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# Dye Laser Applications in Cosmetic Dermatology: Efficacy and Safety in Treating Vascular Lesions and Scars

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**Abstract:** Cosmetic dermatology increasingly utilizes laser technologies to address various aesthetic concerns. This study evaluates the efficacy of the flash-lamp pulsed-dye laser (FPDL) in treating vascular and scar-related conditions. A cohort of 71 patients with diverse vascular lesions, including facial telangiectasia, port-wine stains (PWSs), striae rubrae, erythematous acne scars, facial traumatic scars, and keloids, was treated using the FPDL (Synchro Vas-Q, Deka MELA). Treatment protocols varied based on lesion type, with sessions ranging from one to eight at intervals of four to eight weeks. Clinical outcomes were assessed using a four-point grading scale and patient satisfaction surveys. Results indicated that 70.4% of patients achieved excellent clearance of lesions, while 16.9% and 9.9% showed moderate-good and slight clearance, respectively. Minimal or no improvement was observed in 2.8% of cases. High patient satisfaction was reported, correlating with effective lesion reduction and manageable side effects, primarily post-operative purpura. The study underscores FPDL's selective efficacy for hemoglobin-rich lesions and its safety profile, advocating for its continued use in cosmetic dermatological practices. These findings contribute to the growing evidence supporting laser therapy as a pivotal tool in aesthetic medicine, emphasizing the importance of tailored treatment protocols and patient education for optimal outcomes.

**Keywords:** pulsed-dye laser; vascular lesions; cosmetic dermatology; scar treatment



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## 1. Introduction

Cosmetic dermatology has undergone significant advancements with the integration of laser technologies, particularly the flash-lamp pulsed-dye laser (FPDL), which has emerged as a pivotal tool in addressing various aesthetic concerns [1,2]. The FPDL operates on the principle of selective photothermolysis, utilizing specific wavelengths of light (typically around 585–595 nm) that are preferentially absorbed by hemoglobin within blood vessels. This selective targeting minimizes damage to surrounding tissues, thereby enhancing both the safety and efficacy of treatments [3,4]. The ability of FPDL to precisely target vascular structures makes it exceptionally effective for treating conditions such as facial telangiectasia and port-wine stains (PWSs), which are not only cosmetically distressing but can also impact an individual's psychological well-being [5–7].

In clinical practice, the assessment of lesions prior to treatment is crucial for determining the appropriate laser parameters and ensuring optimal outcomes. In this study, lesions were evaluated using multispectral analysis, a sophisticated imaging technique that allows for the detailed examination of the vascular components within the skin [8,9]. This comprehensive analysis facilitates the precise application of the dye laser by identifying

the extent and depth of vascular involvement, thereby tailoring the treatment to each specific lesion. The utilization of multispectral analysis enhances the effectiveness of FPDL, particularly in the treatment of keloids, where the vascular component plays a significant role in scar formation and persistence [10,11].

Beyond vascular lesions, the application of FPDL has expanded to include scar-related conditions, such as keloids, hypertrophic scars, and striae rubrae. However, the variability in patient responses and the occurrence of side effects such as post-operative purpura necessitate a nuanced understanding of optimal treatment protocols [12,13]. Additionally, while FPDL has shown promise in treating erythematous acne scars and traumatic scars, the long-term outcomes and comparative effectiveness with other laser modalities remain areas of ongoing investigation [14,15].

Controversies in the field primarily revolve around the balance between achieving maximal lesion clearance and minimizing adverse effects. Some studies advocate for higher fluence settings to ensure complete vascular targeting, while others emphasize the importance of patient comfort and satisfaction by utilizing lower, non-purpuragenic settings [14,16]. This divergence underscores the need for individualized treatment plans tailored to specific lesion types and patient preferences.

The purpose of this study is to evaluate the efficacy and safety of FPDL in treating a spectrum of cosmetic dermatological conditions, including vascular lesions and various types of scars. By analyzing clinical outcomes and patient satisfaction in a diverse patient population, this research aims to propose a refined treatment protocol developed through clinical experience that incorporates progressively escalating fluences, tailored pulse overlaps, and optimal intervals between treatment sessions. Ultimately, the study seeks to contribute to the growing body of evidence supporting the use of laser therapy in cosmetic dermatology, emphasizing the importance of personalized treatment strategies and comprehensive patient education to achieve optimal clinical outcomes.

