Lasers in Medical Science (2019) 34:737–742
https://doi.org/10.1007/s10103-018-2652-0

ORIGINAL ARTICLE

Multi-wavelength laser treatments of spider nevi

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Received: 26 April 2018 / Accepted: 27 September 2018 / Published online: 11 October 2018

Abstract

Spider nevi (SN) are one of common vascular diseases. Different treatment techniques have been described for SN previously, including electrocoagulation, argon laser, pulsed dye lasers (PDL), pulsed potassium titanylphosphate laser (KTP), and 1064-nm neodymium yttrium-aluminum-garnet (Nd:YAG) laser. These methods are effective but may require good technical management, multiple treatments, and often result in scarring or pigmentation. Multi-wavelength laser combined with 595-nm PDL followed by 1064-nm Nd:YAG and can be selectively absorbed by hemoglobin in vessels. The 595-nm laser can target shallow vessels whereas the 1064-nm laser may target deeper vessels due to the different penetration capacities of these wavelengths. Moreover, Nd:YAG absorption is remarkable increased following by PDL treatment. Multi-wavelength laser treatments have been successfully used for vascular diseases but there is little experience in SN therapy. Consequently, these treatment parameters have not been established for SN, particularly in Asian patients with Fitzpatrick skin type (FST) IV. Report experience with using multi-wavelength laser for SN treatment in Asian patients with FST IV. Forty-three SN lesions received multi-wavelength laser treatments via a PDL followed by an Nd:YAG laser. The treatment was performed at 7 mm spot size at 9.5–11 J/cm^2, 10 ms with PDL, followed by Nd:YAG at 40–50 J/cm^2, 15 ms. The laser treatments were performed with a single pass without overlap. Complete resolution was observed in 40 lesions and an 80–90% improvement in the other three lesions after one treatment session. One patient had superficial scarring. Four patients had hyperpigmentation that resolved within 3 months. Multi-wavelength laser treatments are fast and effective interventions for SN treatment in Asian patients with minimal adverse effects when appropriate parameters are set.

Keywords Spider nevus · Multi-wavelength lasers · 595-nm PDL laser · 1064-nm Nd:YAG laser

Introduction

Spider nevi (SN), also known as spider angiomas, vascular spiders, or nevus araneus, are considered as special type of telangiectasia and are composed of a central arteriole and superficial radiating branches leading to a "spider-like" appearance.

These nevi are observed in up to 15% of healthy adults with a higher incidence seen among young children [1, 2]. The face, neck, upper trunk, arms, and other sun-exposed areas are the most commonly involved regions and a single nevus or multiple nevi can be present. In some cases, SN can be associated with certain systemic diseases such as alcoholic cirrhosis [3, 4], or with high estrogen conditions [5], such as pregnancy and the intake of oral contraceptives.

Treatments for SN are usually undertaken due to cosmetic concerns. Different treatment techniques have been described in previous studies including electrocoagulation [6, 7], argon laser [8, 9], PDL [10, 11], KTP laser [7, 12, 13], and a 1064-nm Nd:YAG laser [14]. Electrocoagulation has been the traditional treatment for SN since 1980 [6] and is a readily available method. However, good technical management and a cooperative patient are a prerequisite for this approach to avoid known side effects such as pit scarring and bleeding [6]. Later, laser has been used for SN treatment. Laser is highly coherent light source with same wavelength. Laser beams can be focused and emitted at high peak powers with highly repetition rates. Compare with other light source, laser treatments produce specific injury of tissue effectively. However, most laser treatments have some relatively nonspecific thermal injury of tissue due to inappropriate pulse duration or dose and often result in complications, such as scarring and

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hyperpigmention. In previous reports, the complication incident rate of laser therapies is higher and less safe than that of other light source [15]. The argon laser has also been used previously for SN treatment [8, 9]. However, as this laser uses a continuous wave and can induce nonselective thermal injury to tissues, scarring and pigmented changes have often been reported. Selective photothermolysis was first described by Anderson and Parrish in 1983 [16] and the PDL was the first laser to be developed based on this principle. Later, pulsed KTP laser and 1064-nm Nd:YAG laser were developed subsequently. These different pulsed lasers can be specifically absorbed by hemoglobin, although they have different penetration depths. PDL, KTP, and Nd:YAG laser treatments of SN have been reported previously [7, 10–14] and been shown to be effective and have fewer side effects. Nevertheless, multiple treatment sessions were required in these cases for complete clearance [10, 11, 13, 14].

