

Split-Face Comparison of Intense Pulsed Light With the Flashlamp-Pumped Pulsed Dye Laser and the Long-Pulsed Tunable Dye Laser for the Treatment of Port-Wine Stains: A Comparative Study

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Background: So far, pulsed dye lasers have been regarded as the gold standard in the treatment of port-wine stains (PWS). Recently, intense pulsed light (IPL) has been reported to achieve more pronounced fading in some patients.

Objectives: To evaluate the efficacy and the side effects of IPL treatment of PWS in a direct comparison to the flashlamp-pumped dye laser (FPDL) and the long-pulsed tunable dye laser (LPTDL).

Methods: Test spots ($n = 158$) were applied with IPL ($\lambda_{em} = 555\text{--}950$ nm, pulse duration: 8–14 milliseconds (single pulse), fluence: 11–17.3 J/cm²), the FPDL ($\lambda_{em} = 585$ nm, pulse duration: 0.45 milliseconds, fluence: 6 J/cm²), and the LPTDL ($\lambda_{em} = 585/590/595/600$ nm, pulse duration: 1.5 milliseconds, fluence: 12/14/16/18 J/cm²) in a side-by-side modus in untreated ($n = 11$) and previously treated ($n = 14$) patients with PWS. Lesion clearance was evaluated by three blinded investigators based on follow-up photographs 6 weeks after treatment. Incidence of side effects was assessed.

Results: In previously untreated PWS as well as in pretreated PWS, IPL treatments were rated significantly ($P < 0.05$) better than treatments with the FPDL. In both groups, IPL and LPTDL treatments did not differ significantly. Side effects were few in all settings.

Conclusions: Based on the results of this study, IPL treatment induced a higher clearance rate in untreated and in previously treated PWS than FPDL therapy. In PWS resistant to dye laser therapy, IPL showed additional lesion clearance. Complementary use of IPL increases the therapeutic possibilities in PWS. *Lasers Surg. Med.* 00:1–8, 2010. © 2010 Wiley-Liss, Inc.

Key words: port-wine stain; laser; pulsed dye laser

INTRODUCTION

Port-wine stains (PWS) are benign congenital vascular malformations that are localized in the dermis and affect 0.5–2% of newborns [1,2]. PWS do not involute spontaneously and are characterized by an abnormal dermal plexus of layers of dilated blood vessels, which increase in diameter with age [3,4]. PWS are commonly located on the face or the neck (83%) but can basically affect

any part of the body [5]. Especially if located on the face, PWS implicate the highest cosmetic and psychological relevance for affected individuals.

The standard treatment of PWS is laser therapy [5]. The basic principle is the preferential absorption of laser light by hemoglobin and the subsequent conversion of the absorbed light into thermal energy, leading to the coagulation of blood vessels. Selectivity and spatial confinement to spare the tissue surrounding blood vessels is achieved by selecting an appropriate wavelength, pulse duration, spot size, and fluence [5–7]. This process is called selective photothermolysis (SP) and was first described by Anderson and Parrish [6]. The flashlamp-pumped pulsed dye laser (FPDL) with a wavelength of 585 nm and a pulse duration of 0.45 milliseconds or the long-pulsed tunable dye laser (LPTDL; pulse duration: 1.5 milliseconds; tunable wavelengths: 585–600 nm) have become the method of choice for the treatment of PWS [5,8–12] because of their proven efficacy and the relatively low incidence of side effects. Although clinical results are excellent in some cases, complete clearing of PWS is hardly ever achieved [5,8]. PWS almost universally require multiple sessions of laser treatment for maximal lightening, and reports indicate that the majority of PWS clearance is achieved after approximately 4–5 treatment settings [9,13–16]. Moreover, about 20% of PWS are resistant to dye laser treatment; especially lesions in adults and in patients with darker skin types are difficult to treat [7,12,14,16,17]. Therefore, improvement of PWS treatment is highly desirable.

Philipp Babilas and Stephan Schreml contributed equally to this study.

The authors certify that they have no affiliation with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the manuscript (e.g., employment, consultancies, stock ownership, honoraria).

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Accepted 21 January 2010

Published online in Wiley InterScience

(www.interscience.wiley.com).

