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Q-Switched Laser Treatment of Pigmented Lesions in Asian Skin

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ABSTRACT

Background: Q-switched lasers are an effective tool for treatment of pigmented lesions.

Aim: The purpose of this study was to determine the efficacy and safety of different 1064-nm Q-switched (QS) Nd:YAG and 532-nm KTP laser treatment protocols used in the treatment of pigmented lesions of Asian skin.

Methods: A total of 72 subjects with Fitzpatrick skin types III to V were treated for the following pigmented lesions: melasma, lentigines, freckles, Hori's nevus, Ota's nevus, PIH, dark lips, Cafe au lait spot and acanthosis nigricans. Evaluation methods included clinical evaluation of the clearance of lesions and patient-reported satisfaction with the treatment results.

Results: Melasma was the most commonly treated lesion (46%), followed by lentigines (17%) and freckles (11%). More than 50% clearance was achieved by 91.2% of patients treated for melasma and 100% of patients treated for lentigines and freckles. The most common side effect was short-term erythema.

Conclusions: All of the Q-switched 1064-nm Nd:YAG and 532-nm KTP laser protocols used seem to be safe and effective for the treatment of a variety of pigmented skin lesions in Asian skin.

Key words: Pigmented lesions, QS 1064-nm Nd:YAG, QS 532-nm KTP, Asian skin.

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I. INTRODUCTION

Pigmented lesions are among the most common skin disorders in the Asian population. There are many different laser treatments offered today for treating pigmented lesions, however, higher Fitzpatrick skin types, in Asian patients in particular, are extremely sensitive to post-inflammatory hyperpigmentation (PIH) as well as hypopigmentation (white spots). To avoid any of these side effects, it is thus extremely important to consult a physician with experience in treating Asian patients and to use protocols that have proven to be safe and effective in this specific population[1].

A greater amount of melanin endows Asian skin with superior natural photoprotection, however, as a consequence, this population shows a greater tendency to have pigmentary disorders. Lentigines, freckles, and melasma are the most common abnormalities, while nevus of Ota and Hori's nevus are also frequent dermal pigmentary disorders in this group. PIH is common to this skin type, occurring after cutaneous damage, including after the use of lasers and other light sources[2].

The treatment of pigmented skin lesions by Q-switched (QS) lasers (ruby, alexandrite, and Nd:YAG), fractional photothermolysis and other non-ablative laser therapies have been shown to be effective[3]. QS lasers in particular, which deliver pulse durations in the nanosecond and picosecond domains, have been widely considered as the laser of choice to treat both epidermal and dermal pigmentary disorders. According to the theory of selective thermolysis, photothermal effects are maximized when chromophores receive energy at wavelengths operating at durations less than or equal to their thermal relaxation times. The short pulse

durations of QS lasers allow for optimal, targeted photothermal damage to melanosomes, which have a thermal relaxation time of 50 nanoseconds[4].

QS lasers have proven effective for a large number of skin pigmentary disorders, such as nevus of Ota, freckles, and other pigmentary concerns. These devices deliver high-powered pulses that act through a non-thermal photoacoustic effect to achieve breakage of excess pigment, allowing enhanced treatment while maintaining a minimal side-effect profile.

In recent years, "laser toning" or "laser facial" has become increasingly and widely performed for the treatment of melasma in Asian countries[5]. Melasma is a common problem in individuals with Asian skin type or higher Fitzpatrick skin tones. Because these individuals have higher levels of melanin in the skin, they are more sensitive to excess pigmentation that results from sun exposure. Melanin absorbs the sun's ultraviolet rays and acts as a natural protection from the sun. However, as the skin is exposed repeatedly to the sun, the amount of melanin increases and in response to this increase, the amount of sun spots, hyperpigmentation, melasma, and sun damage becomes more visible[6].