## 2. Materials and Methods

In this open study, a total of 71 patients (45 females and 27 males, with a mean age of 42 $\pm$ 9.50 years) were enrolled and treated at the Laser Unit of Sapienza and Magna Graecia University in Rome and Catanzaro, Italy. They all presented cosmetic concerns with evidence of vascular involvement. They were affected by various conditions, including 22 facial telangiectasia (with or without associated rosacea), 10 port-wine stains (PWSs), 8 striae rubrae, 12 erythematous acne scars, 4 facial traumatic scars, and 15 keloids.

Patients who had undergone previous laser treatments were excluded to eliminate potential confounding factors. All participants provided informed consent regarding the risks associated with the procedure and agreed to be photographed for documentation and evaluation purposes. The study was approved by the Local Ethical Committee of Calabria Region (protocol code 374; 17 December 2019). Before starting treatment, each patient underwent a comprehensive clinical examination and medical history assessment to identify any potential contraindications. Motivations and expectations were thoroughly discussed to ensure realistic goals and enhance patient satisfaction. A multispectral analysis was conducted before each session and at the end of the study to evaluate the extent of vascularization in each lesion.

Patients underwent between one and eight sessions with the FPDL (Synchro Vas-Q, Deka MELA, Florence, Italy) scheduled at intervals of four to eight weeks, as indicated in Table 1. All laser sessions were performed using fluences ranging from 6 to 10 J/cm$^2$, with spot sizes of either 7 mm or 12 mm. The pulse durations varied between 0.5 and 1 ms, and pulses overlapped by 10% to 50% to ensure uniformity of treatment.

**Table 1.** Treatment protocol for different lesion types.

| Type of Lesions | Sessions Plan | Settings |
|---|---|---|
| Facial telangiectasia | 1–2 Tx every 40 d | |
| Port-wine stain (PWS) | 6–8 Tx every 75–120 d | Wavelength 595 nm<br>Energy 6–7 J/cm$^2$<br>Spot size 12 mm<br>Pulse 0.5–1 ms<br>Overlap 20–30% |
| Striae rubrae | 4–6 Tx every 60–100 d | Wavelength 595 nm<br>Energy 6–10 J/cm$^2$<br>Spot size 7 ÷ 12 mm<br>Pulse 0.5<br>Overlap 20–40% |
| Erythematous acne scars | 3–4 Tx every 40–60 d | Wavelength 595 nm<br>Energy 6–7 J/cm$^2$<br>Spot size 12 mm<br>Pulse 0.5–1 ms<br>Overlap 10–20% |
| Facial traumatic scars | 3–6 Tx every 40–60 d | Wavelength 595 nm<br>Energy 6–10 J/cm$^2$<br>Spot size 7 ÷ 12 mm<br>Pulse 0.5–1 ms<br>Overlap 10–30% |
| Keloids | 4–6 Tx every 60–120 d | Wavelength 595 nm<br>Energy 6–10 J/cm$^2$<br>Spot size 7 ÷ 12 mm<br>Pulse 0.5<br>Overlap 30–50% |

Topical anesthesia was not necessary due to the use of a cooling device during and after each session. Immediately after each laser treatment, compression of the treated area with cold, wet gauze for 10–15 min was essential to reduce edema and inflammation. A non-steroidal anti-inflammatory cream was then applied to soothe the skin and mitigate the inflammatory response.

Patients were advised to avoid trauma to the treated area, refrain from using cosmetics in the early days, and protect the area from direct sunlight exposure. Instructions were given to apply cold, wet gauze compresses several times daily to provide relief and control inflammation. Additionally, an antibiotic ointment (fusidic acid) was prescribed for application to the treated area twice daily for eight days following each laser session to prevent secondary infections. Treatments were performed year-round, with sunscreen application highly recommended between sessions, especially during the summer months.