DOI 10.1002/lsm.20906

Incoherent polychromatic filtered flashlamp (intense pulsed light, IPL) devices developed in the early 1990s proved to be a safe and effective treatment of several skin conditions, such as vascular lesions [18–30], photoaging [31–35], or the removal of hair [36–38]. The emission spectrum of IPL devices ranges from 500 to 1,300 nm with pulse durations in the millisecond range. With the aid of convertible cut-off filters, the IPL device can be easily adjusted to the desired wavelength, which accounts for a high versatility. Adjustment to the absorption spectrum of hemoglobin allows the use of IPLs for vascular lesions. Several studies confirm that IPLs may be used for the treatment of PWS [20,22,24,27,28,39,40]. However, controlled randomized clinical trials that allow a side-by-side comparison of the impact of IPL versus the standard treatment, that is, the dye laser, are rare in the literature.

The aim of this study was to assess the effectiveness and safety of IPL in the treatment of untreated and previously treated PWS in a direct comparison to the FPD and the LPTDL.

PATIENTS AND METHODS

Patients

Eleven patients with previously untreated PWS and 14 patients who had been previously treated with laser were included in this study (Figs. 1 and 2). All patients had Fitzpatrick skin types I–III. None of the patients was suntanned. The PWS were located on the face and neck region (72%; $n=18$), the trunk (12%; $n=3$), or the extremities (16%; $n=4$). Previously untreated lesions were pale red (18%; $n=2$), red (72%; $n=8$), or purple (9%; $n=1$) in color. All patients were given written and verbal information on the nature of the laser and IPL treatment. Signed informed consent was obtained prior to treatment from patients or their parents. Treatments were conducted from May 2007 to April 2009 at the Department of Dermatology, University Hospital Regensburg, Germany.

Laser Devices and Treatment Parameters

Lesions were photo-documented prior to treatment. Areas representative with regard to the color and surface structure of the PWS were chosen for laser treatment. Each previously untreated patient received treatment with the IPL, the FDPL, and the LPTDL in a split-lesion modus. Pretreated patients were treated with the IPL and, in dependence on the pretreatment, additionally with the FPD or the LPTDL, or both. If pretreatment with the FPD or the LPTDL turned out to be ineffective (no clearance or clearance <25%), the respective light device was omitted. The treatment settings in terms of fluence rate and pulse duration were chosen according to the manufacturer's recommendations and the clinical appearance of the lesion. For IPL treatment, the Ellipse Flex PPT ($\lambda_{em}=555\text{--}950\text{ nm}$; Danish Dermatologic Development, Hoersholm, Denmark) with a rectangular foot print (spot size: $10\times 48\text{ mm}^2$), a pulse duration of 8–14 milliseconds (single pulse), and a fluence of 11.0–16.7 J cm^{-2} was used depending on the clinical appearance of the PWS and the

skin type. At least one pulse was applied for each used set of parameters. The emitted wavelength band is produced by a xenon arc flashlamp and shows a median wavelength of the power spectrum at 705 nm. A 1–2 mm thick layer of colorless optical coupling gel (Danish Dermatologic Development) was applied to the treatment area before each shot to protect the epidermis from thermal injury and to allow uniform light delivery. The handpiece was always kept parallel to the skin to ensure even light application. Treatments were conducted without applying any mechanical pressure to the skin surface to avoid expelling blood from the treatment area. In close proximity, FPD treatment ($\lambda_{em}=585\text{ nm}$, cbeamTM, Candela Corp., Wayland, MA) with a pulse duration of 450 microseconds and a fluence of 6 J cm^{-2} was applied (circular foot print, diameter: 7 mm). Side-by-side, lesions were treated with the LPTDL (ScleroTM, Candela Corp.), if possible with each of the four applicable wavelengths ($\lambda_{em}=585, 590, 595,$ and 600 nm) with a circular foot print (diameter: 5 mm), 1,500 microseconds pulse duration, and a fluence depending on the respective wavelength (12 J cm^{-2} (585 nm), 14 J cm^{-2} (590 nm), 16 J cm^{-2} (595 nm), and 18 J cm^{-2} (600 nm)) (Fig. 1). The epidermis was cooled with the integrated cooling system of the respective device. Treatments were conducted without anesthesia. All patients avoided UV exposition for 8 weeks after laser treatment.

Assessments and Response Evaluation

Results were photo-documented and clinically evaluated 6 weeks after treatment. Photographs of all treatment sites were taken under standardized conditions (magnification, lightening, positioning) with the same camera (Canon Digital Camera EOS D30, Canon Macro Lens, EF-50 mm 1:2.5, and lens mounted ring lite (MR-14EX); all Canon, Tokyo, Japan). Assessment and response evaluation for this study were carried out on basis of the patient record and the photo-documentation (Fig. 1). Effectiveness was retrospectively evaluated by three independent and blinded investigators (trained dermatologists) other than those conducting the laser treatments. If the investigators documented different values, the mean was calculated. As the investigators could infer from the spot size on the used laser, a stencil was used so that equal skin areas of the respective spots were visible for evaluation. Lightening was graded in comparison to the untreated area as excellent (>75%, score 5), good (51–75%, score 4), fair (25–50%, score 3), bad (<25%, score 2), or no clearance (score 1).