Multi-wavelength laser treatments (at 595 and 1064 nm) have now been successfully used for the treatment of venous lake [17] and glomuvenous malformations [18]. However, there is little experience of these methods with SN and treatment parameters have therefore not been established, especially for Asian patients with FST IV. In our current study, we report our experiences with multi-wavelength laser treatment of 41 Chinese FST IV patients and provide an evaluation of the effectiveness and safety of this approach. To our knowledge, there has been no comparable study of this previously.

Materials and methods

Forty-one patients diagnosed with SN were enrolled from August 2016 to October 2017. Forty-three SN lesions were diagnosed by clinical appearance in accordance with the descriptions in previous reports [5, 19]. Informed consent was obtained from each study participant prior to treatment. A detailed history was obtained, including the site of the lesion, treatment duration, and any previous therapy. Moreover, detailed dermatological examinations were performed for each subject. Local anesthetic EMLA cream (comprising 5% lidocaine HCl and 5% prilocaine) was an optional part of the treatment regimen and was administered to about 50% of the patients at 1 h prior to laser treatment.

Laser treatments

Local anesthetic EMLA cream was optionally used in some cases. The SN lesions were treated with a sequential application of a 595-nm PDL and 1064-nm Nd:YAG laser (Cynergy Multiplex, Cynosure Inc. Westford, MA) over a 7-mm spot size. The laser parameters were as follows: PDL, 9.5–11 J/cm^2 for 10 ms followed by a medium delay; Nd:YAG, 40–50 J/cm^2 for 15 ms. Continuous airflow cooling (Cryo5a, Zimmer Medizinsysteme GmbH, Neu-Ulm, Germany) was applied at level "6" during the treatment. The clinical endpoint was the disappearance of the surrounding radiating branches and a color change in the central arteriole from red to shallow purpura (Fig. 1). A single pass without any overlap of the laser was performed. Treatment for larger area with the diameter over 7 mm, the laser was emitted to the central vascular papule of the spider nevi. If the "legs" of spider nevi were immediately disappeared after laser irradiation, then no more treatment required; if not, a single pass laser treatment was performed for surrounding branches. After laser treatment, patients were instructed to keep the lesion clean and apply antibiotic ointment twice daily for 1 week. Photographs were taken prior to treatment and at each subsequent visit to evaluate the treatment efficacy. Laser treatments were repeated every 1–2 months if a further treatment was required. Follow-ups were conducted via phone over a duration of 4 to 17 months.

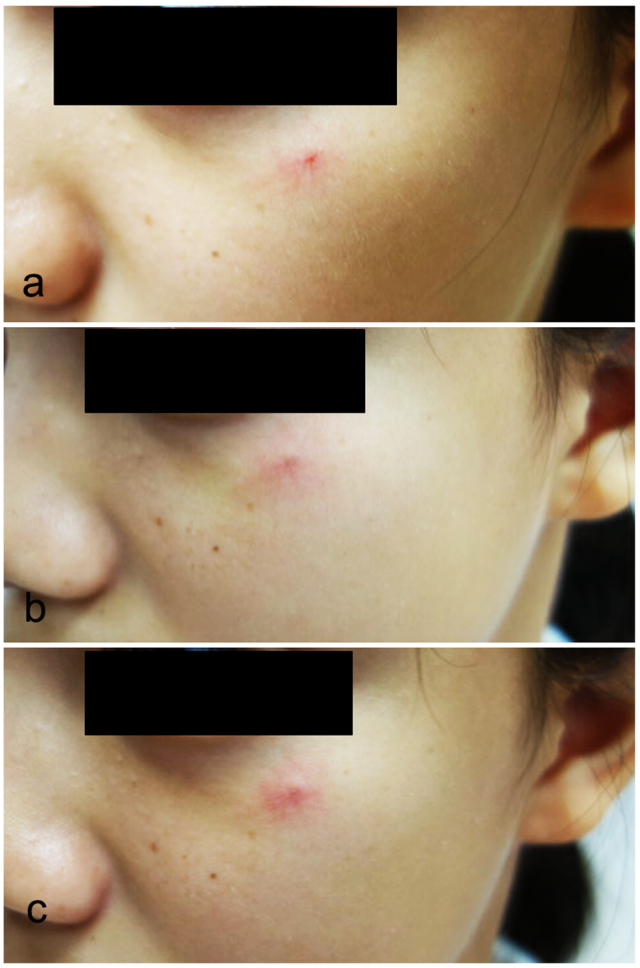

Fig. 1 Typical tissue reaction before and after multiple-wavelength laser treatment: before laser treatment (**a**); immediate after irradiation: the color change of central papule from red to light purpura and with disappearance of the surrounding radiating "legs" (**b**) and 5 min after treatment (**c**)

