
Treatment of Facial Venous Malformations with Combined Radiofrequency Current and 900 nm Diode Laser

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BACKGROUND. Laser treatment of venous malformations is a major challenge because of the large variations in skin pigmentation, anatomic location, and vessel size and depth.

OBJECTIVE. To determine the safety and effectiveness of electro-optical synergy, a new technology that combines the 900 nm diode laser with radiofrequency current for the treatment of facial venous malformation.

METHODS. Fourteen patients with Fitzpatrick skin types II to IV were treated for facial venous malformations with simultaneous radiofrequency energy (60–80 J/cm³) and optical diode laser energy (fluence 80–100 J/cm²) in one to three sessions. All lesions measured less than 100 cm². Lesion clearance was evaluated by

three specialists on the basis of digital photographs taken before the first treatment and 1 and 2 months after the last treatment.

RESULTS. Thirteen patients showed a complete response and one patient a partial response. The results were rated excellent in the 13 patients and good in one patient. Transient swelling, erythema, and pain were present in all patients, with permanent scarring in only one patient.

CONCLUSION. The combination of laser light and radiofrequency energy is effective and safe for the treatment of facial venous malformations. It provides additional heating of the vessels without increasing laser intensity. The side effects are minimal.

THE LASER USED IN THIS STUDY WAS PROVIDED BY SYNERON MEDICAL LTD., YOKNEAM, ISRAEL.

THE ANGIOARCHITECTURE of venous malformations is variable, ranging from focal, multifocal, and diffuse forms. Focal lesions may be intramuscular, cutaneous, or mucosal. They usually consist of collections of abnormal interconnecting channels or spaces that are “sequestered” or drain through fairly small vessels to normal adjacent conducting veins. The affected channels become progressively enlarged, and the resulting stagnation of blood causes thrombosis, swelling, and pain. The most common site of venous malformations is the head and neck.^{1–3}

In the last 20 years, there have been many attempts at laser treatment of venous malformations with the argon laser, the neodymium:yttrium-aluminum-garnet (Nd:YAG) laser (1,064 nm), the KTP frequency-doubled Nd:YAG laser (532 nm), the copper vapor laser, the flashlamp-pumped pulsed dye laser, and broad-spectrum intense pulsed light sources. However, laser use was often limited by the poor light absorption in the deep blood vessels or the high rate of side effects.^{4–20} Recently, greater success was reported for the diode laser (940 nm) in the treatment

of large, deep leg veins.²¹ The diode laser has a higher absorption coefficient than the Nd:YAG laser, making it more suitable for venous treatment.

To protect the tissues against thermal injury, researchers have introduced an electro-optical synergy system that combines the diode laser with the selective conduction of energy in the radiofrequency range via electrodes placed over the blood vessels. The aim of the present prospective study was to determine the safety and efficacy of this new technology for the treatment of facial vascular malformations.

Subjects and Methods

The study group consisted of 14 patients with different types of facial venous malformations. There were six male and eight female patients aged 3 to 76 years (mean 33.8 years, median 25 years). Eleven had focal lesions, and three had multifocal lesions. The anatomic sites affected included the upper lip in four patients, the lower lip in five patients (one also with tongue involvement and two also with buccal area involvement), the cheek in three patients, the tongue in two patients (one also with lip involvement), the buccal area in two patients (two also with lip involvement), and the forehead in one patient. All of the lesions

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were apparent at birth and grew with time. Exclusion criteria were photosensitivity, intake of photosensitive medications, and a history of bleeding or coagulopathy. Patients were provided with a detailed description of the purpose and possible outcomes of the study and signed consent forms to participate in the study and for the clinical photographs. Six patients had previously been treated with sclerotherapy. Six patients had Fitzpatrick skin type II, six patients had type III, and two patients had type IV.

The Polaris LV System (Syneron Medical Ltd., Yoknean, Israel) was used to apply simultaneous optical and radiofrequency energy. A maximal radiofrequency energy of 80 J/cm³ was used for all treatments. The optical energy varied individually by skin phototype (range 80–100 J/cm²). However, since most of the patients had skin type III or IV, the average fluence was 90 J/cm². A thin layer of transparent gel was applied on the treatment site to cool the skin surface and to ensure coupling of the radiofrequency electrodes. In two patients, we used general anesthesia; in four, local anesthesia (lidocaine 1%); and in nine, external cooling only (Crio 5, Zimmer, Ulm, Germany) with no topical agent or other type of anesthetic. The number of treatment sessions ranged from one (10 patients) to three (1 patient).