Side effects (hypopigmentation, hyperpigmentation, atrophy, scar, hypertrophic scar, keloid formation, infection) in the treated areas were assessed. Therapy sequelae, such as blistering, purpura, or crusting were documented as reported by the patient.

Statistical Methods

All data were analyzed using Sigma Plot 11.0 (Systat Software, Inc., Chicago, IL). Ratings of the treatment results are given as medians, 25% percentiles (x_{25}), 75% percentiles (x_{75}), minimum (min) and maximum (max). All other data are given as means \pm standard deviation. Data

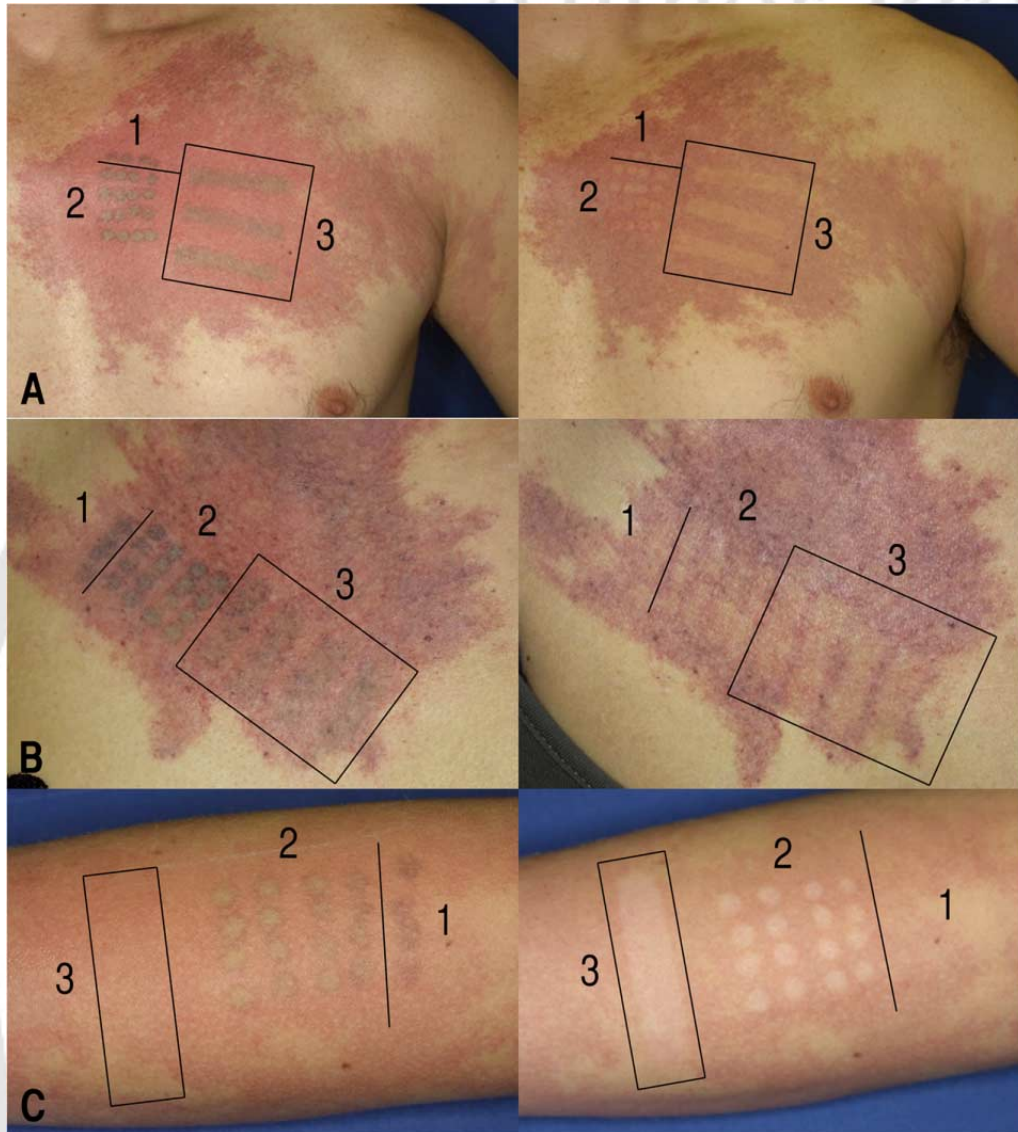


Fig. 1. Clinical photographs of PWS located on the chest (A), the décolleté (B), and the forearm (C) immediately after treatment (left column) and six weeks after treatment (right column). FPD and LPTDL resulted in circular test spots, IPL in quadratic test spots. Note the purpuric reaction of the treated area. In (c), FPD treatment (right column of test spots) induced no clearance of the lesion 6 weeks after treatment. However, LPTDL and IPL induced hypopigmentation in this case.

for primary treatments and pretreated patients were separately analyzed using one-way analysis of variance (ANOVA) on Ranks and multiple pairwise comparisons using Dunn's method. Subgroups (wavelengths 585, 590, 595, and 600 nm for LPTDL, irradiation times 8, 10, and 14 milliseconds for IPL) were also analyzed using one-way ANOVAs on Ranks. Differences between the treatment modalities for primary treatments and pretreated patients were analyzed using Mann-Whitney Rank Sum test. A P -value below 0.05 was considered significant, $P < 0.01$ was considered highly significant and results

