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Treatment of Resistant Port Wine Stains With the V Beam® Pulsed Dye Laser

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Background and Objectives: Pulsed dye lasers (PDL; 585 nm, 0.45 millisecond) are the treatment of choice for port wine stains (PWS). However, clearance rates vary widely and are in many patients incomplete. The objective of this prospective pilot study was to investigate the effects of a long pulse-duration 595 nm PDL (V Beam®, Candela Laser Corporation, Wayland, MA) on previously treated PWS to ascertain whether further lightening can be obtained. Treatment response was assessed subjectively (photographs) and objectively with noninvasive techniques (reflectance spectrophotometer and spectrophotometric intracutaneous analysis scope (SIAscope)).

Study Design/Materials and Methods: Twelve adult patients with congenital PWS each had four test patches with different spot sizes, fluences, and pulse widths carried out. The test area with the best response was selected and two laser treatments were performed at weeks 8 and 16. Photographs and measurements with a reflectance spectrophotometer and SIAscope (Astron Clinica, Cambridge, UK) were performed at baseline, before each treatment and at final review at week 24.

Results: Of the nine patients who completed the study three patients showed a good response (51–75% lightening), which was supported by measurements with the reflectance spectrophotometer and the SIAscope. A further three patients had fair improvement (26–50% lightening) and three patients had a minor or no response (0–25% lightening). In two patients a discrepancy between the degree of clinical response and some of the objective measurements was noticed.

Conclusions: The 595 nm V Beam® PDL appears to achieve further lightening of therapy-resistant PWS in the majority of patients (67%). Both reflectance spectrophotometer and SIAscope appear to permit assessment of objective treatment responses. Results require confirmation in larger studies. Lasers Surg. Med. 33:282–287, 2003.

Key words: birthmarks; flashlamp-pumped pulsed tunable dye laser; PDL; PWS

INTRODUCTION

Port wine stains (PWS) are congenital vascular nevi consisting of circumscribed ectatic dermal capillaries, arterioles, and venules. They have no tendency to spontaneous resolution. In contrast, with advancing age PWS tend to get darker and often nodular due to progressive ectasia. A deficit in the numbers of autonomic perivascular nerves resulting in failure to regulate blood flow appears to be of etiological importance [1].

Flashlamp-pumped pulsed tunable dye lasers (PDL) operating at a wavelength of 585 nm and fixed pulse duration of 0.45 millisecond are the treatment of choice for PWS. They are based on the principle of selective photothermolysis [2]. Multiple treatments are usually required and clearance rates vary widely. Eighty percent of PWS lighten by at least 50% and 10—15% do not clear substantially [3].

The development of longer wavelength, longer pulse width lasers with cooling devices should theoretically result in faster and more complete clearance of PWS [4]. There is little published data from clinical studies to confirm this [5,6]. The V Beam® PDL (Candela Laser Corporation, Wayland, MA) operates at a wavelength of 595 nm and pulse durations from 1.5 to 40 millisecond made up of a series of smaller pulses within the macropulse therefore, targeting larger caliber and more deeply situated vessels in the skin. The associated dynamic cooling device should enable the delivery of higher energy fluences while protecting the epidermis and superficial dermis from thermal damage. It also significantly reduces treatment-associated discomfort and pigmentary changes.

The aim of this prospective study was to investigate the effects of the V Beam® PDL on previously treated PWS which no longer responded to conventional PDL operating at 585 nm and 0.45 millisecond to ascertain in an objective and subjective manner whether further clearance can be achieved.

MATERIALS AND METHODS

Twelve adult patients with congenital PWS were recruited. Each patient had previously received at least three PDL treatments at adequate fluences and no further lightening was achieved from the last two treatments. Children, pregnant, and breast feeding women were excluded as well as patients who had developed in the past

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persistent adverse reactions to PDL therapy e.g., eczema, scarring, hypo- and hyperpigmentation. The V Beam® PDL was used for the study, which operates at a wavelength of 595 nm. The in-build liquid cooling spray was programmed to activate for 30 millisecond duration and 30 millisecond before each laser pulse.