Follow-up examinations were performed immediately after the first (usually only) treatment session and 1 and 2 months after the last session. Side effects and complications were recorded each time.

Photographs were taken with a digital macrophotography camera (Camedia C-2500L, 2.5 megapixel resolution, Olympus, Tokyo, Japan) before and after the first treatment and at the 2-month follow-up visit after the last treatment. The desired visual end points of treatment were blanching or erythema above the lesion.

At the 2-month follow-up, an ear, nose, and throat specialist, a plastic surgeon, and a dermatologist independently assessed the pre- and post-treatment clinical photographs. A 5-point scale was defined to rate treatment outcome: excellent (75–100% lesion clearance), good (50–75% clearance), fair (25–50% clearance), poor (< 25%), or worse (results worse than the pretreatment findings).

Results

All 14 patients completed the study. Eleven patients exhibited complete resolution of the venous malformations with a single treatment, two patients needed one additional treatment, and one patient needed two additional treatments. At the clinical assessment 2 months after the last treatment, the outcome was rated excellent in 13 patients (92.8%) and good in 1 patient. The latter patient was a 5-year-old boy with a focal lesion of the right cheek treated with 80 J/cm² and 60 J/cm³. There were no grades of fair, poor, or worse.

The usual initial reaction to treatment was vessel spasm, followed by swelling, erythema, and moderate pain above the treated area, lasting about 24 to 48 hours. Figures 1 to 4 illustrate the typical results of the Polaris LV application.

The complication rate was relatively low. However, permanent scarring was noted in one patient (see Figure 4B), a 23-year-old man with a focal lesion of the forehead treated with 100 J/cm² and 80 J/cm³.

Discussion

The treatment of venous malformations generally includes aspirin and/or anticoagulants (to decrease thrombosis or diffuse intravascular coagulation), compression garments, sclerotherapy, and excision. Angiogenesis inhibitors are not effective. Sclerotherapy is effective in patients with

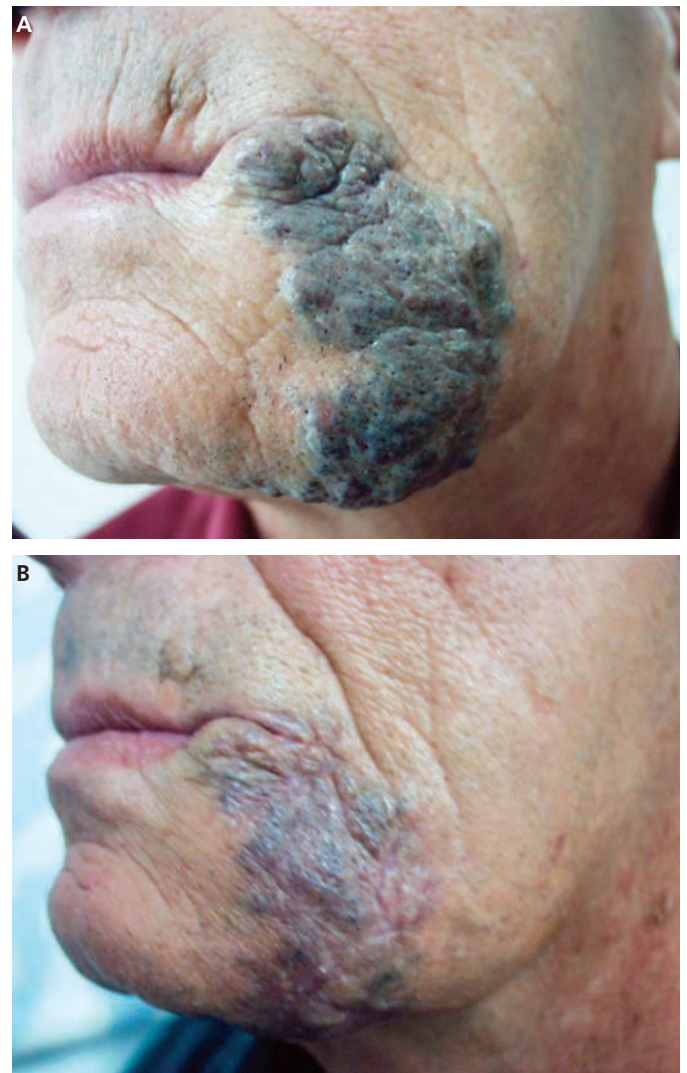


Figure 1. Patient 12. (A) Before treatment. (B) Two months after a single treatment.