marked with one or two asterisks within the graphs, respectively.

RESULTS

Patients

The primary treatment group ($n = 11$) consisted of four male (36.3%) and seven female (63.6%) patients, the youngest patient being 1.5 and the oldest being 66 years old. In the pretreated patient group 4 (28.6%) male and 10 (71.4%) female patients were included, the youngest

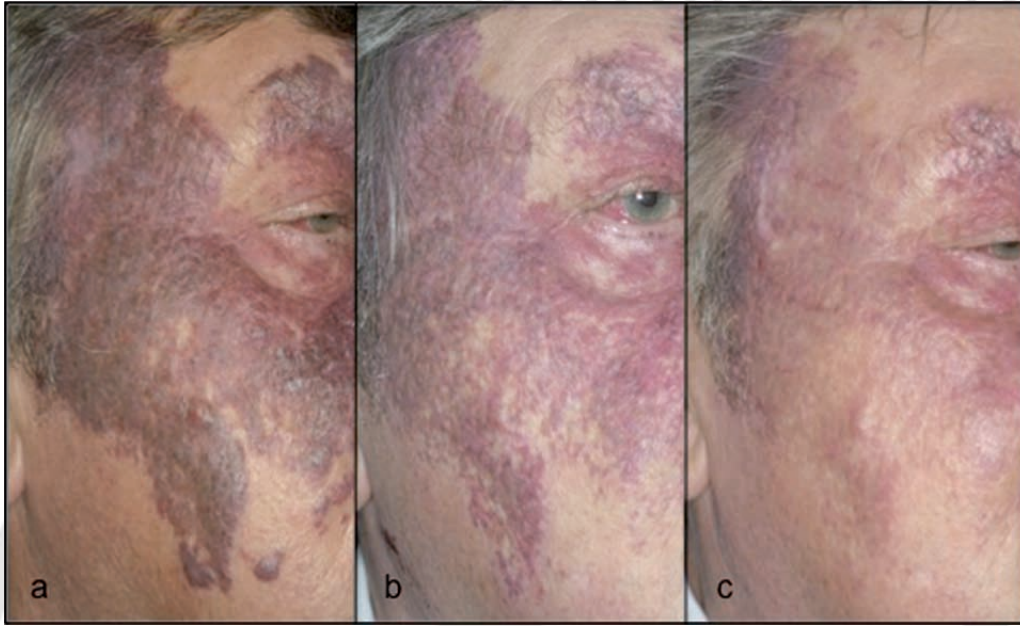


Fig. 2. Clinical photographs of a patient suffering from a facial PWS (a) at first consultation (already pretreated at another clinic) and (b) after multiple full lesion dye laser sessions (in our clinic). Due to dye laser resistance IPL treatment was performed. c: Clinical setting after a single IPL treatment.

patient being 2 and the oldest being 69 years old. Mean age was 24.2 ± 17.5 years for the primary treatment group and 28.4 ± 18.9 years for the group of pretreated patients.

Subgroup Analysis

There was neither a significant difference between the ratings of LPTDL treatments using different wavelengths (585, 595, 590, and 600 nm) for primary ($P = 0.698$) nor for follow-up ($P = 0.857$) treatments. Based on this analysis, the results for the different wavelengths applied in LPTDL treatments were grouped as LPTDL treatment results. In addition, there was neither a difference between the ratings of IPL treatments using different irradiation times (8, 10, and 14 milliseconds) for primary ($P = 0.972$) nor for follow-up treatments ($P = 0.513$). Again, treatment results for the different irradiation times applied in IPL treatments were grouped as IPL treatment results, accordingly.

