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To cite this article: Murtadha Hashim Al-janabi, Noor Taha Ismaeel Ali, Karrar Deiaa Mohamed Al-Sabti, Muhsin A. Al-Dhalimi & Sahib Neamh Abdul Wahid (2017) A new imaging technique for assessment of the effectiveness of long pulse Nd:YAG 532 nm laser in treatment of facial port wine stain, Journal of Cosmetic and Laser Therapy, 19:7, 418-421, DOI: [10.1080/14764172.2017.1341985](https://doi.org/10.1080/14764172.2017.1341985)

To link to this article: <http://dx.doi.org/10.1080/14764172.2017.1341985>



Accepted author version posted online: 28 Jun 2017.
Published online: 28 Jun 2017.



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A new imaging technique for assessment of the effectiveness of long pulse Nd:YAG 532 nm laser in treatment of facial port wine stain

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ABSTRACT

Background: PWS is a vascular malformation presented at birth and associated with a psychological problem to the patients. Many types of laser systems were used to solve this problem. **Aim of the study:** To assess the efficacy of long-pulsed Nd:YAG 532-nm laser in the treatment of port wine stain both clinically and by imaging technique. **Patients and methods:** This is an interventional therapeutic clinical study for the treatment of facial port-wine stain with long-pulsed, 532-nm, Nd:YAG laser. The treatment sessions were done every 4 weeks for 12 sessions and follow-up after 3 months of the last session. The assessment of the response was done before and at the end of follow-up period, both objectively (percent of improvement, photo comparison by using PSNR) and subjectively (patient satisfaction). **Results:** Sixteen patients completed all sessions of the treatment. The improvement score for the PWS were failure = 0%, mild = 6.25%, moderate = 12.5%, good = 31.25%, and excellent = 50%. The values of PSNR for all the patients have been recorded and were fewer than 25 which means that the response for the treated lesions was very good. **Conclusion:** The long-pulsed Nd:YAG laser 532 nm is an effective and safe method of treatment of facial PWSs without significant residue. The PSNR was a new, simple, cheap and noninvasive method for assessment of the response of PWSs to laser therapy.

ARTICLE HISTORY

Received 19 October 2016
Accepted 5 June 2017

KEYWORDS

Laser; Nd:YAG; portwine stain; PSNR

Introduction

Port-wine stain (PWS) is a congenital and progressive vascular malformation characterized by ectatic capillaries and post-capillary venules in the dermis. It occurs in 0.3–0.5% of neonates (1). The stains are initially flat macules, irregular in shape, with a pink to red appearance. With time, the PWSs tend to darken progressively to purple and undergo hypertrophy or nodule formation (2). PWS is a clinically relevant problem that may adversely influence a patient's psychological well-being and overall health. Seventy to eighty percent of the patients with PWSs seeking treatment for PWSs had lesions located in the head and neck (3).

The cause and origin of PWS remain incompletely understood. The most likely hypothesis for their development is the deficiency or absence of surrounding neurons regulating blood flow through the ectatic post-capillary venules. As a result, the blood vessels are unable to constrict properly and remain permanently dilated (4). The expression of the potent endothelial cell mitogen vascular endothelial growth factor (VEGF-A) and its most active receptor, VEGF-R2, are significantly increased in capillary malformation skin tissue compared with control skin (5). Familial cases of PWSs (6) and rare cases related to trauma (7) had been reported. It is believed that PWSs develop within the first 2–8 weeks of gestation (4).

A variety of vascular-selective lasers were employed, with the pulsed-dye laser being the most common and well-studied. The early treatment produces more optimal results. Advances in imaging and laser treatment technologies demonstrate a

potential to further improve clinical outcomes. Frequency-doubled neodymium-doped yttrium aluminium garnet (Nd:YAG) and potassium titanic phosphate lasers produce 532 nm green light. Although it is significantly absorbed by haemoglobin, its absorption by melanin, make it used primarily in skin phototype I–III and, sometimes, skin phototype IV (8).

Peak signal-to-noise ratio (PSNR)

PSNR is an acronym to peak signal-to-noise ratio, PSNR has been expressed in terms of the logarithmic decibel scale and it was most commonly used to measure the quality of image processing by using MATLAB (Matrix Laboratory) program. This measure has been used to compare two images in terms of the identity between them (9). The result of PSNR has been presented as a mathematical matrix (10). Typical values for the PSNR in lossy image processing were between 30 and 50 dB, where higher, means the better similarity, and there was no difference between the two images and vice versa (11).

Patients and methods

This Interventional therapeutic clinical study was carried out in the Laser Research Unit, College of Medicine, University of Kufa, during the period from June 2014 to December 2015. Twenty patients with facial PWS were enrolled in this study. Patients were excluded if they had a personal or family history of hypertrophic

scar or keloid formation, the presence of chronic systemic disease, history of skin tumors, and/or immunosuppression.