Results were evaluated through clinical assessments and both photographic and multispectral documentation at each follow-up visit and eight weeks after the final session. The number of treatment sessions recommended for each lesion type, as outlined in Table 1, was based on our extensive clinical experience with similar cases. However, during each follow-up visit, the decision to schedule additional treatments was determined by the clinical outcomes achieved and the persistence of residual vascular components.

The efficacy of the treatments was assessed using a four-point grading scale that quantified lesion clearance relative to baseline. This scale categorized the outcomes as follows: a score of 1 indicated no or minimal improvement, corresponding to 0–25% of the lesion area cleared; a score of 2 represented slight clearance, with 26–50% of the lesion area cleared; a score of 3 denoted moderate to good clearance, reflecting a 51–75% reduction in the lesion area; and a score of 4 indicated excellent clearance, with 76–100% of the lesion area cleared.

At the conclusion of the treatment, patients were also asked to provide a subjective evaluation of the results with one of the following options: unsatisfied, moderately satisfied, satisfied, and very satisfied.

## 3. Results

Almost all patients exhibited overall improvements following the treatment protocol (Figures 1–7).

The majority of lesions were successfully removed, with the exception of six cases involving striae rubrae and eight cases involving keloids (Figures 2 and 3). Although complete elimination of the lesions was not achieved in these cases, the removal of the vascular component was observed in almost all instances.

Similarly, six cases of acne scars, two cases of port-wine stains (PWSs), and two cases of traumatic scars did not achieve complete clearance (Figures 4 and 5). Notably, there was an improvement and a reduction in vascularization, as evidenced by multispectral analysis.

A total of 50 patients (70.4%) demonstrated excellent clearance, corresponding to a 76–100% reduction in lesion area. A reduction in lesion area between 51 and 75% was observed in 12 patients (16.9%). Seven patients (9.9%) exhibited slight clearance, indicating a 26–50% reduction. Only two patients (2.8%) demonstrated minimal or no improvement in their lesions (Table 2). No recurrences were observed after one year in patients who achieved excellent clearance.

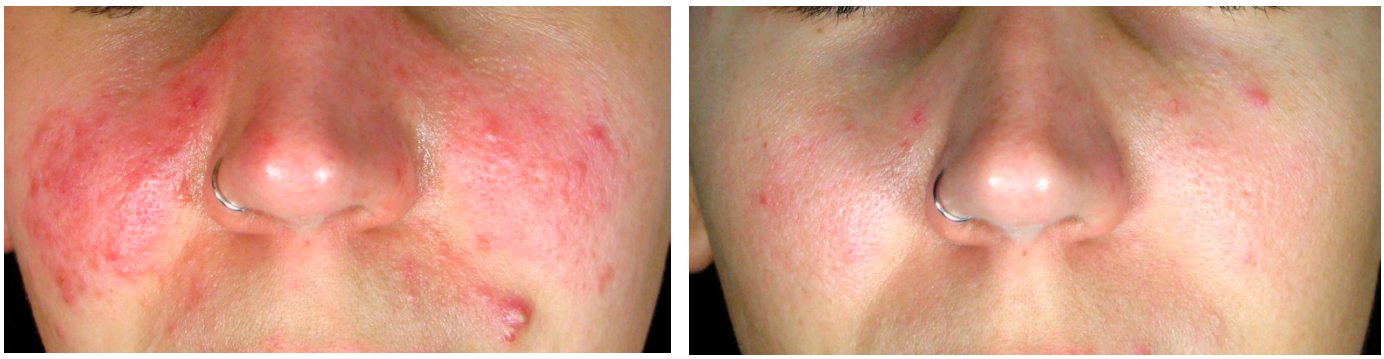
At the conclusion of the treatment, patients were invited to provide a subjective evaluation of the results. A total of 50 patients (70.4%) were very satisfied, 15 patients (21.1%) were satisfied, 4 patients (5.6%) were moderately satisfied with the results, and 2 patients (2.8%) were unsatisfied (Table 3).

These high satisfaction rates highlight the necessity of meticulous patient selection and the establishment of realistic expectations prior to treatment.

The lower satisfaction ratings observed in some patients may be attributed to a lack of comprehensive understanding of the achievable results or discomfort with the postoperative purpura.