Assessments

The treatment results were evaluated in accordance with lesion size changes. Treatment effectiveness and side effects were evaluated via photographs and phone contact by two experienced dermatologists. The treated area was compared to the baseline photo in each patient. Since the color of the lesions among the study patients was very similar, this was not

Table 1 Demographic and clinical characteristics of the patients with spider nevi

Number	Gender	Age	Location	Duration (years)	Laser treatment				Previous treatment	Improvement (%)
					PDL (J/cm^2)	Pulse (ms)	YAG (J/cm^2)	Pulse (ms)		
1	F	18	Left cheek	1	10	10	50	15	No	100
2	F	48	Left cheek	1	10	10	50	15	No	90
3	F	8	Left cheek	6/12	10.5	10	45	15	No	100
4	F	6	Left cheek	3	10	10	45	15	No	100
5	F	5	Right cheek	1	10	10	45	15	No	100
6	F	6	Left cheek	10/12	10	10	45	15	No	100
7	F	10	Upper eyelid	2/12	10.5	10	45	15	No	100
8	F	4	Right cheek	1	10.5	10	45	15	No	100
9	M	10	Left cheek	1	10.5	10	45	15	No	100
10	F	8	Right cheek	6/12	10.5	10	45	15	No	90
11	F	6	Lower eyelid	6/12	10.5	10	45	15	No	100
12	F	21	Both cheeks	1	10.5	10	45	15	No	100
13	F	5	Left cheek	2/12	11	10	45	15	No	100
14	F	8	Right arm	1	11	10	45	15	No	100
15	M	6	Right cheek	2	10.5	10	45	15	No	100
16	F	37	Right cheek	1	10.5	10	45	15	No	100
17	M	7	Right cheek	6/12	10.5	10	45	15	No	100
18	F	21	Right cheek	2	10	10	45	15	No	100
29	F	23	Left cheek	1	10.5	10	45	15	No	100
20	F	3	Right cheek	6/12	11	10	45	15	No	100
21	M	7	Left cheek	3	10.5	10	45	15	No	100
22	F	6	Left cheek	2	10.5	10	45	15	No	100
23	F	3	Right cheek	3/12	10	10	45	15	No	100
24	M	11	Left cheek	1	10	10	45	15	No	100
25	F	5	Left cheek	6/12	10	10	45	15	No	100
26	M	11	Left cheek	1	11	10	45	15	No	100
27	M	8	Right cheek	6/12	11	10	45	15	No	100
28	F	9	Nose	4	11	10	45	15	No	100
29	F	7	Right cheek	6/12	11	10	45	15	No	100
30	F	9	Left cheek	5	11	10	45	15	No	100
31	F	7	Right cheek	1	10	10	45	15	No	100
32	M	8	Right cheek	1	10	10	45	15	No	100
33	M	5	Periorbital	1	11	10	45	15	No	100
34	F	29	Right cheek	5	10.5	10	45	15	Laser treatment	80
35	M	9	Left cheek	2	11	10	45	15	No	100
36	F	36	Lower eyelid	4	10.5	10	45	15	No	100
37	F	49	Lower eyelid	2	11	10	45	15	Laser treatment	100
38	F	21	Both cheeks	2	9.5	10	45	15	No	100
39	F	5	Left cheek	1	10	10	40	15	No	100
40	F	5	Periorbital	6/12	9.5	10	40	15	No	100
41	F	8	Upper lip	6/12	10	10	40	15	No	100

measured separately. Lesions that had completely disappeared were classed as a "100% improvement." In the cases of incompletely cleared lesions, two dermatologists compared the maximum diameter of the lesion to that of the baseline. Different scores for the same lesion were resolved by consensus between these two clinicians. The observed side effects included scarring, hyperpigmentation, hypopigmentation, textural changes, blisters, infection, edema, and purpura.

Results

All of the patient subjects were Chinese with FST IV skin. Thirty-one of these cases were female and the female-to-male ratio was 3.1:1. There were 31 patients younger than 12 years and 10 patients older than 12. The mean patient age was 12.6 years (range, 3–49 years), whereas the mean duration of disease was 1.4 years (range, 2 months–5 years). Thirty-nine patients had a single SN and the remaining two patients had two of these lesions on the cheeks. Most lesions (34/43) were detected at the cheek, six were detected at the eyelid and periorbital region, and three nevi were detected at the nose, upper lip, and arm, respectively. The SN diameters ranged from 0.5 to 1.0 cm. Twenty-eight hypertrophic lesions (28/43) with raised central papules. Two patients had received previous laser treatments (Table 1).