A detailed history and careful physical examination were carried out in all patients. Colour photographs of each patient were taken at baseline, after completing all the twelve sessions of laser therapy and after the follow-up period using Sony digital, high sensitivity, 9.1 megapixels, DSC-HX1 still camera; in the same place with fixed illumination and distance.

Treatment protocol

All patients (eighteen females and two males) were included in the study. Each lesion was treated with long pulse 532-nm Nd:YAG laser (Quanta system – DNA laser technology – ULTRALIGHT, Milan, Italy). Parameters used were as follows: fluence of 30 J/cm², spot size; 3 mm, frequency; 1 Hz and pulse duration 25 ms.

For child participants, local anaesthesia EMLA cream (lidocaine 2.5% and prilocaine 2.5%) was applied under occlusion, 30 minutes before each session. During laser therapy, a gel was applied to the treatment area. The patient wore eye protection. The total number of sessions for each patient was twelve, at four-week interval. The probe was held perpendicularly with guide beam to target the skin with the laser with a one pass mode. The end point was blanching of the treated area. Before each pulse, contact cooling was used by an application of the cool sapphire of the device to the treated area. After the end of each session, cool air was applied to the laser-irradiated area. Patients were asked about any pain or discomfort during laser treatment. At the end of each session, the treated sites were observed, and the early skin reactions to laser treatment were recorded. All patients were instructed to avoid sun exposure and use a sunscreen of sun protection factor (SPF) greater than 30 during the treatment and follow-up periods. The patients were seen regularly every four weeks during the treatment period; side effects were recorded at each visit. The patients were followed for three months after the last treatment session to observe response, note any complications or recurrence of the lesion.

Assessment

All treated patients were evaluated objectively and subjectively regarding their response to treatment by the following methods.

Objectively

1 – The degree of improvement was assessed as:

- Failure = 0%
- Mild = 1–25%
- Moderate = 26–50%
- Good = 51–75%
- Excellent = >75%

2 – All the photos processed by PSNR to assess the changes before and at the end of follow-up period.

Subjectively

At the end of the treatment sessions, we asked the patients about their satisfaction regarding each parameter and their responses were recorded. The degree of satisfaction ranged in scale from 0 to 10.

Results

Sixteen patients have completed all sessions of the treatment, and the other four patients were defaulted from the study due to different causes including poor compliance for treatment and they failed to come to their appointments.

They were all females. The mean age of patients was 20.75 ± 8.925 years (range 8–45 years). Two patients (12.5%) were Fitzpatrick's skin types III and 14 patients (87.5%) were typed IV. There was no hypertrophy in any of the lesions. The colour of PWSs was pink-red in 13 patients (81.25%), dark-red in 2 patients (12.5%) and purple-dark in 1 patient (6.25%) (Table 1).

The improvement score for the PWS were failure = 0%, mild = 6.25%, moderate = 12.5%, good = 31.25%, and excellent = 50% (Table 2) (Figure 1).

The PSNR results were summarized in Table 3. All the PSNR results were less than 30. This means that there are significant differences between the images before and after the treatment with long pulse Nd:YAG laser 532 nm (Figure 2).

Most of the patients were satisfied and the mean score for the satisfaction of long pulsed Nd:YAG 532 nm was 8.9 ± 1.1.

Side effects

All patients developed transient erythema, scaliness and burning sensation lasting not more than 5 days after each session.

Follow up

None of the patients showed hyperpigmentation, recurrence or any scar after three months of the last treatment session.

Discussion

PWS is a vascular malformation presented at birth and associated with a psychological problem to the patients. Many types of the laser were presented to solve this problem, but none of them are 100% curable.

Table 1. Demographic data of the patients.

Demographic data	Patients no. and percentage
Patients No.	16
Mean age, year ± (SD)	20.75 ± 8.925
Female No.	16 (100%)
Male No.	0 (0%)
Type of skin	
III	2 (12.5%)
IV	14 (87.5 %)
Type of PWSs	
Pink-Red	13 (81.25%)
Dark-Red	2 (12.5 %)
Purple-Dark	1 (6.25 %)

Table 2. Percentage of improvement of facial port wine stain following the treatment with long pulse Nd:YAG laser 532 nm.

Improvement	No.	%
Failure	0	0.0
Mild	1	6.25
Moderate	2	12.5
Good	5	31.25
Excellent	8	50
Total	14	100%

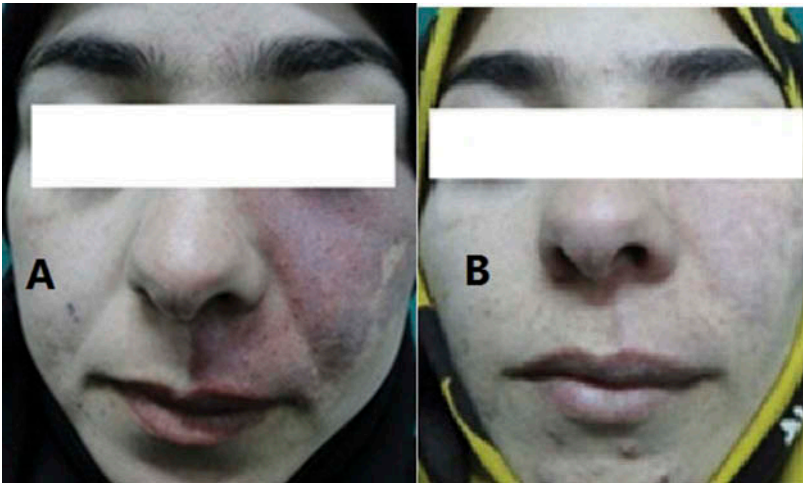


Figure 1. Thirty-year-old female with left-side facial portwine stain showing excellent response following the treatment with long-pulse Nd:YAG laser 532 nm.