Primary Treatments

Table 1 summarizes the used parameters of the respective light devices, the number of treated patients, treatment outcome, and side effects of treatments of previously untreated patients. FPDL treatments were rated ($n = 11$) as 2.00 ($x_{25} = 2.00$; $x_{75} = 2.75$; min = 1.00; max = 4.00), LPTDL treatments ($n = 38$) as 3.00 ($x_{25} = 2.00$; $x_{75} = 4.00$; min = 1.00; max = 5.00) and IPL treatments ($n = 35$) as 3.00 ($x_{25} = 3.00$; $x_{75} = 4.00$; min = 1.00; max = 5.00). IPL treatments were rated significantly ($P < 0.05$) better than treatments using FPDL. No other statistically significant

differences could be detected (Fig. 3a). Excellent ($> 75\%$, score 5) or good (51–75%, score 4) clearance was obtained in 1 out of 11 (9.1%) test spots applied with the FPDL, in 11 out of 38 (28.9%) test spots applied with the LPTDL, and in 17 out of 35 (48.6%) test spots applied with the IPL (Table 1). According to a patient based analysis, IPL treatment showed excellent or good clearance in at least one test spot in 7 out of 11 patients, LPTDL treatment in 5 out of 11 patients, and FPDL treatment in 1 out of 11.

Treatments of Pretreated Patients

Table 2 summarizes the used parameters of the respective light devices, the number of treated patients, treatment outcome, and side effects of treatments of previously untreated patients. FPDL follow-up treatments ($n = 12$) were rated as 1.50 ($x_{25} = 1.00$; $x_{75} = 2.00$; min = 1.00; max = 3.00), LPTDL treatments ($n = 32$) as 2.00 ($x_{25} = 1.50$; $x_{75} = 3.00$; min = 1.00; max = 4.00) and IPL treatments ($n = 30$) as 3.00 ($x_{25} = 2.00$; $x_{75} = 3.00$; min = 1.00; max = 4.00). IPL treatments were rated significantly ($P < 0.05$) better than treatments using FPDL. No other statistically significant differences could be detected (Fig. 3b). Excellent ($> 75\%$, score 5) or good (51–75%, score 4) clearance was obtained in 5 out of 32 (15.6%) test spots applied with the LPTDL, and in 7 out of 30 (23.3%) test spots applied with the IPL. FPDL test spots showed no clearance $> 50\%$ (Table 2). According to a patient-based analysis, IPL treatment showed excellent or good clearance in at least one test spot in 4 out of 14 patients, and LPTDL treatment in 1 out of 14 patients.

TABLE 1. Parameters of Light Devices, Number of Treated Patients, Outcome, and Side Effects of Treatment of Previously Untreated Patients

Light device	Photo-physical parameters					Outcome					
	Wave-length (nm)	Pulse duration (milliseconds)	Fluence (J/cm ²)	Spot size (mm)	No. of treatments (n)	Excellent (n)	Good (n)	Fair (n)	Bad (n)	None (n)	Side effects
FPDL	585	0.45	6	7	11	0	1	2	6	2	2
LPTDL					38	4	7	13	9	5	
	585	1.5	12	5	10	1	1	4	3	1	1,2,3
	590	1.5	14	5	9	1	2	4	2	0	1,2,3
	595	1.5	16	5	10	1	2	2	2	3	1,1,2,3
	600	1.5	18	5	9	1	2	3	2	1	1,1,2,3
IPL					35	3	14	14	3	1	
	555	8	11.0–16.1	10 × 48	20	0	11	6	3	0	Crusts
	555	10	14.3–16.9	10 × 48	15	3	3	8	0	1	1

Side effects: 1 = hypopigmentation, 2 = hyperpigmentation, 3 = midget scar, 4 = scar, 5 = hypertrophic scar, 6 = keloid, 7 = infection.

Comparison of the Modalities for Primary Treatments and Pretreated Patients

There was no significant difference with regard to the ratings for primary and follow-up FPD (P = 0.088). Results using LPTDL for primary treatments were significantly better than for follow-up treatments (P = 0.043). There was a highly significant difference between the results for primary IPL treatments as compared to the use of IPL for pretreated patients (P = 0.004), that is, results for primary IPL were significantly better as compared to follow-up treatments using IPL.

