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BRIEF REPORT

Treatment of flat and elevated pigmented disorders with a 755-nm alexandrite picosecond laser: clinical and histological evaluation

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Abstract

The novel picosecond lasers, initially developed for faster tattoo removal, have also shown great efficacy in endogenous pigmentary disorders. To describe the efficacy and safety profile of an alexandrite (755-nm) picosecond laser in a wide range of pigmented flat and elevated cutaneous lesions. A retrospective study was performed in which we collected all the clinical images of patients treated with the 755-nm alexandrite picosecond laser for 12 months (November 2016–November 2017). Clinical features were obtained from their medical charts. Patients treated for tattoo removal were excluded. All the images were analyzed by three blind physicians attending to a visual analogue scale (VAS) from 0 to 5 (0, no change; 1, 1–24% clearance; 2, 25–49% clearance; 3, 50–74% clearance; 4, 75–99% clearance; 5, complete clearance). Patient satisfaction was obtained from a subjective survey including four items: very satisfied, satisfied, non-satisfied, and totally dissatisfied. Thirty-seven patients were included (12 males; 25 females). The mean age of the study was 42.35 years. Twenty-five patients (68%) were treated for different pigmented flat disorders such as solar and mucosal lentigines (5), stasis dermatitis (4), or nevus of Ota (4), among other diagnoses. Twelve patients (32%) were treated for epidermal elevated lesions such as warts (5), epidermal nevi (2), and seborrheic keratosis (3), among other elevated lesions. Mean number of laser treatment was 3.02 sessions while mean follow-up after last laser treatment was 4.02 months. Mean VAS score of the three observers was 3.44 (61% of clearance) for pigmentary flat disorders and 3.60 (67%) for elevated lesions. Adverse effects reported were mild blistering in the first 2–5 days following laser treatment in some of the patients. Overall satisfaction among the patients included was high. The novel 755-nm picosecond alexandrite laser is effective not only for the resolution of pigmented flat lesions of different nature but also for the treatment of the more difficult elevated pigmented lesions.

Keywords Laser · Picosecond laser · Alexandrite laser · Pigment laser · Nevus of Ota · Becker's nevus

Introduction

Different approaches such as cryotherapy, depigmenting agents, or dermabrasion can be used for the treatment of hyperpigmented lesions [1, 2]. Since the description of selective photothermolysis, many laser devices have been developed in the past decades to more precisely achieve the challenge of treating pigmented lesions [3]. Q-switched nanosecond lasers, fractional non-ablative or fully-ablative lasers and intense pulsed light devices are the standard modalities for melanin directed therapies [4–6].

In the past years, a new generation of lasers with shorter pulses, in the range of the picoseconds, has been developed with the objective of targeting more precisely the pigmented chromophores (i.e., tattoo inks, Melanin). These novel picosecond lasers have proven its efficacy for the faster resolution of tattoos and there are few series that demonstrate their utility in the treatment of endogenous pigmentary disorders such as nevus of Ota, Becker's nevus, solar lentigines, or café-au-lait macules among others [7–13]. However, its efficacy in pigmented elevated disorders such as warts, epidermal nevi, or seborrheic keratosis has not been reported yet.

The objective of our study was to describe the efficacy and safety profile of a novel 755-nm alexandrite picosecond laser

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in the treatment of different pigmentary disorders including both flat and elevated lesions.

Materials and methods

A retrospective study was conducted in the laser unit of a tertiary hospital in which we recruited the clinical photographs and information of the chart records of all the patients treated with a 755-nm alexandrite laser (Picosure®, Cynosure, Westford, MA, USA) in a period of 12 months from November 2016 to November 2017. Approval by the IRB office of our hospital was obtained prior to the study. Exclusion criteria were poor quality in photographic documentation or tattoo removal treatments. Clinical outcomes were evaluated by two independent, treatment-blind, physicians using a visual analog score from 0 to 5 (0, no change; 1, 1–24% of improvement; 2, 25–49% of improvement; 3, 50–74% of improvement; 4, 75–99% of improvement; 5, complete clearance). Patient satisfaction was assessed after treatment (2 months after the first session) in a scale of four items: very satisfied, satisfied, non-satisfied, and totally dissatisfied. In one of the patients, histological evaluation pre-treatment and post-treatment was also available.