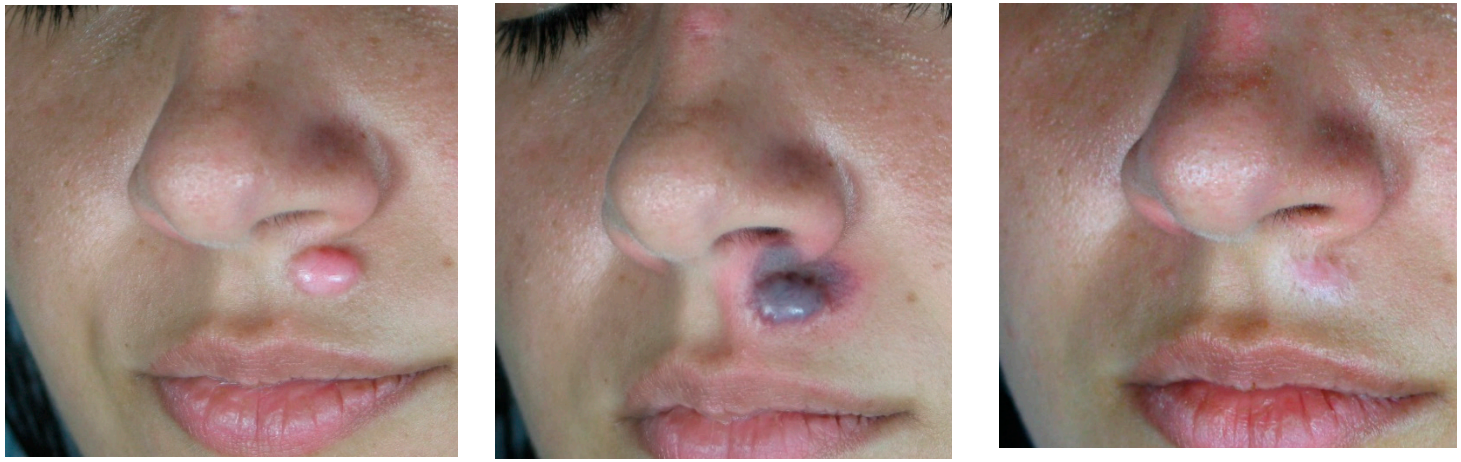
The only adverse effect observed was the anticipated post-operative purpura, which was accompanied by mild burning sensations and swelling in the treated areas. This purpura typically resolved within 12 to 14 days post-treatment. In rare instances, purpura persisted for up to 25 days.

No severe adverse effects, such as blistering, scarring, or significant pigmentary changes, were reported throughout the course of the study.



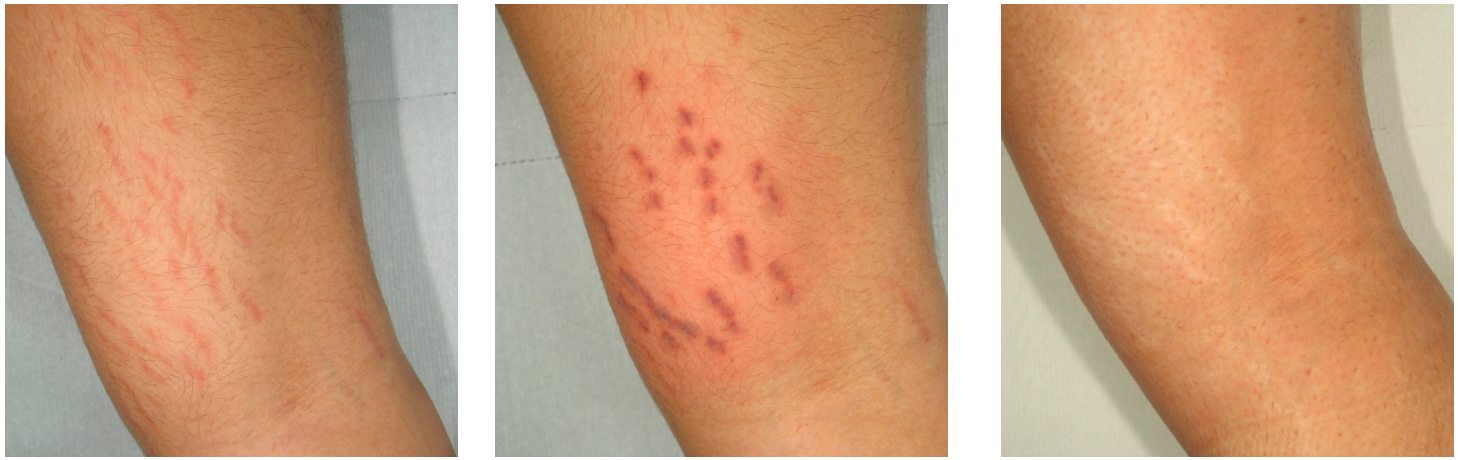
(**a**) (**b**)