Fractional laser therapy, also known as fractional photothermolysis, may be useful for resistant cases and may also be very effective[7]. Fractional photothermolysis (FP) involves the delivery of narrow beams of high-energy light to the skin in a pixelated pattern. Only fractions of skin are treated by small 3-dimensional zones of thermal damage known as "microscopic thermal zones" (MTZs). There is sufficient energy in the fractionated columns of the laser beam to induce thermal damage without compromising the adjacent tissue. The surrounding skin acts as a structural reservoir that allows fast epidermal repair through migration of the untreated viable tissue[8]. Due to the preservation of these zones of undamaged tissue, the integrity of the epidermis can recover quickly. This considerably reduces the recovery time[9].

The aim of this study was to retrospectively gather clinical data for a larger number of Asian patients with a variety of pigmented lesions undergoing laser treatment in order to analyze the efficacy and reported side effects of QS 1064-nm Nd:YAG and 532-nm KTP lasers. Another aim was to gather the information about the different treated indications and treatment modalities and protocols used in clinical practice across Asia.

II. MATERIALS AND METHODS

A total of 72 patients with nine types of pigmented lesions were included in this study. Patient demographic data is presented in Table 1. The study was conducted in accordance with the Declaration of Helsinki. A full explanation of the nature of the procedure, risks, benefits, and alternative treatment options were explained, and written informed consent was obtained. Data for this study were retrospectively obtained from multiple private clinics: Choice Dermatology Clinic (South Korea), PMT Aesthetic Clinic (Vietnam), Dr. Nazelia Clinic (Malaysia), Treasure Aesthetic Clinic, (Taiwan), WeCoMed Clinic (Singapore) & IDO'S Clinic, (Malaysia), VERITAS, Medical Aesthetics (Singapore), Skin Rachel Clinic (Indonesia) and Skinsense Skin and Laser Clinic (India).The treated clinical indications included melasma, café-au-lait spots, freckles, lentigines, Ota's nevus, and Hori's nevus (Table 2). Some patients had multiple lesions treated. Cases where treatment parameters overlapped with various lesions were evaluated separately.

Table 1: Patient demographics

	Number	%
Sex		
Male	8	11
Female	64	89
Fitzpatrick skin type		
III	21	29
III-IV	2	3
IV	44	61
V	5	7
Age	min	max
	18	73

All patients were treated using a QS laser capable of emitting both 1064-nm Nd:YAG and 532-nm KTP laser beams (StarWalker, Fotona, Slovenia). For detailed treatment parameters see Tables 3–12. Pulse modalities used in the study were in the range from nanoseconds to long-pulsed milliseconds. Fotona's StarWalker has incorporated MaQX-1, -2, -5 and -10 modes for nanosecond pulse ranges, which consist of high peak-power picosecond micro pulse bursts lasting 5 nanoseconds, thus forming hybrid (pico-nano) macro pulses. In MaQX-1 all the energy is in a single hybrid pulse, while in MaQX-2, -5 and -10 the energy is distributed between 2, 5 and 10 hybrid pulses in the train, respectively. These pulse trains (MaQX-2, -5, -10) are "softer" than a MaQX-1 pulse of the same energy, as the energy is distributed among 2, 5 or 10 hybrid pulses inside the train and the peak power of these distributed hybrid pulses are lower than that of the single MaQX-1 hybrid pulse. The longer the train, the softer the effect. FRAC3 mode utilizes a short sub-millisecond pulse duration and high peak power density at 1064-nm to produce a self-induced three-dimensional fractional pattern within the epidermis and dermis, with damage islands predominantly located at the

sites of minute skin imperfections or inhomogeneities[1]. VERSA is a millisecond long 1064-nm mode with range durations 15, 20, 25 and 50 ms. Both full-spot and fractional handpieces were used by the participants in the study. FS20A is a 1064 nm fractional handpiece with a 9x9 mm matrix area (81 pixels, pixel size 200 μm). R28 is a full-spot handpiece with variable spot sizes (2–8 mm) for wavelengths of 1064-nm and 532-nm. R58 is a full-spot handpiece with variable spot sizes (1.5–6 mm) for a wavelength of 532-nm with a millisecond pulse range (VERDE).The level of clearance achieved was clinically assessed by the treating physician at the follow up visit on a 6-degree scale; 4: 76–100%, 3: 51–75%, 2: 26–50%, 1: up to 25%, 0: no changes, -1: worse than before. Photographs were taken before the first session and at the last follow-up. Patients were asked to grade their satisfaction rate on a 4-point scale (0-3); 0–not satisfied, 1–somehow satisfied, 2–satisfied, 3–very satisfied.

