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A Clinical Study on Treatment of Benign Pigmented Skin Lesions in Dark Skin Patients by the Ablative Er:YAG and the Pigment-Selective ND:YAG Lasers

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ABSTRACT

Benign pigmented skin lesions and tattoos represent a challenging cosmetic problem to plastic surgeons. Current therapeutic modalities are not satisfactory and surgery may require mobilization of tissues in the form of a skin graft or a flap. Both ablative and selective lasers have been recently used for treatment of pigmented skin lesions. However, dark-skin patients with high epidermal melanin content may be at risk of pigmentary changes in response to laser therapy. We carried out this clinical study on 38 patients of Fitzpatrick skin types III-V. Of these, 25 had endogenous pigmented skin lesions and 13 had tattoos. We used short-pulsed Er:YAG as an ablative laser and Q-switched Nd:YAG as a pigment-selective laser. The study showed that both laser modalities produce significant lightening of superficial pigmented lesions and tattoos. Q-switched Nd:YAG laser is more effective in scar-free eradication of deep dermal pigmentation. Hyperpigmentation was common and preservation of the background pigmentation was difficult to achieve.

INTRODUCTION

Pigmented skin lesions, whether endogenous or exogenous, represent a clinical and aesthetic challenge to both plastic surgeons and dermatologists. Several therapeutic modalities had been tried in the treatment of pigmented skin lesions. These include topical application of bleaching agents, cryosurgery, chemical peel, dermabrasion, salabrasion, and surgical excision, with or without skin grafting or flap coverage [1,2]. However, these modalities are either ineffective or grossly destructive and lead to scarring [3]. One of the therapeutic modalities that have been recently introduced in the treatment of pigmented skin lesions is laser. In this study, we describe our clinical experience in treating pigmented skin lesions with the ablative Er:YAG laser and the pigment-selective, Q-switched Nd:YAG laser as regards their efficacy and potential complications.

PATIENTS AND METHODS

This study had been done on 38 adult patients of both sexes. Of these, 25 had endogenous pigmented skin lesions and 13 had tattoos (Table 1). All patients were dark-skinned of skin types III-V, according to Fitzpatrick skin type scale [4].

Table (1): Indications of laser modalities.

	Short-pulsed Er:YAG	Q-Switched KTP	Q-Switched Nd:YAG
Lentigines	5	4	0
Café au lait macules	4	3	0
Congenital nevi	2	3	0
Nevus of Ota	0	0	4
Tattoo	8	0	5
Total number of cases	19	10	9

Local exclusion criteria were unsatisfactory laser test, cosmetic, skin-colored tattoos, and pigmented lesions with malignant or premalignant potential [5-7]. General exclusion criteria included prisoners, pregnant women, patients with localized or systemic infection, immuno-compromised patients, and patients with coagulation or photosensitivity disorder [8].

Two types of laser were used in this study. The ablative Er:YAG (2940nm) and the pigment-selective, Q-switched Nd:YAG (1064nm), including its double frequency, KTP (532nm) mode. The decision to use KTP laser was based on the lighter color of the pigmented lesion or enhancement by Wood's lamb examination, both suggesting epidermal pigmentation [9].

A test area is done to detect the least energy that can produce the desired effect [6]. If the result of the test was satisfactory, laser sessions are started after 2 weeks and can be repeated every 6-8 weeks.

The end point with Er:YAG laser ablation is fine spots of dermal bleeding [10]. Immediate whitening is the clinical end-point that indicates melanosomes or phagosomes rupture produced by the Q-switched laser pulses [3,11]. Failure was considered when there is no improvement after 4 sessions [12]. The therapeutic parameters of each laser modality are shown in Table (2).

Table (2): Laser parameters.

	Er:YAG	Q-Switched Nd:YAG	Q-Switched KTP
Wavelength	2940 m	1064nm	532nm
Pulse width	300u-sec.	5-10n-sec.	5-10n-sec.
Fluence	20-40J/cm^2	3-10J/cm^2	1-3J/cm^2
Spot size	3mm	3mm	3mm
Number of pulses/sec.	5Hz	5Hz	5Hz
Scanner	No	No	No
Number of passes	2-4	1	1
Number of laser sessions	1-2	2-8	1-2
Pulse overlap	50%	50%	50%
Target chromophore	Water	Melanin, blue-black tattoo pigment	Melanin, hemoglobin
Mechanism of action	Non-selective ablation	Selective photothermolysis	Selective photothermolysis
Absorption/penetration characteristics	Superficial in the epidermis	Deep into the dermis	Limited into the epidermis and upper dermis

Post-laser medication includes application of steroid-containing topical antibiotic ointment and an oral non-steroidal anti-inflammatory analgesic. Sun-exposed areas are maintained on sunscreen with SPF 15. A hydroquinone-containing bleaching agent is prescribed if hyperpigmentation occurred.