**Figure 1.** (**a**) A young woman affected by rosacea at baseline; (**b**) Outstanding results observed after two PDL sessions.



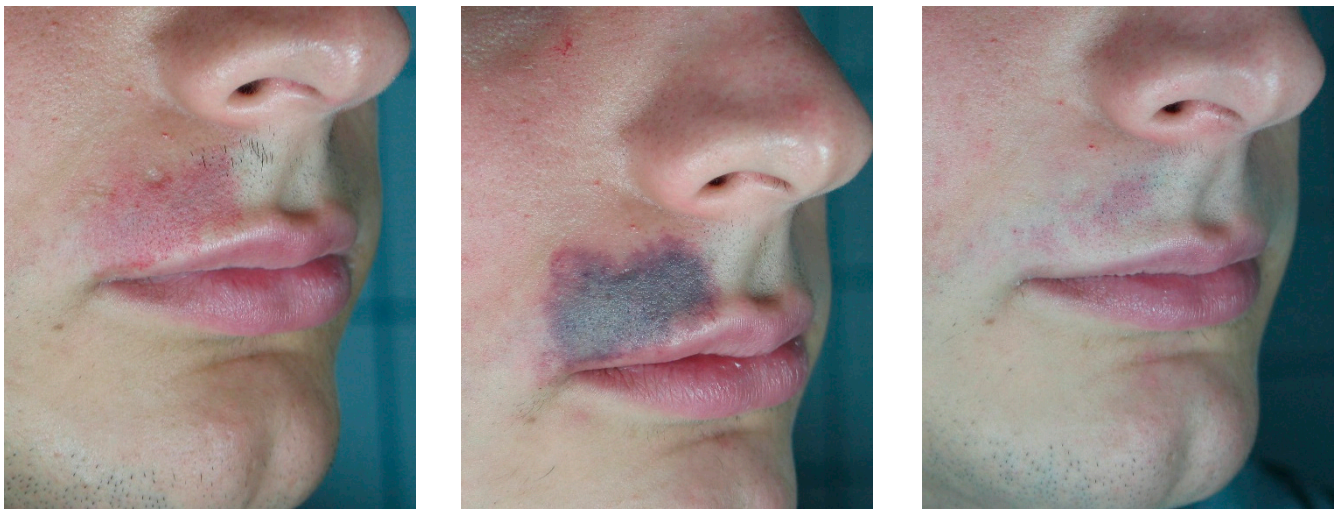
(**a**) (**b**) (**c**)

**Figure 2.** (**a**) Baseline appearance of a patient with a keloid on the nasolabial fold; (**b**) Typical post-PDL purpura; (**c**) Impressive improvement following four sessions of PDL therapy.