III. RESULTS

a) Patients

Patient demographics are shown in Table 1, while the results of treatments divided by pigmented lesion types are shown in Table 2. The laser parameters used for treatment of individual lesions are summarized in Tables 3–11.

Table 2: Distribution of lesion types, number of lesions, passes and treatment sessions, follow-up, clearance and patient satisfaction.

	No. of lesions	No. of treatment sessions (median, range)	Follow up	Average degree of clearance (-1–4)	Patient satisfaction (0–3)	% of patients with > 50% of clearance at last follow up
Melasma	34	5, 1-15	2 w–14 m	3.4	2.8	91.2
Centrofacial lentiginosis, lentigines, solar lentigines	12	7, 5–16	3 w–14 m	3.8	2.9	100
Freckles	8	5, 1-10	2 w–6 m	3.8	2.6	100
Hori's nevus	6	10, 5-16	2 w–12 m	3.8	3	100
PIH	4	4.5, 3-7	0–3 w	4	2.5	100
Ota's nevus	3	8, 1-30	1 m–12 m	3	2.7	66.7
Dark lips	1	4	1 m	3	2	100
Cafe au lait spot	1	2	1 m	3	3	100
Acanthosis nigricans	1	6	1 m	3	3	100
Total single lesions	**70**	**/**	**0 w-14 m**	**3.4**	**2.7**	**/**
Multiple lesion types cases	**6**	**9.5 (3-12)**	**2 w-3 m**	**3.4**	**3**	**100**

w-week, m-month

b) Melasma

A total of 34 cases of melasma were treated in the study (Fig. 1). Various protocols were used, all achieving clearance rates in the range from 2 to 4 (Table 3). Average patient satisfaction was very high: 2.8 on a 0–3 VAS scale. In all cases, the treatment consisted of 1 – 3 steps with MaQX-1 or MaQX-2 mode. In three cases, an additional step with FRAC3 modality, and in one case a step with VERSA for visible vascular lesions, were included. A VERDE modality over the mottled pigmentation was used in one case. Full spot sizes (R28 handpiece) from 4 to 8 mm were used. In nine cases, the treatment included an additional step with fractional handpiece (FS20A). Most often (7/9 cases), the fractional step was performed in 1–5 sessions out of 6–10 sessions over full face in brushing technique. Fluence range was 1.0–9.0 J/cm^2 when full spot and MaQX-1 or MaQX-2 modes were used and 1.7–13.0 mJ/px, fractional spot and MaQX-1or MaQX-5. FRAC3 mode fluence was 15–20 J/cm^2 and VERSA mode fluence 160 J/cm^2 for vascular lesions.

The number of passes and sessions were highly variable among protocols. The number of passes ranged from two to 15 for different steps with the R28 handpiece and from one to three passes with the FS20A handpiece. The number of sessions ranged from two to 15 with intervals from one to eight weeks. In most cases, the brushing technique with frequency from two to 10 Hz was used. In some cases, spot hunting with two or 3 Hz frequency was also used.