On each patient four test areas were performed with the following parameters: 14 J/cm^2, 1.5 millisecond, 7 mm; 12 J/cm^2, 1.5 millisecond, 7 mm; 14 J/cm^2, 6 millisecond, 7 mm, and 7.5 J/cm^2, 1.5 millisecond, 10 mm. A 10% overlap of spots was used during treatments. The test area with the best visual response was selected on review 8 weeks later and the PWS treated at these parameters. The laser treatment was repeated with the same parameters at week 16. EMLA® cream (lidocaine 2.5%, prilocaine 2.5%) under occlusion was applied to the PWS prior to treatment if requested by patients. If there was no response to the test patches no further treatment was performed.

At baseline, before each treatment and at the final review at week 24 each PWS was photographed and measured with a reflectance spectrophotometer (Dermotronics, Cardiff, UK) and spectrophotometric intracutaneous analysis scope (SIAscope) (Astron Clinica, Cambridge, UK). Representative areas of each PWS were measured and recorded photographically and on computer graphics so that the same locations were used on each visit. Clinical assessment was based on comparing baseline photographs with photographs taken after laser treatments in percentage of lightening of PWS (>95%: clearance, 76–95%: excellent, 51–75%: good, 26–50%: fair, 0–25%: minor to none). A mean of three measurements was used for each analysis with the reflectance spectrophotometer and SIAscope. Normal skin on the contra lateral body site was measured with both instruments at each session for each patient and used as baseline for analysis. The changes in hemoglobin content of the PWS were displayed as percentages rather than absolute values to highlight the differences in blood volume before and after laser treatments and minimize variations between sessions.

The reflectance spectrophotometer is based on the theory that the logarithm of the inverse reflectance of the skin approximates to the sum of absorbances of the skin's pigments. It measures the reflectance ratio between the light emitted by the optical head and the light reflected from the subject at three wavelengths (566, 640, 670 nm) to devise indices of the melanin and hemoglobin content of the skin [7]. A built-in computer processes the readings and the results are displayed as "erythema index." The SIAscope is a computer-based technique using an optical model of the skin to interpret skin colors occurring in a lesion in terms of lesion histology. The model is based on the interaction of light with the skin structure using the Kubelka–Munk theory of scattering and absorption in inhomogeneous materials. It operates by probing the skin spectrally over an area of 12 × 12 mm using 8 wavebands of light in the visible and near infrared spectra (450–1,000 nm) [8]. Complex computer algorithms compare the data to a normal skin color model and calculate concentration and location of separate components. The results are displayed as SIAgraphs separately detailing the distribution of total melanin, collagen, hemoglobin content as well as presence of melanin in the papillary dermis. SIAgraphs for hemoglobin only were used in our study to assess blanching response. Scanning depths with reflectance spectrophotometer and SIAscope both reach the superficial vascular plexus in the dermis.

RESULTS

Eight women and four men, age range 23–68 years (mean 49.3) were recruited in a prospective method. The PWS was located in eight patients on the face, two on the arm, and one patient each on the chest and leg. Nine patients (75%) completed the study. The test area with the most lightening in six patients (67%) and the most commonly selected

TABLE 1. Patient Details, Selected Treatment Parameters, and Side Effects

Age (years)/gender	PWS site	Selected energy fluence (J/cm^2)	Selected pulse width (millisecond)	Side effects
37/male	Right forehead	14	1.5	
36/female	Right chest	14	6	
32/female	Right face	14	1.5	
68/male	Left cheek	14	1.5	
28/female	Right cheek	14	1.5	Pyogenic granuloma
32/female	Left forearm	12	1.5	
24/female	Right cheek	14	1.5	Hyper pigmentation
23/male	Right forehead	14	6	Hyper pigmentation
35/female	Left face	14	1.5	
25/female	Left leg	N/A	N/A	Hyper pigmentation, atrophic scar
29/male	Right face	N/A	N/A	
23/female	Left arm	N/A	N/A	

PWS, port wine stain; N/A, not applicable. Note: Test areas with 7 mm spot sizes were superior to 10 mm and therefore selected in all patients.

parameters for further treatment was the setting at 14 J/cm^2, 1.5 millisecond, and 7 mm (Table 1). One patient with a PWS on the arm showed the best response at 12 J/cm^2. In two patients a longer pulse width of 6 millisecond was chosen for treatment of the PWS. The results were superior with the 7 mm spot size compared to 10 mm in all patients. Healing time after the laser treatments ranged from 7 to 14 days. Some patients experienced weeping and crusting which did not appear to be worse compared to previous laser treatments.