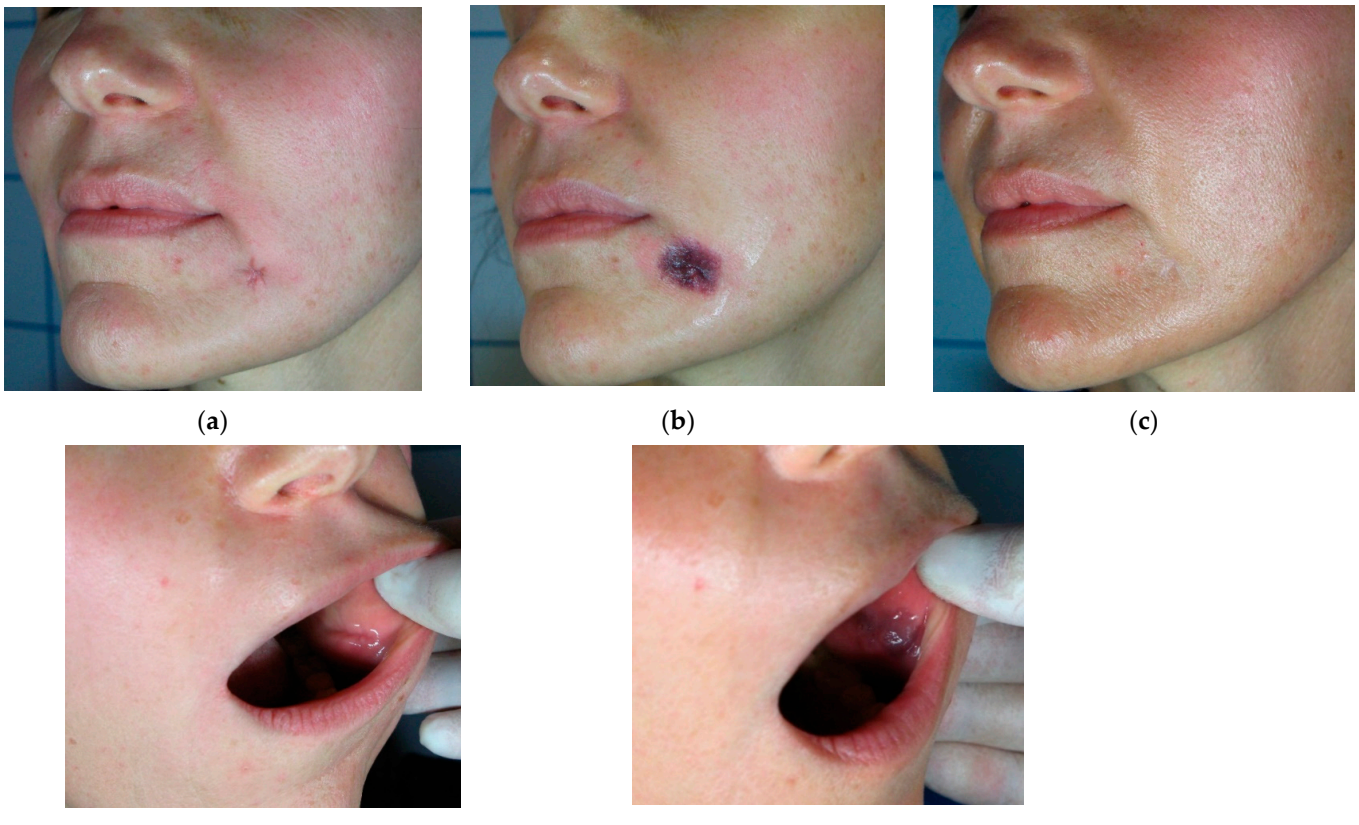
(**a**) (**b**) (**c**)

**Figure 3.** (**a**) Striae rubrae in a female patient prior to treatment; (**b**) Typical post-PDL purpura; (**c**) Marked clinical improvement with four PDL sessions.



(**a**) (**b**) (**c**)