Table 3: Treatment parameters for melasma

	Wavelength	Handpiece	Spot size (mm)	Mode	Fluence	Frequency (Hz)
Protocol 1						
Step 1	1064 nm	R28	8	MaQX-2	1.8 J/cm²	6
Step 2	1064 nm	R28	6	MaQX-2	3 J/cm²	6
Step 3	1064 nm	R28	4	MaQX-1	2 J/cm²	10
Protocol 2						
Step 1	1064 nm	R28	8	MaQX-1	1.6 J/cm²	10
Step 2	1064 nm	R28	4 or 6	Frac3	15–20 J/cm²	2–3.5
Step 3	1064 nm	FS20A	9x9	MaQX-1	4.0–7.0 mJ/px	1–2
Protocol 3						
Step 1	1064 nm	R28	8	MaQX-1	1.1 J/cm²	8
Step 2	1064 nm	R28	6	MaQX-1	1.4 J/cm²	8
Step 3	1064 nm	FS20A	9x9	MaQX-1	6 mJ/px	2
Protocol 4						
Step 1	1064 nm	R28	8	MaQX-1	1.6 J/cm²	10
Step 2	1064 nm	R28	6	FRAC3	20 J/cm²	2
Step 3	1064 nm	R28	3	VERSA	160 J/cm²	0.5
Step 4	1064 nm	FS20A	9x9	MaQX-1	4 mJ/px	2
Protocol 5						
Step 1	1064 nm	R28	4 or 8	MaQX-1	6–8 J/cm²	10
Step 2	1064 nm	FS20A	9x9	MaQX-1	1.7–2.5 mJ/px	6–7
Protocol 6						
Step 1	1064 nm	R28	8	MaQX-1	1–2 J/cm²	10
Step 2	1064 nm	R28	6	MaQX-1	1.2–2.6 J/cm²	10
Protocol 7						
Step 1	1064 nm	R28	4–8	MaQX-1	1.4–10 J/cm²	2–10
Protocol 8						
Step 1	1064 nm	FS20A	9x9	MaQX-5	10 mJ/px	1.5
Step 2	1064 nm	FS20A	9x9	MaQX-5	13 mJ/px	1.5
Step 3	1064 nm	FS20A	9x9	MaQX-5	7 mJ/px	1.5
Step 4	1064 nm	R28	4	MaQX-1	1.5 J/cm²	1.5
Protocol 9						
Step 1	1064 nm	FS20A	9x9	MaQX-5	20 mJ/px	1.5
Step 2	1064 nm	R28	4	MaQX-1	1 J/cm²	1.5
Step 3	532 nm	R58	3	VERDE	4 J/cm²	0.5

Fig. 1: Melasma at baseline (a, c) and 12 months after 15 sessions of protocol 7 (b, d). Courtesy of Dr. Hoon Hur.

c) Lentigines, solar lentigines and centrofacial lentiginosis

Out of 12 cases, two were treated with QS 532-nm laser and 10 with QS 1064-nm laser (Table 4). In two cases, a step with long-pulse (VERDE) mode for spot hunting was included in the treatment. In one case, a step with FRAC3 mode over full face was applied (Fig. 2). In two cases, a step with fractional handpiece FS20A was included in one out of seven sessions, one pass over the full face. Fluences applied with full spot and MaQX-1 mode were from 1.2 to 12 J/cm^2. Average clearance was 3.8 and patient satisfaction was 2.9.

Table 4: Treatment parameters for lentigines, solar lentigines and centrofacial lentiginosis.

Protocol	Wavelength	Handpiece	Spot size (mm)	Mode	Fluence	Frequency (Hz)
Protocol 1						
Step 1	1064 nm	R28	3 or 6	MaQX-1	3–11 J/cm^2	3–10
Protocol 2						
Step 1	1064 nm	R28	8	MaQX-1	2 J/cm^2	10
Step 2	1064 nm	R28	6	Frac3	20 J/cm^2	2
Step 3	532 nm	R58	4	VERDE (15 ms)	4 J/cm^2	1
Protocol 3						
Step 1	1064 nm	R28	8	MaQX-1	1.4 J/cm^2	10
Step 2	532 nm	R58	4	VERDE (15 ms)	4.0– 6.0 J/cm^2	1
Step 3	1064 nm	FS20A	9x9	MaQX-1	6 mJ/px	2
Protocol 4						
Step 1	1064 nm	R28	8	MaQX-1	1.2 J/cm^2	10
Step 2	1064 nm	R28	3	MaQX-1	12 J/cm^2	3
Step 3	1064 nm	FS20A	9x9	MaQX-1	5 mJ/px	7
Protocol 5						
Step 1	532 nm	R28 (+white cap)	2	MaQX -5	3 J/cm^2	1
Protocol 6						
Step 1	1064 nm	R28	4	MaQX-1	9–10 J/cm^2	5
Step 2	1064 nm	FS20A	9x9	MaQX-1	5 mJ/px	5