Photographs of the pigmented lesions are taken prior to laser treatment, during the subsequent follow up visits, and one month after the final laser session. The photographs are evaluated by an independent dermatologist [9]. The clinical response is assessed according to the degree of pigmentary lightening, using the grading system described by Leuenberger et al., into excellent (>75%), good (50-74%), fair (25-49%), and poor <25%) [8]. The follow-up period ranged from 3-6 months.

RESULTS

Short-pulsed Er:YAG and Q-switched Nd:YAG lasers were used to treat 38 patients with endogenous pigmented skin lesions and tattoos. The outcome and complications are shown in Tables (3,4).

Both Er:YAG and Q-switched KTP lasers were equally effective in removal of superficial pigmented skin lesions (Fig. 1). One to two laser sessions were clinically satisfactory for ablation of the superficial skin pigment. Recurrence of café au lait macules occurred in 2 out of 3 cases with either modality. The response of nevus of Ota to Q-switched Nd:YAG laser is variable and Er:YAG laser was not tried because of the depth of the endogenous pigment.

Significant lightening of the deep dermal tattoo pigment occurs in response to Q-switched Nd:YAG laser, without unsightly scarring or hypopigmentation (Fig. 2). Er:YAG laser eradicates superficial dermal tattoo pigment but with significant incidence of pigmentary changes and scarring (Fig. 3).

The overall pigmentary changes and scarring were more common with Er:YAG laser compared with Q-switched Nd:YAG-KTP laser (Table 5, Fig. 4).

Fig. (1-A): Medium-sized congenital nevus before treatment by Q-switched KTP laser.

Fig. (1-B): The outcome of Er:YAG and KTP laser tests.

Fig. (1-C): The same patient after 2 laser sessions.

Fig. (2-A): Tattoo before treatment by Q-switched Nd:YAG laser. See the ugly scar after attempt at surgical removal.

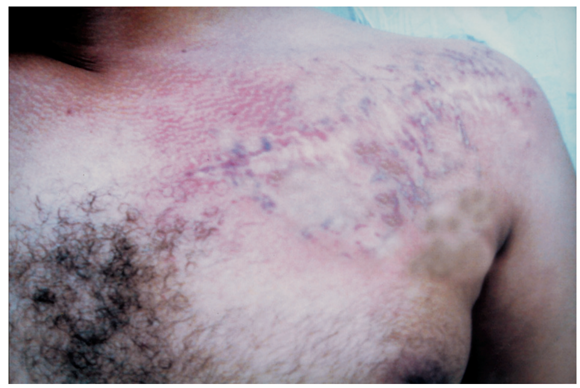

Fig. (2-B): The same patient showing >75% clearance of the tattoo pigment after 4 laser sessions.

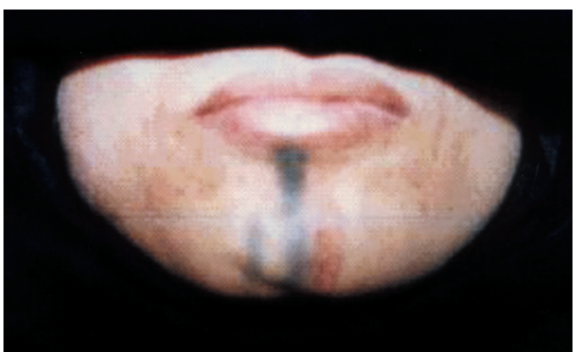

Fig. (3-A): Tattoo before ablation and after test by Er:YAG laser.

Fig. (3-B): Complete clearance after one laser session.