One session treatment was performed for all patients in this study. Complete resolution was observed in 40 lesions (40/43, 93.02%) after a single treatment session (Fig. 2), and an 80–90% improvement was observed in the remaining three lesions (Fig. 3). All of the subjects exhibited light edema during the first 3 days and shallow purpura for 5–7 days after treatment. Four patients (9.8%) had hyperpigmentation in the zygomatic region which resolved within 3 months by simply avoiding sun exposure. One child patient (2.4%) had superficial scarring on the back of the nose but there was no obvious necrosis in the local laser treatment area of this case. A thin scab had formed and been removed unintentionally by the child at 4 days after treatment without completely healing. We believe that this scarring may have been the result of poor postoperative care.

Discussion

We here describe the use of a multi-wavelength laser that combined a 595-nm PDL followed by a 1064-nm Nd:YAG to treat SN lesions. It has been established that both the 595-nm PDL and 1064-nm Nd:YAG can be selectively absorbed by hemoglobin in blood vessels. The 595-nm laser can target shallow vessels whereas the 1064-nm laser may target deeper vessels due to the different penetration capacities of these wavelengths (Fig. 4) [20]. In addition, Nd:YAG absorption is increased by three- to fivefold following the transformation of oxyhemoglobin to methemoglobin by PDL treatment. Thus, the multi-wavelength laser approach is a good option for the treatment of vascular lesions when the choice of a suitable pulse duration is dependent on the target vessel diameter.

Selective photothermolysis has represented a significant advance in clinical laser therapy. However, selective thermal destruction of the target vessel without injury to the surrounding tissues requires optimal laser parameters to be chosen including the laser wavelength, pulse width, and energy fluence based on the target vessel depth and diameter [12, 14]. In our current study series, excellent results were

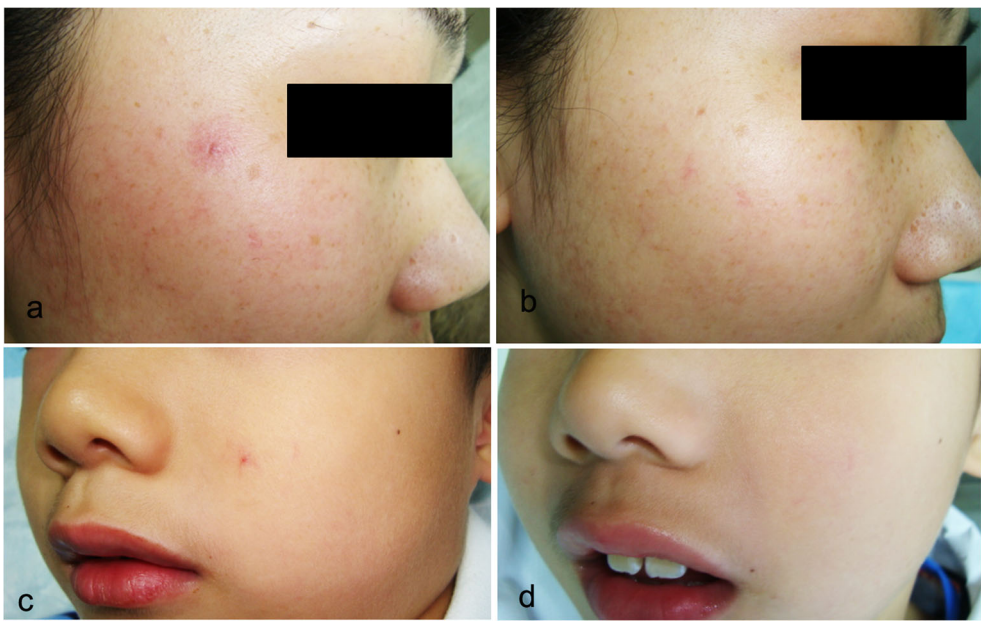

Fig. 2 Spider nevi present on the cheeks of a study subject prior to laser therapy (**a** and **c**), had completely disappeared after a single multiple-wavelength laser treatment (**b** and **d**)