Regarding laser settings, the 755-nm picosecond laser that we used is the Picosure® system (Cynosure, Westford, MA, USA) which has a fixed pulse duration of 550–750 picoseconds. The spot diameter can be modified and the fluency delivered changes automatically with the diameter size. In our study, we used smaller spot sizes for lesions with the pigment situated more superficially such as solar lentigines (2.5–3 mm) and larger spots (3–3.5 mm) in deeper lesions such as nevus of Ota or Becker's nevus. Total fluency varied from 2 to 4 J/cm^2. Pulse frequency ranged from 5 to 10 Hz.

In flat lesions, we used the laser device in contact with the skin, but in the elevated ones, we tend to separate it from the skin from a distance of 3–5 cm, so that a great part of the energy could be focused on the more superficial layers of the epidermis and therefore producing an epidermal disruption.

Statistical analysis was performed to compare the efficacy between the groups of "pigmented disorders" and "epidermal disorders". *T* Student test was used for this purposed, using the IBM SPSS Statistics (2015) software for Mac (IBM corp. Armonk, NY, USA).

Results

Clinical and epidemiological features of the patients included are summarized in Table 1. A total of 37 patients were included (12 males; 25 females). Mean age at time of treatment was 42.35 years (range 12–76 years). Fitzpatrick skin types were I–IV being the most frequent type II (21 patients, 57%).

Twenty-five patients (68%) were treated due to mainly pigmentary disorders that included solar lentigines and mucosal lentigines (5 patients), stasis dermatitis (4), pigmented purpuric dermatoses (2), nevus of Ota (4), post-inflammatory hyperpigmentation (2), lichen pigmentosus (1), Becker's nevus (1), nevus spilus (1), congenital melanocytic nevus (1), cafe-au-lait macules (1), pigmentovascularis phakomatosis (1), radiodermatitis (1), and macular amyloidosis. Twelve patients (26%) were treated because of mainly epidermal disorders including warts (5), epidermal nevus (2), seborrheic keratosis (4), and porokeratosis (1) (Figs. 1 and 2). The number of laser treatments ranged from just one session to five sessions with a mean of 3.02 treatments. After last treatment, a mean follow-up of 4.02 months was available in the population studied with a range from 3 to 7 months.

The scores of the mean visual analog scale (VAS) are summarized in Table 2. A cumulative mean score of 3.44 was obtained for flat lesions corresponding to a 61% of total clearance. The mean score for elevated, papular disorders was 3.60 (65% of clearance). Overall mean score for all the lesions treated was 3.49 (63%). No significant difference was found between pigmented and epidermal disorder treatment efficacy of the picosecond alexandrite laser.

The histological examination of one patient treated due to a purpuric pigmented dermatosis in lower extremities revealed the complete resolution of the deposition of hemosiderin in dermis, detected with a Perl's stain (Fig. 2c, d).

Most common complication reported was mild erythema and pain on the first 2–3 days following treatment. In some cases, the treatment led to bullae formation and crusts that resolved spontaneously without any further complications. Of note, one of the patients treated due to a purpuric pigmented dermatosis of the lower extremities developed big blisters that resolved in 5–7 days.

Overall satisfaction was high with all the patients evaluating the treatment as "very satisfied" (22 patients; 59%) or "satisfied" (12 patients; 32%).

Discussion

The treatment of pigmentary disorders is a challenge that has to be faced by dermatologists in their daily practice. Until now, Q-switched nanosecond lasers of different wavelengths have been the most used devices for the resolution of pigmented lesions, under the principle of selective photothermolysis [3]. The nanosecond pulse duration of these devices allows an irradiation to the pigmented chromophore (melanosomes, hemosiderin, or tattoo ink particle) for a duration less than its thermal relaxation times, producing a photothermal and photomechanical damage. With the new

Table 1 Clinical and epidemiological features and treatment specifications of patients included in the study