Table 3. The PSNR of all the patients.

No. of patient	PSNR
1	16
2	12
3	23
4	8
5	17
6	14
7	19
8	22
9	19
10	14
11	15
12	12
13	21
14	18
15	25
16	19

The aim of the study was to assess the efficacy of long-pulsed Nd:YAG 532 nm for the treatment of portwine stain both clinically and by an imaging technique.

The efficacy of the Nd: YAG laser is accorded by the principle of selective photothermolysis along with the underlying endovascular laser–tissue interactions and subsequent biological responses that lead to PWS clearance.

A previous study that was done to assess the effectiveness of long-pulsed 532 nm Nd:YAG laser in the treatment of facial PWSs. There was more than 50% improvement after six sessions of treatment and the recommendation was to increase the sessions for better improvement (12). In the present study, the improvement increases up to 80% following 12 sessions with the use of the same previous parameters.

Pence et al. have assessed the response PWSs to frequency-doubled Nd:YAG laser 532 nm. The response was excellent (>95% improvement) in 13%, good (75–94% improvement) in 38% and moderate (50–74% improvement) in 44% of the patients (13). Chowdhury et al. achieved >50% improvement in 17% of the patients in

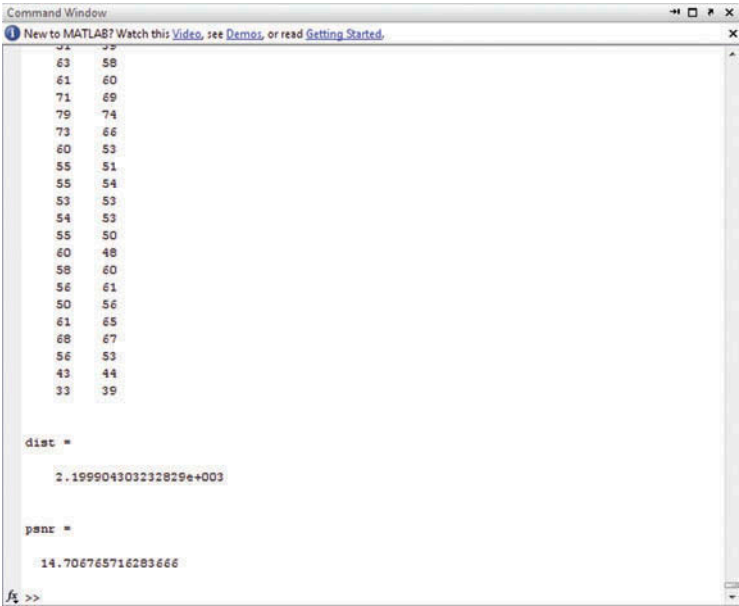


Figure 2. Mathematical matrix PSNR 14 dB of the above patient.

addition to side effects including scarring and hyperpigmentation in some of the patients (14).

The present study achieved more than 50% improvement in 80% of the patients without any side effects. Most of the patients were satisfied with the response and ask to continue further sessions.

These results may be attributed to the parameters that were selected and two methods of cooling that were used. Chowdhury et al. concluded that the fluence 18–24 J/cm² achieved the best response. Chan et al recommended using high fluence for achieving better clearance (15).

Many objective techniques are available for the assessment of the response of PWSs following laser treatment. These either invasive like biopsy, which many patients refused to do it as most lesions localized to the face or noninvasive likes spatial frequency domain imaging (SFDI) device (16), which is not available in our research unit and a little bit expensive for our budget. So the target was the search for an app that is cheap, simple, available and applicable, which is the PSNR.

The PSNR is used to clarify the difference between two identical images before and after treatment, since the standard ratio of the PSNR was from 30 to 50 dB represents the acceptable ratio to the identical between the two images, in this work the opposite has been used, if the PSNR value was lower than 30 it means that there were a big difference between the two images before and after treatment, which shows patient's response to treatment was more when the value of PSNR was low. It was important to mention that all the values of PSNR in this work for all the patients have been recorded fewer than 25 which mean that the response for the treated lesions was very good.

Conclusion

The long-pulsed Nd:YAG laser 532 nm is an effective and safe method of treatment of facial PWSs without significant residue. The PSNR was a new, simple, cheap and noninvasive method for assessment of the response of PWSs to laser therapy.

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