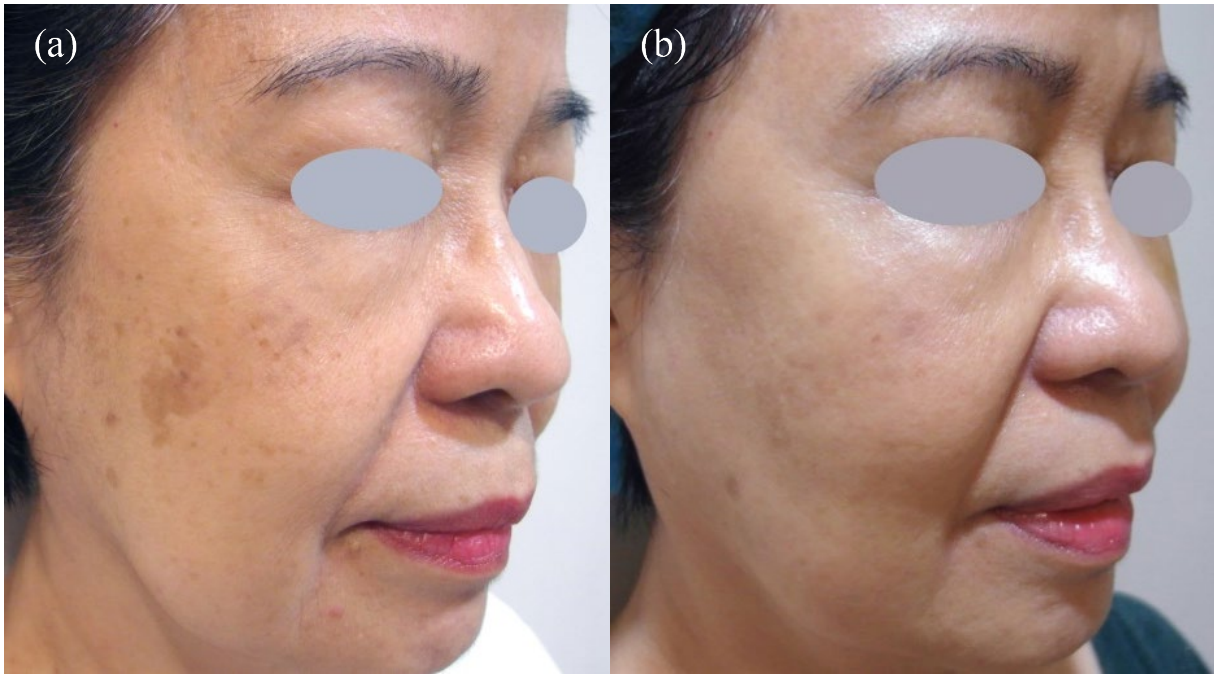

Fig. 2: Solar lentigines at baseline (a) and 1 month after 7 sessions of protocol 2 (b). Courtesy of Dr. Lucas Chia Liang Choong.

d) Freckles

Eight cases of freckles were treated with three different protocols (Fig. 3, Table 5). Where bigger spot sizes (6–8 mm) were used, a brushing technique over the entire lesion area was used. The average clearance level was 3.8 and patient satisfaction was 2.6. The number of sessions ranged from one to 11. A fluence of 3 J/cm^2 was used with 532 nm and from 1.2 to 3 J/cm^2 with 1064 nm. A full spot in the range from 6 to 8 mm was used in all cases.