Side Effects

In the group of previously untreated patients, IPL treatment (n = 35) induced hypopigmentation in one single case. FPD treatment (n = 11) led to hyperpigmentation in one patient. LPTDL treatment (n = 38) induced hypopigmentation (6 out of 38), hyperpigmentation (4 out of 38), and midget scarring (i.e., minimal form of scarring) (4 out of 38). In the group of pretreated patients, FPD treatment (n = 12) induced no side effects, LPTDL treatment (n = 32) induced midget scarring in one patient, and IPL treatment (n = 30) led to hyperpigmentation (2 out of 30) or hypopigmentation (1 out of 30). Crusting was reported only by one patient after IPL treatment and was completely reversible 6 weeks after treatment.

DISCUSSION

This study compares the effectiveness and safety of IPL, the FPD, and the LPTDL in untreated as well as in previously treated PWS. Treatment was conducted in a side-by-side modus so that the clearance rate of the three treatment modalities could be directly compared in each patient. As a varying number of treatment settings are a source of bias, evaluation of this study was based on a single treatment setting. To further homogenize study

parameters, the collective was divided into untreated and previously treated patients. FPD and LPTDL were used with approved parameters [8,41]. The IPL device used in this study contained a dual mode light filter that filtered out wavelengths shorter than 555 nm and longer than 950 nm. Thus, the emitted wavelength band (median wavelength: 705 nm) was suitable for absorption in hemoglobin, while absorption in water and subsequent unselective epidermal heating could be reduced [20]. Response was classified in percent clearance as accepted in the literature [20,22,24,27,28,39,42].

In previously untreated PWS, a single IPL or LPTDL treatment induced an average clearance rate of 25–50%; a single FPD treatment induced an average clearance rate of less than 25%. IPL treatments were rated significantly (P < 0.05) better than treatments with the FPD. There was no statistically significant difference between the clearance rate of IPL and LPTDL. Remarkable is the fact that a clearance rate of 50% or more was achieved in 48.5% of test spots applied with IPL versus 9.1% with the FPD versus 28.9% with the LPTDL. In previously treated PWS, a single IPL treatment induced an average clearance rate of 25–50%; a single LPTDL or FPD treatment induced an average clearance rate of less than 25%. IPL treatments were rated significantly (P < 0.05) better than treatments with the FPD. Again, there was no statistically significant difference between the clearance rate of IPL and LPTDL. In this group, IPL treatment showed excellent or good clearance in at least one test spot in 4 out of 14 patients, and LPTDL treatment only in 1 out of 14 patients while FPD treatment induced no clearance > 50%.

Several studies in the literature confirm the potential of IPLs in fading PWS [20,22,24,27,28,39,40,43]. Only three studies provide data from controlled side-by-side comparisons of IPL and the standard therapy, that is, the dye laser [39,40,43]. Faurschou et al. [39] treated 20 patients with PWS in a side-by-side trial using a pulsed

