|------|-------------------|-------------------|-------------------|
| Hypopigmentation | - | 4% | 3% | 2% |
| Hyperpigmentation | - | 4% | 3% | 3% |
| Telangiectatic matting | - | 0% | 0% | 0% |
| Textural change | - | 0% | 0% | 0% |

TABLE IIIB. INCIDENCE OF SIDE EFFECTS AFTER 3 TREATMENTS

| | post | 1 month post Tx I | 1 month post Tx II | 1 month post TxIII |
|------------------------|------|-------------------|--------------------|--------------------|
| Hypopigmentation | - | 3% | 3% | 4% |
| Hyperpigmentation | - | 4% | 7% | 6% |
| Telangiectatic matting | - | 0% | 1% | 1% |
| Textural change | - | 0% | 0% | 0% |

The immediate response to treatment of this diode laser system in order of increasing fluence is subtle vasodilation, vessel coagulation, and immediate vessel disappearance. Within a few minutes, erythema and minor local swelling develop, similar to sclerotherapy. Post-operative purpura was never observed.

By evaluating the clearance of different classifications of leg veins, the investigation established a dose-response relationship for the laser treatment. Based on the leg vein clearance grades in the polarized photographs, the optimal treatment parameters for vessel size 1 (vessels less than 0.4 mm in diameter) is 40 J/cm² fluence at a pulse width of 20 milliseconds. Size 2 vessels (between 0.4 mm and 1 mm in diameter) are optimally treated with 40 J/cm² fluence at a 30-millisecond pulse width.⁴

After a single treatment, vessel clearance improved each month after treatment. As seen in Figure 1, the percentage of patients who had greater than 50% clearance increased over time. In all cases, as seen in Figure 2, multiple treatments were more effective than a single treatment. Size 2 vessels responded better than size 1 vessels, with 100% of the patients having greater than 50% clearance after three treatments.

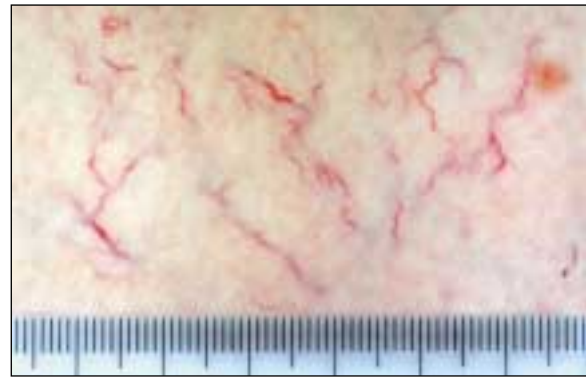


Figure 1A.
Patient with skin type II before treatment.

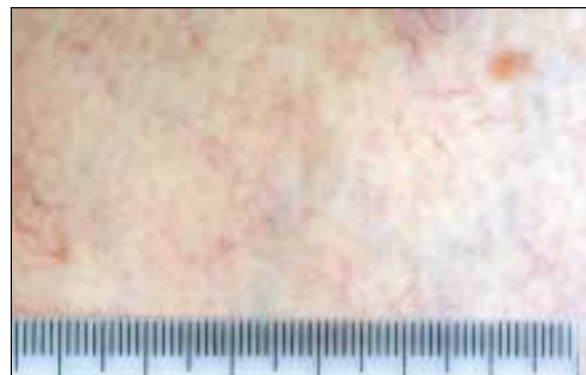


Figure 1B. Same patient six months after three treatments. The treatment fluence was 40 J/cm² and the pulse duration was 20 ms.

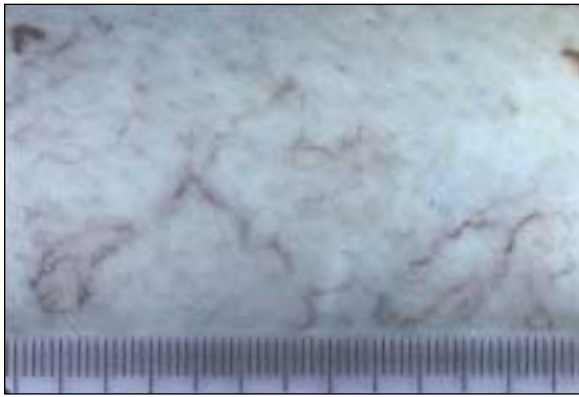


Figure 2A. Patient with skin type III before treatment.