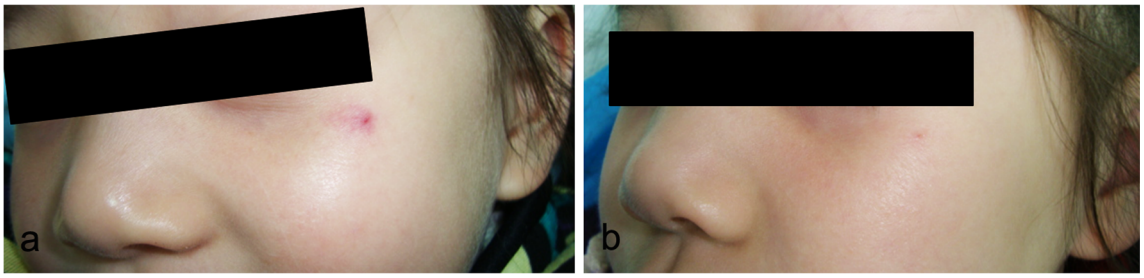

Fig. 3 A spider nevus on the left cheek of a study patient prior to laser treatment (**a**) and a 90% improvement in this case after one treatment with a multiple-wavelength laser (**b**)

achieved with no severe complications by setting these parameters appropriately. The methods we use to select these variables are outlined further below.

PDL has typically been used for SN treatment but with multiple treatment sessions often required as indicated in previous reports. Scheepers et al. reported 97 pediatric cases of SN treated by PDL using a 0.45-ms pulse duration, with 29% of these children requiring more than one treatment session to achieve complete clearance [10]. Polla et al. reported six SN cases that showed only partial clearance after two treatment sessions using a PDL [11]. These results may have been due to a PDL pulse duration (0.45 ms) that was insufficient to match the thermal relaxation time of the vessel in the SN, thus allowing heat to build up in this vessel [21]. SN vessel diameters are around 0.1–0.5 mm [14], and are larger than those of port-wine stains (PWS). A 1–10-ms pulse duration has been suggested for PDL in the past [22] and a pulse duration of longer than 10 ms can cause secondary heat effects [21]. Thus, we chose 10 ms as the PDL pulse duration in our current study.

The use of the long-pulsed 1064 nm Nd:YAG laser for SN treatment has been reported as it facilitates higher wavelength penetration to control deeper vessels [14]. In the previous report of Kemal et al., a 20-ms pulse duration was used in initial treatment of SN but an increased fluence after decreasing the pulse duration was then chosen until the desired clinical results were achieved [14]. Based on these previously

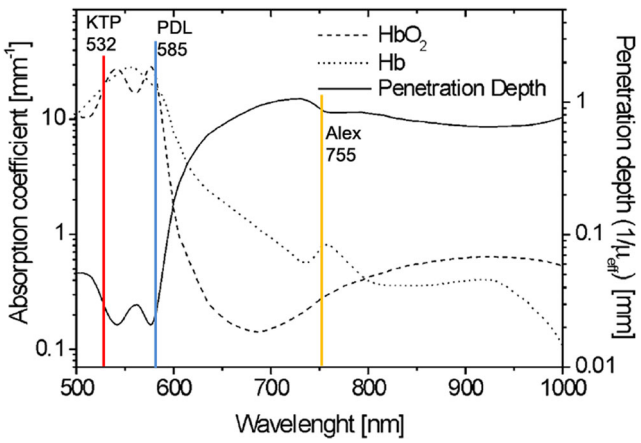

Fig. 4 Tissue absorption coefficient and penetration depth of different wavelength lasers (wavelength range from 500 to 1000 nm)

reported experiences, we chose 15 ms as the pulse duration for the Nd:YAG laser in our current SN patient series.

It has been established that the Nd:YAG laser also targets melanin, which could possibly lead to nonspecific thermal damage and adverse side effects, particularly in FST V and IV individuals with increasing amounts of melanin in the epidermis. Based on our own previous experience [23], a fluence range of 40 to 50 J/cm^2 can be safely used for FST IV Asian patients and was used for the Nd:YAG laser in our present study.

In our current study series, a single treatment session comprising PDL over a 7-mm spot size at 9.5–11 J/cm^2 for 10 ms, followed after a medium delay with an Nd:YAG treatment at 40–50 J/cm^2 for 15 ms, completely removed 93% of the SN lesions without severe complications except for one case of superficial scarring. We contend therefore that the multi-wavelength SN treatment parameters we have here described are appropriate for FST IV Asian patients.

One superficial scar was found on the back of the nose in a child from our present cohort. We make the following three suggestions for avoiding such scar formation. First, the fluence must be within a safe range, especially for FST IV cases. Second, continuous high level airflow cooling is very important during the treatment. This can not only relieve pain, but also can decrease the surface temperature and thereby provide additional epidermal protection of the laser treatment area [24]. Third, appropriate postoperative care is vital, especially in the case of children such as our aforementioned patient.

In conclusion, with appropriate parameters, a multi-wavelength laser approach is a fast and effective method of SN treatment in Asian patients that has minimal adverse effects.

Funding This study was funded by a grant from the National Natural Science Foundation of China (No. 81301363 to Yang Jing).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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