Table 5: Treatment parameters for freckles

	Wavelength	Handpiece	Spot size (mm)	Mode	Fluence	Frequency (Hz)
Protocol 1						
Step 1	1064 nm	R28	6 or 7	MaQX-1	2.0–2.5 J/cm^2	10
Protocol 2						
Step 1	532 nm	R28 (+ white cap)	2	MaQX-5	3 J/cm^2	1
Protocol 3						
Step 1	1064 nm	R28	8	MaQX-1	1.2 J/cm^2	10
Step 2	1064 nm	R28	6 or 7	MaQX-1	1.4 J/cm^2	10

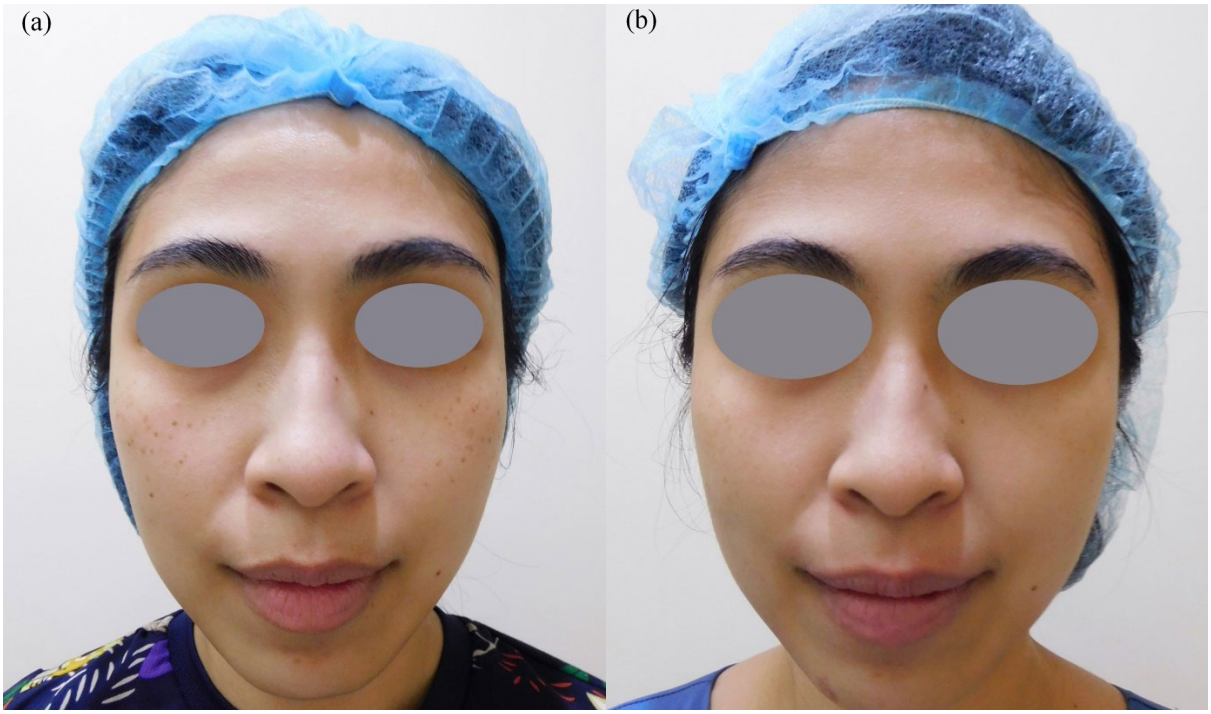

Fig. 3: Freckles at baseline (a) and 1 month after 5 sessions of protocol 1 (b). Courtesy of Dr. Lucas Chia Liang Choong.

e) Post-inflammatory hyperpigmentation (PIH)

The protocols for treatment of PIH are presented in Table 6. The average clinical level of clearance of four treated patients was 4 and the average patient satisfaction was 2.5 (Fig. 4). Between 3–7 sessions were performed; in 4 out of 6–7 sessions, a step with 532 nm was performed. In two cases, a step of one pass with 532 nm and 0.3 J/cm² was used to treat the darkest areas of PIH.