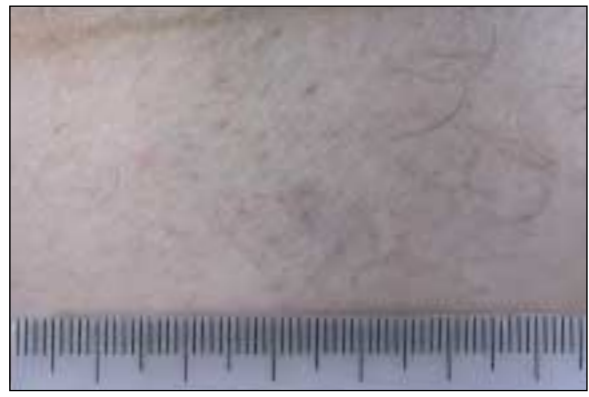


Figure 2B. Same patient two years after three treatments. The treatment fluence was 40 J/cm² and the pulse duration was 20 ms.

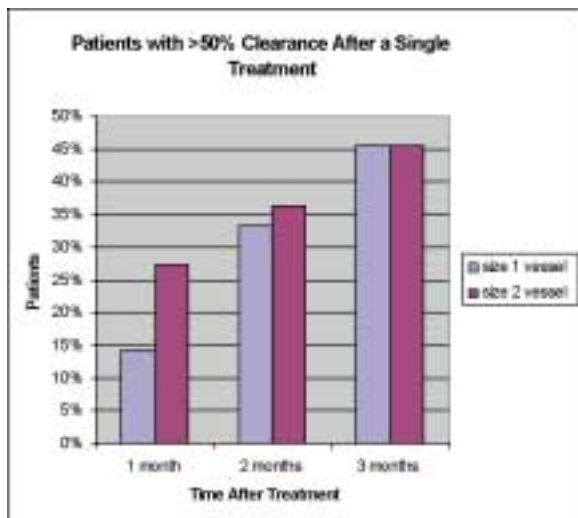


Figure 3. After one treatment, the number of patients who had greater than 50% vessel clearance increased over time.

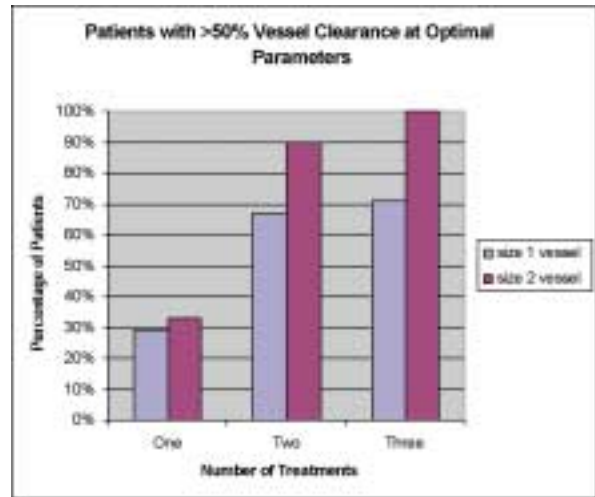


Figure 4. Patients with greater than 50% vessel clearance after one, two and three laser treatments.

CLINICAL GUIDELINES DERIVED FROM THE STUDY

Pre-Treatment

It is important to select patients who will be most responsive to laser treatment by assessing the size, color, and depth of the target vessels. Vessels between 0.4 mm and 1 mm in diameter have been shown to respond best to 800 nm laser treatment. Blue or purple vessels also respond better to laser treatment than do red vessels. Patients should expect at least two treatments, while three treatments are recommended for best results.

Patients should avoid sun exposure for six weeks before treatment. Patients with tans or who use self-tanning creams should either delay their treatment or use a bleaching cream for six weeks prior to the start of treatments to reduce the potential interaction of tan with the laser light.