		Diagnosis	Age	Skin type	Sessions	Parameters	Follow-up
1	Female	Solar lentigines	65	II	3	2.5 mm–4.07 J/cm2	5
2	Female	Solar lentigines	54	III	2	2.5 mm–4.07 J/cm2	5
3	Female	Solar lentigines	47	II	3	2.5 mm–4.07 J/cm2	4
4	Male	Solar lentigines	62	I	3	2.5 mm–4.07 J/cm2	4
5	Female	Mucosal lentigines (Laugier síndrome)	41	II	1	3 mm–2.83 J/cm2	3
6	Female	Stasis dermatitis	64	II	3	3 mm–2.83 J/cm2	4
7	Male	Stasis dermatitis	61	III	3	3 mm–2.83 J/cm2	5
8	Female	Stasis dermatitis	76	III	2	3 mm–2.83 J/cm2	3
9	Female	Stasis dermatitis	81	III	3	3 mm–2.83 J/cm2	4
10	Male	Purpuric pigmented dermatosis	43	II	4	3 mm–2.83 J/cm2	5
11	Female	Purpuric pigmented dermatosis	52	II	5	3 mm–2.83 J/cm2	6
12	Male	Nevus of Ota	36	II	3	4 mm–1.59 J/cm2	7
13	Female	Nevus of Ota	65	III	3	4 mm–1.59 J/cm2	5
14	Female	Nevus of Ota	43	IV	3	4 mm–1.59 J/cm2	6
15	Male	Nevus of Ota	32	III	4	4 mm–1.59 J/cm2	4
16	Male	Post-inflammatory hyperpigmentation	29	II	5	3.5 mm–2.08 J/cm2	5
17	Male	Post-inflammatory hyperpigmentation	37	II	4	3.5 mm–2.08 J/cm2	5
18	Male	Lichen pigmentosus	43	II	3	3.5 mm–2.08 J/cm2	3
19	Female	Becker's nevus	22	II	2	3.5 mm–2.08 J/cm2	4
20	Female	Nevus spilus	14	III	3	2.5 mm–4.07 J/cm2	4
21	Male	Congenital melanocytic nevus	15	II	2	3 mm–2.83 J/cm2	4
22	Female	Café-au-lait macule	12	II	2	3 mm–2.83 J/cm2	5
23	Female	Pigmentovascularis phakomatosis	10	II	3	3 mm–2.83 J/cm2	6
24	Male	Radiodermatitis	39	II	4	3 mm–2.83 J/cm2	6
25	Female	Macular amyloidosis	49	II	3	3 mm–2.83 J/cm2	5
26	Female	Warts	12	III	2	2.5 mm–4.07 J/cm2	6
27	Female	Warts	21	II	2	2.5 mm–4.07 J/cm2	3
28	Male	Warts	16	II	4	2.5 mm–4.07 J/cm2	3
29	Female	Warts	18	I	4	2.5 mm–4.07 J/cm2	2
30	Male	Warts	39	III	5	2.5 mm–4.07 J/cm2	1
31	Female	Epidermal nevus	12	II	4	3 mm–2.83 J/cm2	2
32	Male	Epidermal nevus	32	IV	3	2.5 mm–4.07 J/cm2	2
33	Female	Seborrheic keratosis	67	III	4	2.5 mm–4.07 J/cm2	3
34	Female	Seborrheic keratosis	57	I	2	2.5 mm–4.07 J/cm2	4
35	Female	Seborrheic keratosis	71	II	2	2.5 mm–4.07 J/cm2	3
36	Female	Seborrheic keratosis	68	III	3	2.5 mm–4.07 J/cm2	2
37	Female	Porokeratosis	62	II	1	2.5 mm–4.07 J/cm2	1
Media	25 females (68%) 12 males (32%)		42.35 years		3.02 sessions		4.02 months

picosecond lasers, the pulse duration is at least 70 times shorter than the one of the previous Q-switched lasers, thus theoretically allowing a more intense damage to the pigmented chromophore using a photomechanical effect [14, 15]. Although these lasers were initially developed with the aim of allowing faster tattoo removal, they have proved great efficacy in different endogenous pigmentary disorders, even in patients with skin of color and Asian skin [8, 13, 16, 17].