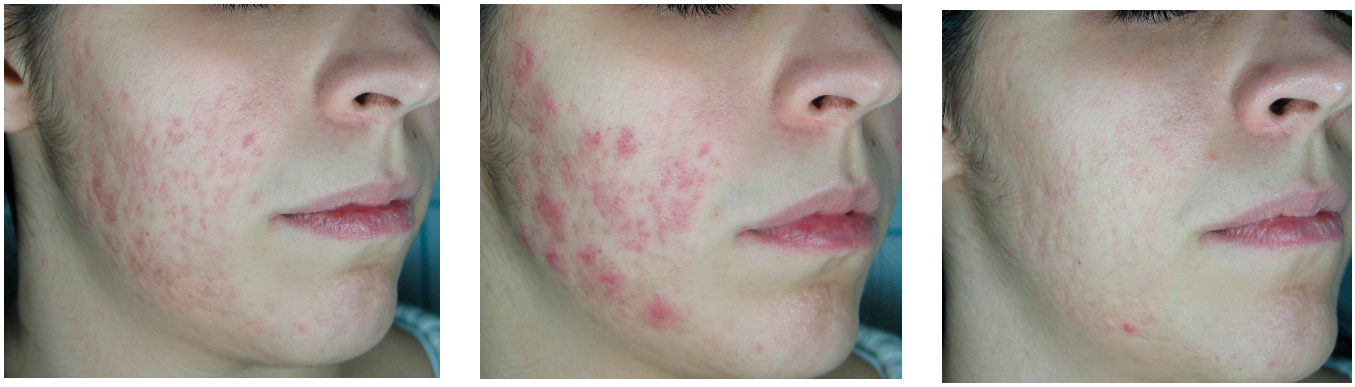
**Figure 4.** (**a**) A PWS on the nasolabial fold at baseline; (**b**) Purpura reaction post-PDL session; (**c**) Significant improvement observed 8 weeks following the last PDL session.



(**a**) (**b**) (**c**)

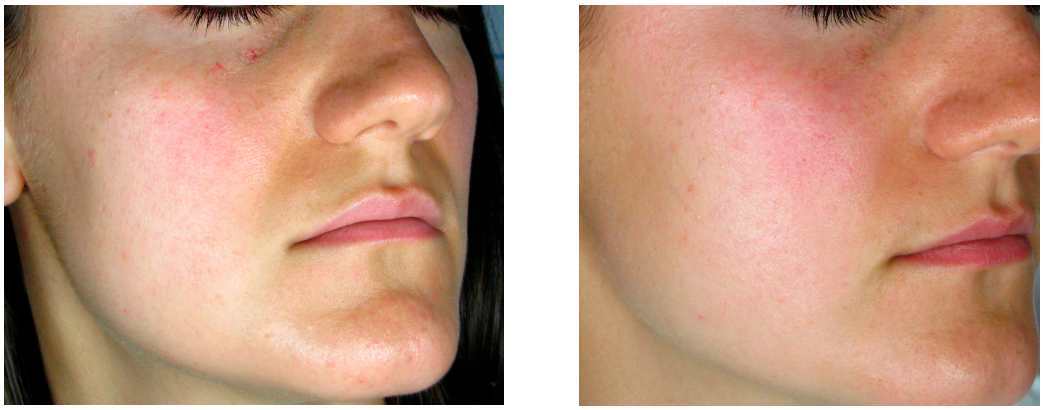
(**d**) (**e**)

**Figure 5.** (**a**) A traumatic scar located in the pre-jowl area; (**b**) Immediate purpura following PDL therapy; (**c**) Disappearance of the lesion after three sessions of PDL therapy; (**d**) Treatment included the oral mucosa due to the presence of scar tissue in that area; (**e**) Typical post-PDL purpura.



(**a**) (**b**) (**c**)

**Figure 6.** (**a**) Erythematous acne scars on the right cheek of a young patient before treatment; (**b**) Post-PDL treatment purpura; (**c**) Substantial reduction of scars after three PDL sessions.



(**a**) (**b**)

**Figure 7.** (**a**) Subpalpebral telangiectasias at baseline; (**b**) Significant improvement following a single PDL session.

**Table 2.** Global improvements.

| Score 1 | Score 2 | Score 3 | Score 4 |
|---|---|---|---|
| Minimal or no improvement<br>2 (2.8%) | Slight clearance<br>7 (9.9%) | Moderate-good clearance<br>12 (16.9%) | Excellent clearance<br>50 (70.4%) |

**Table 3.** Subjective evaluations of the results.

| Unsatisfied | Moderately Satisfied | Satisfied | Very Satisfied |
|---|---|---|---|
| 2 (2.8%) | 4 (5.6%) | 15 (21.1%) | 50 (70.4%) |

## 4. Discussion

The flash-lamp pulsed-dye laser (FPDL) is widely recognized for its efficacy in treating vascular lesions and dermatological disorders with vessel involvement [17–19]. This study underscores the important role of FPDL in cosmetic medicine, having successfully treated patients with primarily aesthetic concerns. This study employed laser settings optimized for vascular targeting, often inducing purpura, which has been shown to enhance efficacy [20,21]. For patients unable to tolerate purpura, comparable outcomes can be achieved through multiple sessions with lower fluence using non-purpuragenic parameters [5,6].