TREATMENT

It is necessary to shave the treatment area immediately before beginning the laser treatment. If hair is present, it will absorb the laser energy and burn, causing discomfort. It is not necessary to use anesthesia. Sensitive patients

may require EMLA; however, this is not recommended because EMLA is a mild vasoconstrictor and will reduce the effectiveness of the treatment.

The diode laser handpiece used in this study incorporates a chilled sapphire window. This window is continuously cooled to 5 °C and protects the epidermis from damage. The chilling handpiece should be turned on during treatments and in contact with the epidermis.

The laser handpiece should gently touch the skin during the treatment. **It is extremely important not to apply pressure.** Even slight pressure can blanch the target vessel, reducing the amount of oxyhemoglobin (the target chromophore) present to absorb the laser energy. This technique is critical to successful treatments. Some practitioners slide the handpiece across the skin. In this case, a very light layer of ultrasound gel can help the handpiece move without friction or "drag". About 10% overlap between pulses is recommended. A polarized light source (Syris Scientific, Gray, ME) can help identify areas that have already been treated.

A few sites with different laser exposures should be tested before beginning the actual treatment. Start with the fluence recommended for the patient's skin type.⁵ It is best to wait at least 24 hours after the test pulses before checking for epidermal damage. With darker skinned patients, one should wait at least one week before checking for epidermal damage.

The desired clinical endpoint is thrombosis, erythema and perivascular edema. These should resolve within 24 hours after treatment.

Follow-up

Outcomes improve when stockings or support hose are worn for at least three days after treatment. Patients should be instructed to avoid sun exposure after treatment. Anecdotally, patients who developed hypopigmentation in this study had a sun tan before exposure to laser. Finally, patients should expect that clearance will increase over time, with the best results observed at least 3 months after the last treatment.

CONCLUSION

The pulsed diode laser utilized in this study provides a safe and effective treatment that achieves reduction of unwanted leg vein telangiectasias. Patients with blue or purple leg veins between 0.4 mm and 1 mm in diameter can be effectively treated with an 800 nm diode laser. Clinical research shows that the optimal treatment parameter for these size vessels is a fluence of 40 J/cm² at a 30 ms pulse width.

ADDITIONAL STUDY FINDINGS

- Size 2 vessels (0.4 –1 mm) responded better than size 1 vessels (less than 0.4 mm).
- Patients with blue or purple leg veins responded better than those with red vessels.
- Multiple treatments resulted in even greater efficacy with 100% of those receiving 3 treatments exhibiting greater than 50% clearance in vessels from 0.4 to 1 mm. From these same size vessels, 90% of those treated twice had greater than 50% clearing.
- None of the patients experienced purpura during or after any of their treatments.
- While pigmentary changes after laser treatment of leg veins are very common, the low incidence in this study can be ascribed to the longer wavelength and the active cooling of the epidermis.
- There were no instances of textural changes or scarring in any of the 200 treatment sites.

Some patients may experience better clearance, while others may show lower levels of clearance due to the variability of leg vessels as well as differing skin types. The selection of patients for treatment of leg veins is critical. Superficial varicose veins are best treated with this 800 nm diode laser when the larger and/or deeper veins are eliminated. Setting proper patient expectations will increase satisfaction levels of these treatments.

The study results support the clinical utility of the high-power, pulsed diode laser as a safe and effective device for the treatment of leg veins and can expand the intended uses beyond that of permanent hair reduction.

FOOTNOTES

1. Dover, Jeffrey S., Sadick, Neil S. and Goldman, Mitchel P. The role of lasers and light sources in the treatment of leg veins. *Dermatol Surg* 1999; 25:328-336
2. Specifications of the prototype device shown. Additional LightSheer products are available that have fluences up to 60 J/cm² and a spot size of 12x12 mm. Contact your Lumenis Inc. representative for further details.
3. Dierickx CC, Anderson RR, Campos VB, Grossman MC. Effective, Permanent Hair Reduction Using a Pulsed, High-Power Diode Laser. Contact Lumenis Inc. for copies of this reprint.
4. Care should be taken to use settings appropriate to the patient's skin type. The parameters here are from experienced laser users. Such parameters are provided as a guide and are not a substitute for clinical observation of laser-tissue interaction and clinical endpoints.
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