Since the main targeted chromophores of the 755-nm alexandrite picosecond laser are the melanin or any other dark pigments, we hypothesized that it could be also useful for the treatment of elevated and hypertrophic disorders with a dark coloration. The absorption of the energy delivered by the laser would be absorbed in this case by the melanin contained in the lesion generating a photothermal and photomechanical effect that would also affect the surrounding

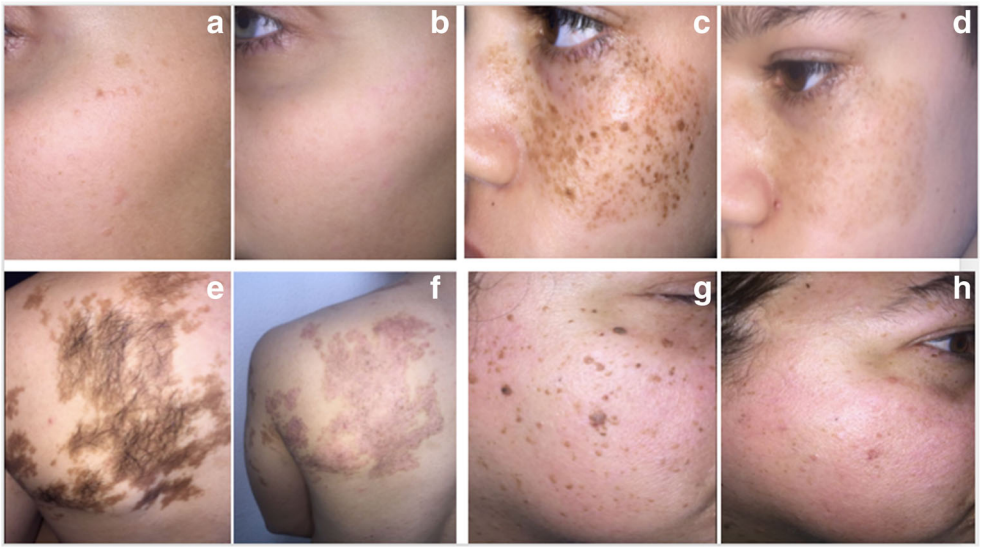

Fig. 1 Clinical response of different pigmented lesions to picosecond alexandrite laser. **a** Flat warts on the left cheek of a child before treatment and **b** after two laser sessions. **c** Nevus spilus before treatment **d** after five laser sessions. **e** Becker's nevus on the left upper back in a male patient before treatment and **f** after four laser sessions. **g** Seborrheic keratosis on the right cheek of a woman before treatment and **h** after three laser sessions

epidermal tissue. In these cases, we used a different technique, defocusing the laser beam by pulsing it from a longer distance to the skin (3–5 cm). The purpose of this technique is to concentrate the laser energy in the more superficial layers of the skin (the epidermis and superficial dermis) in order to treat such elevated lesions. Following these hypothesis, we treated 12 patients with epidermal disorders such as seborrheic keratosis, flat warts or epidermal nevus, obtaining in fact overall great results, 65% of clearance. The end-points that we looked for when using the picosecond laser were a mild blanching for pigmented lesions with most of the chromophore located in the dermis (i.e., nevus of Ota) and an intense blanching for those with superficial epidermal pigmentation (i.e., flat warts or epidermal nevus).

We have observed that even in non-pigmented warts, the alexandrite picosecond laser shows good efficacy. We try to explain this phenomenon by a possible mechanism of epidermal breakage caused by the laser when targeting the normal melanin contained in the skin. Therefore, when used from a certain distance, we could be able to produce an ablative-like effect with the laser that would be responsible of the wart resolution.

Although there are previous studies proving the efficacy of the novel 755-nm picosecond laser for pigmentary lesions; to our knowledge, this would be the first study demonstrating its efficacy also in elevated pigmented lesions such as flat warts or epidermal nevus. Moreover, here we present some cases of hyperpigmented entities with excellent response to the picosecond alexandrite laser that had not been reported previously such as nevus spilus, lichen pigmentosus, or radiodermatitis.