Three patients (25%) discontinued the study. Two patients failed to attend after the initial visit and the third patient with a PWS on the lower leg developed hyperpigmentation and a small atrophic scar in the test areas. Two additional patients had hyperpigmentation in some of the test areas, which was transient and therefore the patients were not excluded from the study. One patient required surgical removal of a pyogenic granuloma, which had developed after the second laser treatment.

Three patients (33%) showed good blanching (51–75%) of their PWS (Fig. 1), which was supported by measurements with the reflectance spectrophotometer and the SIAscope (Figs. 2 and 3). A further three patients had fair improvement (26–50%) and three patients had a minor or no response (0–25%) to the laser treatment. Figures 2 and 3 represent changes in hemoglobin content of PWS before and after each laser treatment measured with the reflectance spectrophotometer and SIAscope. To allow comparison of patient's PWS measurements were subtracted from measurements of contra lateral normal skin used as baseline. Data were displayed in percentage because the results were highly variable between individual patients. In two patients a discrepancy between the degree of blanching and some of the objective measurements was observed (Table 2). For instance, only minor blanching was achieved in the PWS of patient 6. This was confirmed with the reflectance spectrophotometer, but the SIAscope showed a 100% improvement. However, the patient had a light PWS before

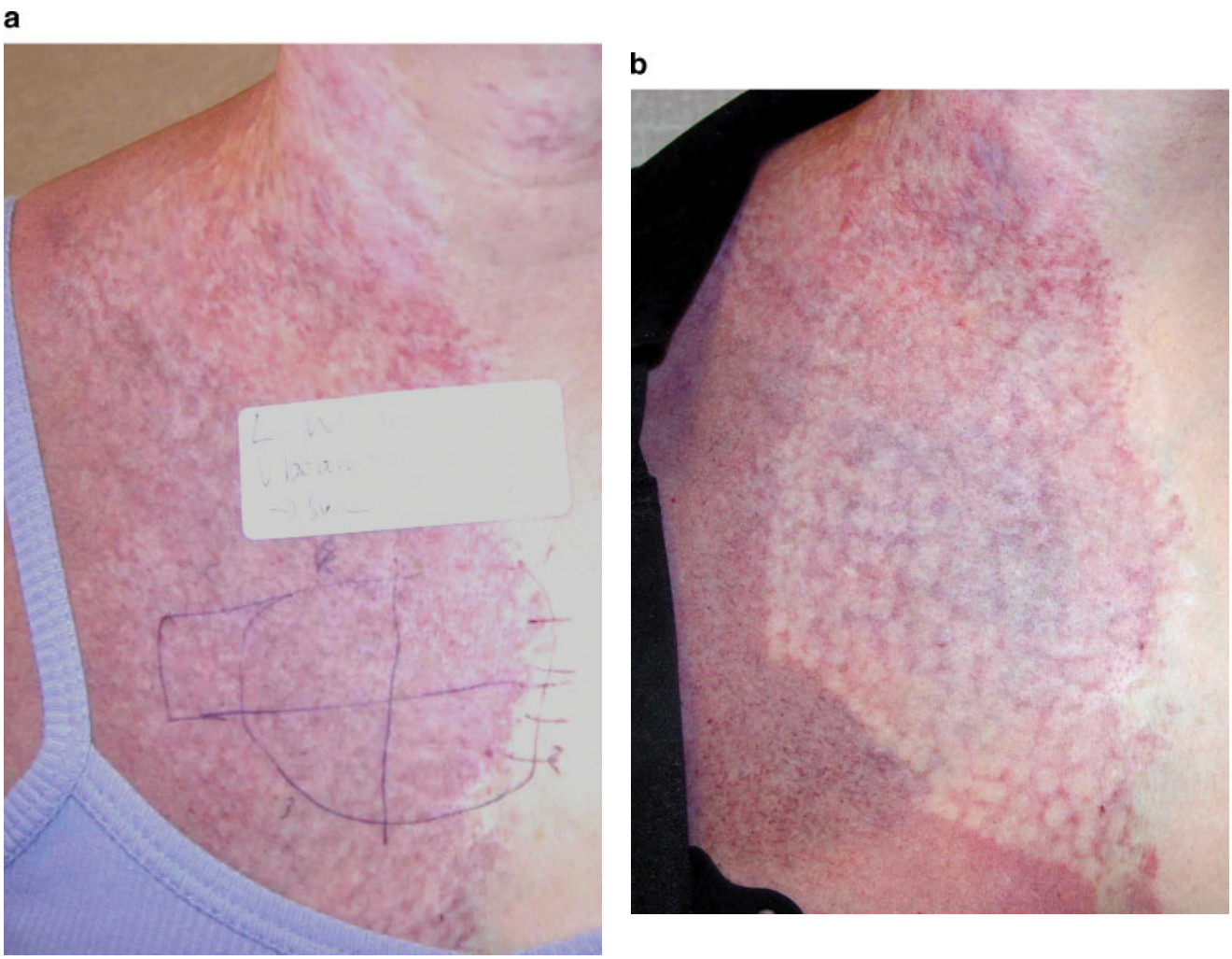