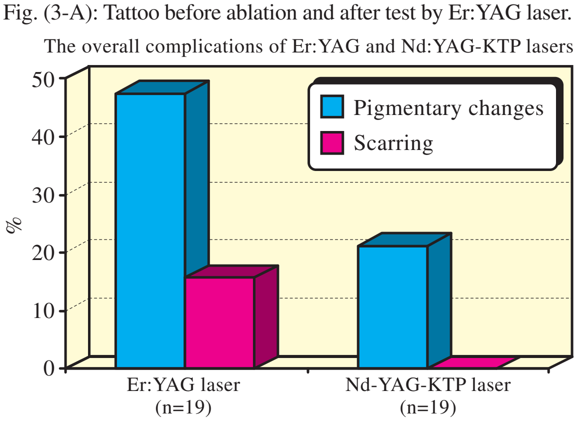

Fig. (4): The incidences of pigmentary changes and scarring with Er:YAG and Nd:YAG-KTP lasers.

Fig. (5): The "dotted effect" in a case of medium-sized congenital nevus treated by Q-switched KTP laser.

Table (3): Efficacy and complications of Er:YAG laser.

	>50% lightening	<50% lightening	Hypo-pigmentation	Hyper-pigmentation	Recurrence	Scarring
Lentigines (n=5)	5	0	0	3	0	0
Café au lait macule (n=4)	3	1	0	0	2	0
Congenital nevus (n=2)	2	0	1		0	1
Nevus of Ota (n=0)	0	0	0	0	0	0
Tattoo (n=8)	8	0	2	3	0	2

Table (4): Efficacy and complications of Nd:YAG-KTP laser.

	>50% lightening	<50% lightening	Hypo-pigmentation	Hyper-pigmentation	Recurrence	Scarring
Lentigines (n=4)	4	0	0	1	0	0
Café au lait macule (n=3)	3	0	0	0	2	0
Congenital nevus (n=3)	3	0	2	0	1	0
Nevus of Ota (n=4)	1	2	0	0	1	0
Tattoo (n=5)	4	1	0	1	0	0

Table (5): The overall complications of Er:YAG and Q-switched Nd:YAG-KTP lasers.

	Er:YAG laser (n=19)	Nd-YAG-KTP laser (n=19)
Pigmentary changes	9 (47.4%)	4 (21.1%)
Scarring	3 (15.7%)	0 (0%)

DISCUSSION

Cutaneous pigment may be endogenous or exogenous. Endogenous lesions are subdivided according to the type of cellular element into non-nevocellular and nevocellular, or according to the location into epidermal, dermal, and combined dermal and epidermal **[6,13]**. Exogenous lesions or tattoos are always dermal, consisting of intracellular, insoluble ink particles that have been ingested by phagocytic cells **[3,13,14]**. Both non-selective and selective laser modalities have been used in the treatment of pigmented skin lesions. Non-selective lasers are absorbed primarily by water in the skin. They eradicate cutaneous pigmentation by ablation of both pigmented and non-pigmented structures indiscriminately **[13,15]**. Selective, short pulsed lasers are preferentially absorbed by the pigment. They selectively damage and confine that damage to the pigment-containing organelles, thus achieving selective photothermolysis **[13]**.

Ablative lasers have been used to treat pigmented skin lesions in various ways. Er:YAG laser was used to treat lentigines in dark-skin patients in an attempt to minimize scarring and pigmentary changes **[10]**. Pulsed CO_2 laser could safely remove cosmetic tattoos containing flesh-colored pigment, without paradoxical permanent darkening **[16]**. Er:YAG resurfacing before treating pigmented lesions and tattoos with one of the Q-switched lasers was described to allow increased penetration of the laser light. However, there is no firm clinical evidence to support this regimen **[17,18]**. Er:YAG laser produces less thermal damage to the surrounding tissues than pulsed CO_2 lasers, and carries a lower risk of permanent melanocytic damage in the skin appendages of dark skin patients **[19,20]**. Another advantage of Er:YAG laser is visualization where the pigment was situated during removal **[10]**. Our study shows that Er:YAG laser is effective in treating superficial pigmented skin lesions and superficial dermal tattoos. Er:YAG laser is unreliable in treating pigmented skin lesions and tattoos with deep dermal involvement. The endogenous pigment visually disappears as we remove the epidermis but the lesion often recurs later, probably due to submacroscopic dermal remnants. However, the exogenous tattoo pigment is clearly visible all through the procedure because of their relative large size. Aggressive attempt at removal leads to hypopigmentation due to melanocytic damage and scarring due to dermal injury.