Also remarkable is that the histopathological examination of one patient with purpuric pigmented dermatosis revealed an

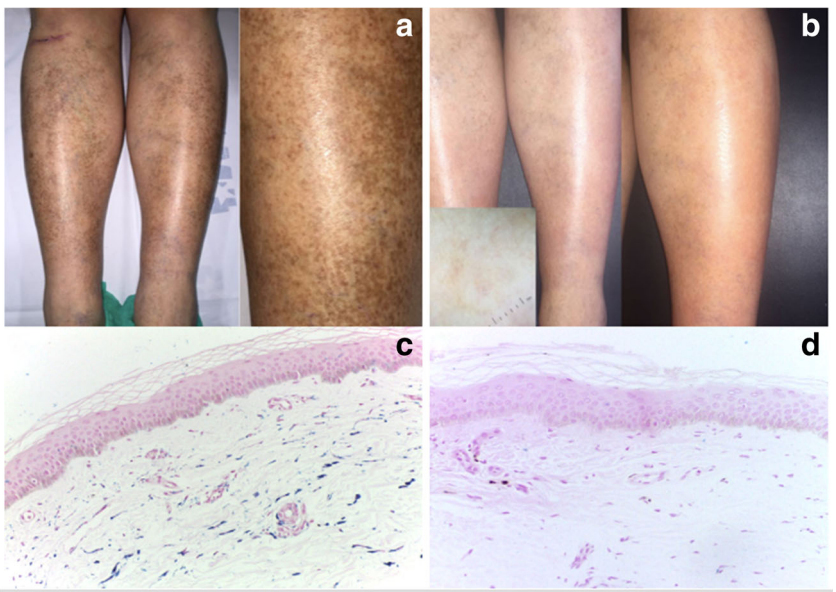

Fig. 2 **a** Pigmentation on the legs of a 45-year-old woman due to purpuric pigmented dermatosis. **b** After three sessions with the 755-nm alexandrite picosecond laser, including dermoscopy image showing normal skin without pigmentation. **c** Histological examination of a biopsy performed before laser treatment 20×; Perl's Prussian blue staining: blue areas correspond to iron contained in hemosiderin deposits. **d** Histological examination of a biopsy performed in an adjacent area, after laser treatment 20×; Perl's Prussian blue staining: very scarce hemosiderin deposits

Table 2 Mean clearance scores provided by the three blinded observers in a visual analog scale from 0 to 5 (0, no clearance; 1, 1–24% of clearance; 2, 25–49% clearance; 3, 50–74% clearance; 4, 75–99% clearance; 5, complete clearance)

Observer	Flat lesions ($n = 25$; 68%)	Elevated lesions ($n = 12$; 32%)	Total
1	3.33	3.6	3.40
2	3.42	3.6	3.47
3	3.58	3.6	3.61
	3.44 (*61%*)	3.60 (*67%*)	*3.49* (*63%*)

almost complete clearance of the hemosiderin deposits that were present before treatment. This demonstrates that the 755-nm picosecond laser might also be effective for the treatment of hyperpigmentation due to other endogenous pigments different from melanin. In fact, we included in our study more patients with pigmentation produced by a purpuric pigmented dermatosis or stasis dermatitis, also with excellent clinical response to the picosecond laser.

Interestingly, we have observed that the use of the picosecond laser lead to a more intense blister formation than the Q-switched nanosecond lasers that we have been using previously. This is in line with previous studies using this type of lasers [7, 8, 16]. In the histological studies reported previously, an intraepidermal optical breakdown could be observed after the picosecond laser treatment, which has also been confirmed under multiphoton microscopy [18, 19].

Some limitations of our study are the small sample of patients and its retrospective nature. Further studies including longer series of patients with more homogenous diagnoses would also be of interest.

In conclusion, the 755-nm alexandrite picosecond laser can be considered as an effective, fast, and safe option for the treatment of pigmented endogenous cutaneous lesions of different nature. It can be used in both flat and mildly elevated lesions with similar results.

Compliance with ethical standards

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

Ethical approval This study was properly approved by the institution of our Center.

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