Figure 2. Patient 1. (A) Before treatment. (B) Two months after a single treatment.



Figure 3. Patient 6. (A), Before treatment. (B) Two months after a single treatment.



Figure 4. Patient 5. (A) Before treatment. (B) Two months after the treatments, an atrophic scar formation.

painful, localized lesions when performed as a series of injection procedures. However, sclerotherapy is invasive and can result in serious complications.¹⁻³ Most of the attempts at treatment with various types of lasers have met with limited success and a significant rate of side effects. In their report on intralesional laser treatment of facial venous malformations, Derby and Low noted a high rate of recurrence in as little as 2 months.¹⁹ Raulin and Werner advocated the potential use of an intense pulsed light source as an alternative to lasers, although our experience has shown that the effective energy in the longer wavelengths of the light source is insufficient in patients with significant, large venous malformations.²⁰

The diode laser, with a wavelength of 900 nm, used in the present study, has a high absorption coefficient by blood so that repeated treatments should induce vessel closure. Our findings indicate that its combined use with radiofrequency energy conduction is highly effective in the treatment of facial venous malformation. Our team of experts noted an excellent response in 13 or 14 patients (92.8%) and a good response in 1 patient.

The pulse configuration of the Syneron device is square. During the first 10 milliseconds, radiofrequency energy is delivered to measure the initial impedance and to determine whether the handpiece is properly coupled to the tissue. This is followed by a laser pulse of 250 milliseconds to preheat the blood vessel and create the conditions for selective radiofrequency energy application. Toward the end of the laser pulse, the main radiofrequency pulse is switched on and bipolar electrical current is conducted via electrodes in contact with the skin.

The system is based on the observation that during treatment with optical and electrical energies, a "package" of heat envelops the entire vessel and the surrounding tissue. The laser wavelength of 900 nm is at the center of the absorption peak of hemoglobin in the infrared band. The low water absorption improves selectivity and ensures that maximum laser energy is absorbed by the blood vessel. The 900 nm wavelength also penetrates deep into the dermis and can be used on large and deep vessels. The absorption of the laser energy by the blood creates a small temperature gradient between the target and surrounding tissues. The heat diffuses centrifugally from inside the vessels, thereby "attracting" the radiofrequency energy from the adjacent tissue, which diffuses centripetally to the vessel interior. Thus, preheating the vessel with the laser light generates a path for the radiofrequency current to travel inside the vessel.²² As the current always follows the route of least impedance, it can be controlled by external skin cooling and preheating of the vessel with the laser pulse. The external contact cooling forces the radiofrequency current to penetrate deeper because it raises the impedance of the cooled skin surface relative to the dermis.

The Polaris LV system therefore offers a number of advantages over standard laser treatment. The presence of a second energy source makes it possible to lower the optical energy needed, which prevents damage to the epidermal layer—the major risk factor in laser- and light-based devices. At the same time, treatment efficacy is not compromised because the conducted electrical current is not sensitive to the optical properties of skin. Moreover, with combined electro-optical energy, pigmentary complications are essentially nonexistent because the radiofrequency energy is "blind" to skin color and the 900 nm optical energy, which is greatly absorbed by hemoglobin, is hardly absorbed by melanin.

The early tissue reaction to combined treatment usually appears after a few minutes and differs somewhat from the response to traditional laser treatment because of the relatively low peak power. With traditional treatment, erythema typically appears above the vessels as a result of heat dissipation from the vessel and not as a result of the direct absorption of laser light by the epidermis. With the combined system, the cooling protects the epidermis from immediate erythema and edema. Long-term clinical evaluations are still necessary to determine the rate of recurrence owing to the interconnecting channels of the venous malformations, especially after pregnancy and other conditions that involve high venous blood pressure.

Conclusion

This clinical study describes a new approach to noninvasive treatment of vascular lesions. The delivery of combined laser light with radiofrequency energy using the Polaris system makes it possible to apply additional heat selectively to the blood vessels for coagulation without increasing the laser intensity, whereas cooling of the contact site protects the epidermis and reduces erythema. The treatment was found to be effective for focal and multifocal lesions in various facial sites in patients with skin types II to IV.

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