Q-switched pulsed lasers are considered ideal for treating pigmented skin lesions [17]. Several types of Q-switched lasers were described for this purpose [21-27]. Among the family of Q-switched lasers, Nd:YAG-KTP laser enjoys selectivity and versatility. It is selective because both wavelengths fall within the broad absorption spectrum of melanin [28]. It is also versatile because superficial pigmented skin lesions can be removed by the short wavelength of KTP laser. Tattoos and deep pigmented skin lesions are treated by deeply-penetrating long wavelength of Nd:YAG laser [6]. The long wavelength is more effective in removal of blue-black tattoos than deep pigmented skin lesions because at 1064nm, there is weak absorption by melanin [8]. This may explain the low incidence of pigmentary changes and why there was more significant lightening in tattoo than nevus of Ota. Scarring was not observed with either wavelength because of the short pulse duration of the Q-switched modes [17]. However, laser tattoo removal is not without drawbacks. Treatment is painful, expensive, and requires from 2-20 sessions. One laser can not remove all the colors and 1/3 of cases still have residual laser-altered tattoo pigmen. According to Dover and Kane, the goal of laser treatment is to remove the unwanted pigmentation and retain the constitutive pigment [13]. With the exception of epidermal pigmented lesions, melanin in the epidermis is an unwanted site for light absorption. Thus, darkly pigmented skin is at high risk for melanocytic injury during any laser treatment using visible or near infrared wavelengths less than 1200nm [28]. Citron recommended exclusion of patients with skin types IV-VI, when treating pigmented skin lesions [6]. Leuenberger et al., recommended exclusion of patients with facial tattoo from treatment by Q-switched lasers [8]. In this study, hyperpigmentation was common with Er:YAG laser, both local and marginal. Local hyperpigmentation was common with facial lesion while marginal hyperpigmentation was seen in hidden areas, denoting a role of sun exposure. Activation of melanocytes was attributed in the local area to exposure to sub-threshold energy and in the adjacent area to exposure to supra-threshold energy [6]. Hyperpigmentation may occur with Er:YAG laser regardless pretreatment with bleaching preparations [10]. Hyperpigmentation is considered a temporary unfavorable outcome because it responds to post-laser bleaching agents [10,12,29]. Hypopigmentation may be associated with scarring due to deep dermal ablation with Er:YAG laser. With Q-switched KTP laser, it is practically impossible to skip the competing background melanin pigment. Hypopigmentation may assume a "dotted" configuration despite the 50% pulse overlap. This may be due to lack uniform distribution of the laser energy or focal repigmentation from the hair follicles (Fig. 5). Pulse overlap is known to increase the laser fluence delivered to the tissue surface and the depth of penetration [10]. Darker-skinned patients may also require starting laser sessions at lower energy levels than white-skin patients [4].

Clinically, epidermal pigment is easier to eradicate than dermal pigment and benign pigmented lesions of the epidermis can be removed by almost any laser of sufficient power [3]. Simple lentigines usually respond to single laser treatment [17]. Café au lait macules show variable results, unrelated to its two histologic subtypes and high rate of recurrence [3,12]. Laser treatment of congenital nevi offered hope for patients with unresectable, disfiguring lesions. Q-switched lasers were used for treating flat, benign-appearing nevi with clinical improvement after multiple treatments [30]. It was reported that congenital nevi often recur after initial good lightening [31]. We had only 20% recurrence of congenital nevi probably because of their superficial nature. Recurrence may be due to the presence of deep nests and sheets of nevus cells extending into the reticular dermis or even the subcutaneous fat [32]. One of the most controversial areas in laser surgery is the theoretical risk of melanoma [12]. There is evidence that large and giant nevi carry the risk of malignant degeneration [7]. However, the 8-year histological follow up study for treatment of congenital melanocytic nevi by laser showed no evidence of malignant change [33]. There might be differences in the epidemiology of melanoma and the biological behavior of melanocytes among different ethnic groups [12]. We had limited success in treating nevus of Ota with Q-Switched Nd:YAG laser. This may be due to inadequate number of laser sessions. Nevus of Ota shows good to excellent lightening after at least 3 laser sessions and the original pigmentation may recur after complete laser-induced clearance [12]. There is also weak absorption by the natural skin chromphores, including melanin at 1064nm [8].

Summary:

This study shows that both Er:YAG and Q-switched KTP lasers produce significant lightening of superficial pigmented skin lesions. Er:YAG laser can be used to treat superficial dermal tattoo but Q-switched Nd:YAG laser is preferable for scar-free treatment of deep dermal tattoo. Pigmentation problems are common, especially with Er:YAG laser. Preservation of the background pigmentation

is difficult to achieve in dark-skin patients. There is a risk of recurrence of endogenous pigmented skin lesions, especially café au lait macules.

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