Fig. 1. Port wine stain (PWS) of patient 2 before (**a**) and after two treatments (**b**) with the V Beam® pulsed dye lasers showing enhanced blanching. [Figure can be viewed in color online via www.interscience.wiley.com.]

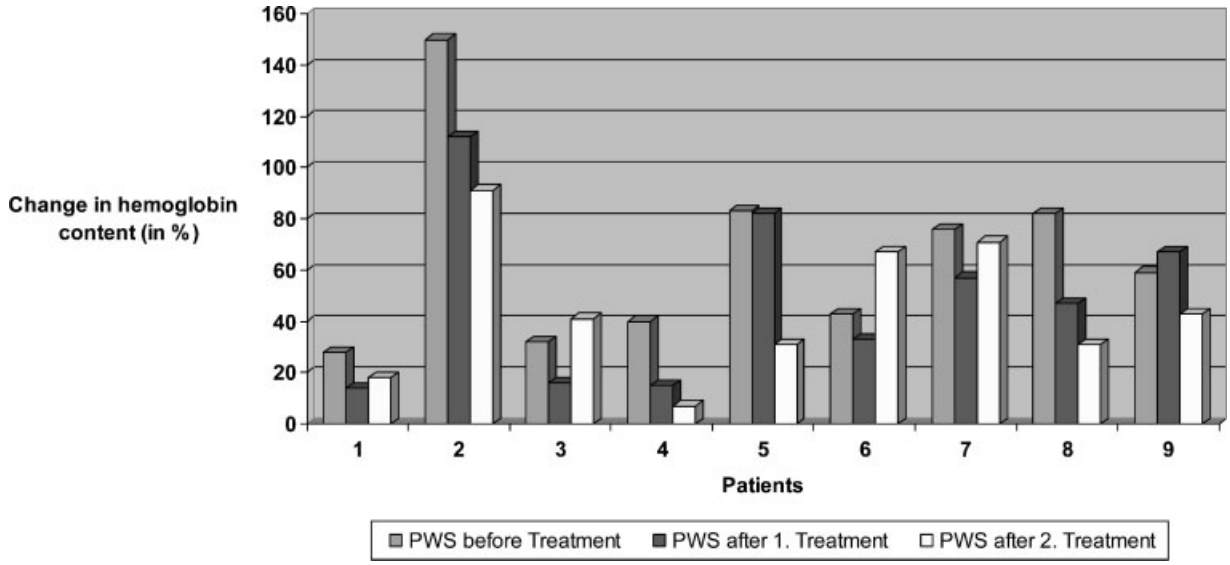

Fig. 2. Reflectance spectrophotometer measurements of PWS before and after laser treatments.

treatment and therefore the difference to normal skin was very small. Measurements in two patients each with the reflectance spectrophotometer and the SIAscope showed an increase in erythema, which was not confirmed clinically (Table 2). Interestingly, all our patients felt that their PWS had improved at least partially.

DISCUSSION

In our study, six (67%) of the nine patients, who completed the study, responded to laser treatments with the V Beam® PDL. Three patients showed considerable blanching of their PWS, which was confirmed in an objective manner. The laser operates at the longer wavelength of 595 nm and allows for longer pulse widths and higher energy fluences. Studies have shown that for PWS the pulse durations for ideal laser treatment are in the 1–10 millisecond range and depend on vessel diameter [9]. Longer pulse duration appears to be more effective for larger caliber PWS vessels. We therefore selected test parameters comparing the commonly used pulse width of 1.5 millisecond (the shortest pulse width available with this laser) with a longer 6 millisecond pulse duration. However, in seven out of nine patients (78%) the 1.5 millisecond setting resulted in a better response. This seems to indicate