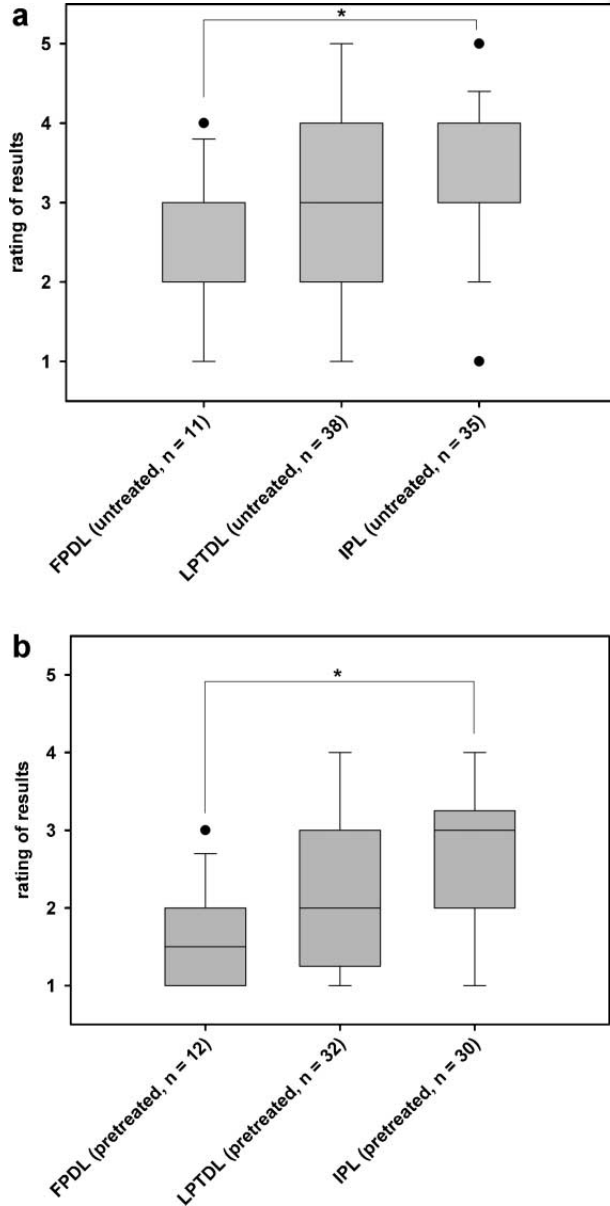


Fig. 3. **a:** Treatment results of primary treatment. Primary IPL and LPTDL treatments yielded better results than primary FPDL treatments, the difference between IPL treatments and FPDL treatments was significant ($P < 0.05$). Clearance was rated as excellent ($> 75\%$, score 5), good (51–75%, score 4), fair (25–50%, score 3), bad ($< 25\%$, score 2), or no clearance (score 1) ($*P < 0.05$). **b:** Treatment results of previously treated PWS. IPL follow-up treatments yielded significantly better results as compared to FPDL follow-up treatments ($P < 0.05$). LPTDL primary treatments showed significantly better results than LPTDL follow-up treatments ($P = 0.043$). In analogy, primary IPL treatments yielded significantly better results than follow-up IPL treatments ($P = 0.004$). No other statistically significant differences could be detected. Clearance was rated as excellent ($> 75\%$, score 5), good (51–75%, score 4), fair (25–50%, score 3), bad ($< 25\%$, score 2), or no clearance (score 1) ($*P < 0.05$).

dye laser (PDL) versus IPL (StarLux, Palomar Medical Technologies, Burlington, MA; pulse duration: 5–10 milliseconds, fluence: 7–14 J/cm²). They found out that both PDL and IPL significantly lightened PWS, but the median clinical improvements were significantly better with the PDL (65%) than with the IPL (30%). These results contrast with our data. One explanation might be the inclusion of not only previously untreated ($n = 8$) but also previously treated ($n = 12$) patients in this study. Unfortunately, the authors did not differentiate the outcome between both groups. Another important difference is the fact that they used a pulse duration of 0.45 milliseconds ($n = 5$) and 1.5 milliseconds ($n = 15$) (according to the clinical appearance) but did not differentiate between both groups. We could show that FPDL treatment resulted in a lower clearance rate than LPTDL therapy. Therefore, both light devices should be evaluated separately. A further difference is the emitted wavelength band of IPL. Faurschou et al. used an IPL that emitted light of 500–670 and 870–1,400 nm, whereas our IPL emitted light of 550–950 nm. Therefore, the IPL used by Faurschou et al. divided the applied energy on a much broader wavelength spectrum, which could be a reason for the lower clearance rate of the IPL in their study. On the other hand, the difference between both studies might be explained by the fact that Faurschou et al. used a more current PDL device that have a larger spot size and deliver (with a pulse duration of 0.45 milliseconds) higher energies, what makes it more efficacious the PDL devices used in our study.

McGill et al. [43] conducted a study on patients ($n = 18$) with previously treated PWS, comparing a single-passed pulsed dye, a double-passed pulsed dye, an alexandrite, a KTP, and a Nd:YAG laser as well as an IPL device (Lumina, Lynton Lasers, Cheshire, UK; $\lambda_{em} = 550–1,100$; spot size: 10 × 10 mm², fluence: 28–34 J/cm², double pulsed 10 milliseconds delay) in a split-lesion modus. One single observer evaluated the effectiveness by means of Munsell color charts. In this study, the alexandrite laser was the most effective treatment modality, resulting in PWS fading in 10 patients, although hyperpigmentation ($n = 4$) and scarring ($n = 1$) was frequent. IPL resulted in PWS fading in six patients; five patients showed further PWS fading after double-passed PDL treatment and three patients showed further PWS fading after single-passed PDL treatment. KTP and Nd:YAG lasers were the least effective with fading seen in two patients for both systems. These results correspond to our findings, in which IPL therapy induced a significantly better clearance rate of pretreated PWS than a single-passed FPDL treatment.