FPDL's exceptional selectivity for blood vessels establishes it as a reliable therapeutic tool for conditions such as facial telangiectasias and rosacea [22,23]. It remains the preferred method in the management of port-wine stains (PWSs), especially when initiated before one year of age and for lesions smaller than 20 cm [24–26].

Recent studies highlight FPDL's role in modulating scarring by reducing fibroblast activity, promoting apoptosis, and enhancing MMP expression, which supports its use in treating keloids and post-traumatic scars [10,11,27]. Moreover, its ability to improve wound healing reduces the risk of abnormal scarring [13,28].

Keloids with a lower vascular component are less responsive to dye laser treatment [29,30]. In these cases, an ablative $CO_2$ laser is necessary to vaporize the fibrotic component of the lesion [31,32]. Careful patient selection is critical, as better outcomes are typically achieved in areas with minimal tension, such as auricular keloids [33,34].

The dye laser has also proven to be a safe and effective treatment for scars and vascular lesions involving the oral mucosa [35–37]. In this study, we achieved excellent results by treating a post-traumatic scar on the inner side of a patient's left cheek (Figure 7). The presence of scar tissue on the mucosal cheek surface caused eating-related discomfort. Treating both the skin and mucosal surfaces was essential for achieving aesthetic improvement and restoring functionality.

The treatment of striae rubrae with FPDL, through the modulation of collagen synthesis and enhancement of elastin production, has been particularly effective on newer or recently occurred striae with a substantial vascular component [12,38].

In most cosmetic applications, a fluence of 6 to 7 J/cm$^2$ with a 12 mm spot size is generally sufficient [39,40]. However, for the treatment of keloids or certain cases of striae rubrae, an increase in fluence is necessary [41,42].

Our experience has shown that higher efficacy can be achieved in such cases by reducing the spot size to 7 mm and increasing the fluence to between 8 and 10 J/cm$^2$. Additionally, increasing the percentage of pulse overlap for these lesions is crucial (Table 1). While this may result in a more pronounced post-treatment purpuric reaction, it ultimately leads to improved treatment outcomes [43,44]. When employing higher fluences and greater pulse overlap, it is essential to provide meticulous post-treatment care and closely monitor the patient's progress over time [45,46].

Furthermore, the efficacy of dye laser treatment for erythematous acne scars has been corroborated by our study, aligning with findings previously reported in the literature [47–49].

The efficacy of combining FPDL and fractional $CO_2$ laser for improving outcomes in lesions such as striae rubrae and scars has been well-demonstrated [50,51].

Several studies have reported simultaneous use of both lasers in the same session [52–55]. An alternative approach could be to initially use FPDL as monotherapy until improvement in the lesion is observed. If no further improvements are obtained, fractional $CO_2$ could be employed in cases where FPDL alone has not yielded the desired outcome.

Our refined treatment protocol (Table 1), defined by the use of progressively escalating fluences and tailored pulse overlaps specific to each lesion, has proven highly effective in clinical practice. Additionally, we propose the optimal interval between treatment sessions, as detailed in Table 1, based on our clinical experience. When combined with meticulous patient selection, this approach has consistently delivered exceptional outcomes and high levels of patient satisfaction.

## 5. Conclusions

The effectiveness of FPDL in this study reinforces its pivotal role in cosmetic medicine. The extreme selectivity for hemoglobin makes FPDL a safe and effective treatment option. To achieve the best possible results, it is crucial to ensure that patients have realistic goals and are informed of all the possible side effects. It is also essential to educate patients about the correct post-treatment care, which is an important part of the treatment process. In the field of aesthetic treatments, especially in laser therapy, careful patient selection is essential to ensure that the expected outcomes align with their expectations.

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**Conflicts of Interest:** The authors declare no conflicts of interest.

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