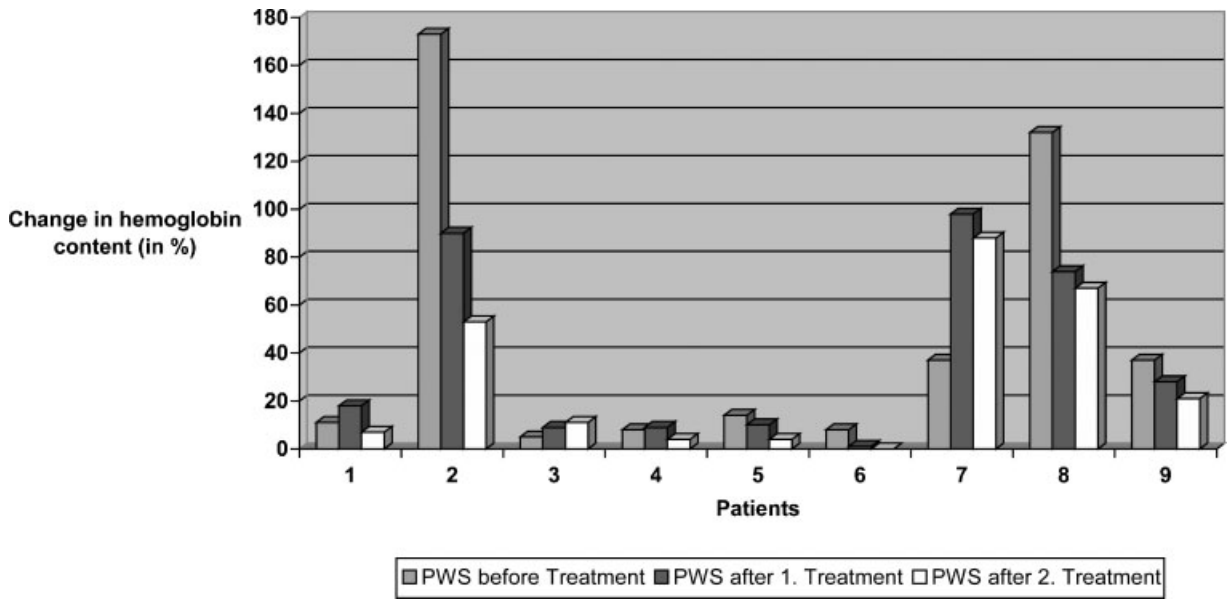

Fig. 3. Spectrophotometric intracutaneous analysis scope (SIAscope) measurements of PWS before and after laser treatments.

TABLE 2. Comparison of Subjective and Objective Results

Patient	Photographic response to treatment (%)	Reflectance spectrophotometer reduction (%)	SIAscope reduction (%)
1	26–50	10	31
2	51–75	59	69
3	0–25	−9	−120
4	51–75	33	50
5	51–75	52	73
6	0–25	−24	100
7	0–25	5	−137
8	26–50	51	49
9	26–50	16	44

Comparison of PWS measurements between pre-treatment (1st visit) and after 2nd laser treatment (4th visit). −, Indicating theoretical increase in erythema readings.

that in the majority of therapy-resistant PWS there are some moderately sized vessels present, which are accessible to further treatment.

The test areas treated with the 7 mm spot size showed better blanching compared to the 10 mm spot size in all patients most likely because higher fluences could be delivered.

A recent study comparing the effectiveness of 585 versus 595 nm wavelength PDL treatment of PWS found the shorter wavelength to be more effective [10]. However, lower energy fluences of 7–10 J/cm^2 were used compared to our treatments with 12–14 J/cm^2. In addition, we treated patients who had previously received adequate therapy with conventional short pulse PDL and the last two treatments had failed to produce any noticeable improvement. It is likely that blood vessels of different sizes and depths respond to different wavelengths. Also, it appears that patients, who showed only minor improvements had lighter PWS and markedly lower initial blood concentrations relative to normal skin (Fig. 3).

It is well accepted that the site of a PWS has prognostic significance for outcome. Results on the face and neck are usually better then those at other sites on the body [9]. The majority (67%) of our patients had their PWS located on the face which could have influenced our results in a positive manner. However, the number of patients in our study was small and results need to be confirmed in larger trials.