In a controlled trial, Stempel and Klein [40] investigated FPDL therapy with a high-energy gas discharge lamp in 32 patients with PWS. The authors included pretreated ($n = 25$) and untreated ($n = 7$) patients in their study. In six patients, the gas discharge lamp induced better lightening of the PWS, in 6 patients both devices induced a similar effect, and in 20 patients better lightening was achieved by FPDL treatment. Again, these results are not differentiated with regard to pretreatment and are thus not comparable to our results. Besides, the authors used a

TABLE 2. Parameters of Light Devices, Number of Treated Patients, Outcome, and Side Effects of Treatment of Pretreated Patients

Light device	Photo-physical parameters					Outcome					
	Wave-length (nm)	Pulse duration (milliseconds)	Fluence (J/cm ²)	Spot size (mm)	No. of treatments (n)	Excellent (n)	Good (n)	Fair (n)	Bad (n)	None (n)	Side effects
FPDL	585	0.45	6	7	12	0	0	1	5	6	
LPTDL					32	0	5	8	11	8	
	585	1.5	12	5	9	0	1	3	2	3	
	590	1.5	14	5	7	0	1	1	4	1	
	595	1.5	16	5	9	0	2	2	4	1	
	600	1.5	18	5	7	0	1	2	1	3	3
IPL					30	0	7	11	8	4	
	555	8	11.0–16.7	10 × 48	19	0	5	7	6	1	2
	555	10	12.8–17.3	10 × 48	8	0	1	4	2	1	1,2,2
		14	12.0–16.2	10 × 48	3	0	1	0	0	2	

Side effects: 1 = hypopigmentation, 2 = hyperpigmentation, 3 = midget scar, 4 = scar, 5 = hypertrophic scar, 6 = keloid, 7 = infection.

high-energy gas discharge lamp (570–1,200 nm) with a light dose of 40 J/cm² and a pulse length of 5 milliseconds. Therefore, parameters are different from those used in our study. A general problem in the discussion of different IPL trials is the fact that a comparison of IPLs on the basis of their wavelength spectrum, fluence ranges, pulse durations, etc. is physically nonsensical and does not provide any evidence for their clinical effectiveness. A serious comparison is much more complex and should account for the fluence per area for every emitted wavelength, for every possible pulse duration, and for every possible pulse shape against the background of the real on-off time, fluence, and spectral jitter during an impulse. Eadie et al. [44] measured the spectral and temporal characteristics of an IPL device and showed a shift in spectral distribution within a pulse and between pulses, which is caused by a variable current delivered to the xenon flashlamp. The delivery of a variable current can be omitted if a large capacitor bank is used within the IPL device. Therefore, technical details of the used IPL device have to be taken into account when comparing different IPL devices. The work of Bjerring et al. [20] should be more suitable for a comparison because the same IPL device (Ellipse Flex, Danish Dermatologic Development; $\lambda_{em} = 555\text{--}950$ nm; spot size: 10 × 48 mm²; pulse duration: 8–30 milliseconds; fluence: 13–22 J/cm²) was used by this group as in our trial to treat 15 patients with PWS resistant to dye laser therapy. Four treatment settings induced a lightening of more than 50% in 7 out of 15 patients according to their results. In the corresponding cohort of our study, a clearance rate of more than 50% was induced in 4 out of 14 patients after one single treatment setting. This discrepancy might be explained by repeated treatments and by the higher fluence used by Bjerring et al. The authors observed no scarring; hypopigmentation occurred in 9%, hyperpigmentation in 3% of patients. In our study, side effects were even less frequent with hypopigmentation in 2% and hyperpigmentation in 4% of patients.

The lower incidence of side effects might be due to the more defensive treatment parameters in our study.

In conclusion, this study, which was conducted as a direct side-by-side comparison, gives strong evidence for the effectiveness and safety of IPL in the treatment of PWS. Furthermore, the study shows the non-inferiority of the used IPL device when compared to the dye lasers of this study which provide, that has to be emphasized, not the most current pulsed dye laser technology. Beside the therapeutic effectiveness of IPL, its higher skin coverage rate than the FDPL and the LPTDL proves its high potential. Further advantages are that the longer wavelengths emitted by IPLs enable a deeper penetration, that oxyhemoglobin is activated over a broad band of wavelengths, and that pulse length is adjustable, allowing the adjustment of treatment parameters to the respective clinical finding.

ACKNOWLEDGMENTS

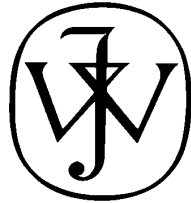
The editorial assistance of Ms Monika Schoell is gratefully acknowledged.

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