Several non-invasive quantitative methods of assessment of the skin in terms of hemoglobin and melanin content have been investigated with varying success. It is also not clear how to quantify the benefit of lightening in statistical terms.

In the majority of our patients (78%) both the reflectance spectrophotometer and SIAscope measurements support the subjective improvements of the PWS (Table 2). Although we used a mean of three measurements for each analysis results were not always consistent. For instance, SIAscope readings of patient 6 indicated clearance of the PWS, but clinically there was only minor lightening. This discrepancy is most likely due to the light color of the PWS before treatment, which made measurement of differences in blood content difficult. Also, in patient 8 the subjective response was less good than indicated by data from objective techniques.

There were sometimes considerable variations between the three measurements of one session with the reflectance spectrophotometer and more frequently variations between sessions with both the reflectance spectrophotometer and the SIAscope. PWS are usually not homogenous

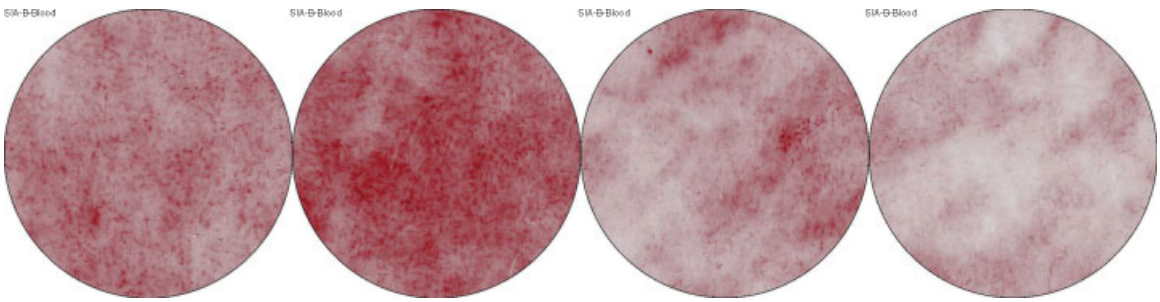

Fig. 4. The four SIAgraphs illustrate the variations in vasculature of a patient's PWS: At baseline, after the test areas showing ruptured blood vessels and increased blood volume and after one and two laser treatments demonstrating decreased blood volume. [Figure can be viewed in color online via www.interscience.wiley.com.]

structures, but rather consist of superficial and deep vessels which results in different colors. In addition, the spectral response varies nonlinearly with the amount of blood in an area of skin. The reflectance spectrophotometer obtains averages and works best in uniformly colored skin. The SIAscope may be more accurate as it takes very small units (400,000 points in our images) and measure the blood concentration at each point. Several factors such as temperature and activity of the sympathetic nervous system influence erythema readings as facial skin color is affected considerably by the rich and easily variable cutaneous blood flow. Although we tried to use the same points for measurements at each session it is possible that differences occurred depending which areas of a PWS were measured.

Analysis of the SIAgraphs showed that after the first laser treatment the blood vessels appeared bigger and measurements were in keeping with increased blood volume indicating that the laser appears to perforate blood vessels. SIAgraphs at the final follow-up visit revealed decreased blood volume and smaller sized vessels were visualized (Fig. 4). The SIAscope was originally developed for the assessment of pigmented lesions especially to aid the diagnosis of malignant melanoma [8]. It has been used for the first time in our study to visualize vascular lesions and proved to be useful. It appears to be able to identify PWS with low initial blood concentrations relative to normal skin, suggesting that the SIAscope could be used to predict which PWS would respond to treatment with the V Beam® PDL. Also, as part of ongoing technical developments of the SIAscope it is planned to introduce software measuring vessel depth over treatment time allowing for additional detailed assessment.

Hyperpigmentation occurred in three patients (30%) and atrophic scarring was observed in one patient (10%), but our study size was small. Side effects with conventional PDL have been reported at 10–25% for hyperpigmentation, 1% for hypopigmentation, 1–5% for atrophic scars, and $<1\%$ for hypertrophic scars [3].

Despite only limited response of some PWS to the V Beam® PDL therapy all patients were keen to continue with the treatments to see if further lightening of the PWS could be achieved.

In conclusion, laser treatment with the V Beam® PDL appears to result in further lightening of PWS therapy-resistant to 585 nm PDL in the majority of patients independent of patient's age, location of PWS, and previous treatments. Larger studies are required to confirm our results and identify patients most likely to benefit from this treatment option.

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