Table 6: Treatment parameters for post-inflammatory hyperpigmentation

	Wavelength	Handpiece	Spot size (mm)	Mode	Fluence	Frequency (Hz)
Protocol 1						
Step 1	1064 nm	R28	8	MaQX -2	1.8 J/cm²	6
Step 2	1064 nm	R28	6	MaQX -2	3 J/cm²	6
Step 3	1064 nm	R28	4	MaQX -1	2 J/cm²	10
Protocol 2						
Step 1	1064 nm	R28	8	MaQX -1	2 J/cm²	2
Step 2	532 nm	R28	8	MaQX -1	0.3 J/cm²	1
Protocol 3						
Step 1	1064 nm	R28	6	MaQX -1	2 J/cm²	2
Step 2	1064 nm	R28	8	MaQX -1	2 J/cm²	2
Step 3	532 nm	R28	8	MaQX -1	0.3 J/cm²	1

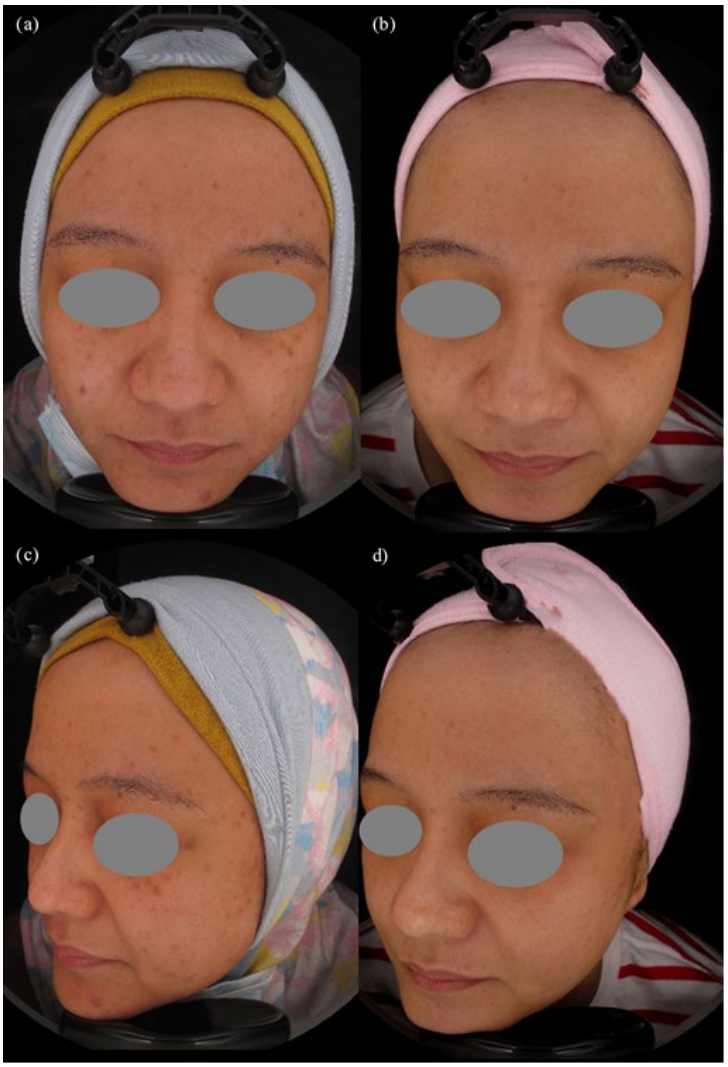

Fig. 4: PIH at baseline (a, c) and 3 weeks after 3 sessions of protocol 1 (b, d). Courtesy of Dr. Nazelia Thibroni & Dr. Ku Shahira.

f) Hori's nevus

One-, two-or four-step protocols were used on six cases of Hori's nevus (Fig. 5, Table 7). The average clearance level was 3.8 and patient satisfaction was 3. In the four-step protocol, the FS20A fractional handpiece was used with one step in five out of ten sessions for full-face irradiation. A full spot in the range from 4 to 8 mm was used. Fluence ranged from 1.6 to 6.5 J/cm². Fluences 3 J/cm² or higher were used for spot hunting and 2 J/cm² or lower for full-face irradiation. The number of sessions was between 5 and 16.

Table 7: Treatment parameters for Hori's nevus

	Wavelength	Handpiece	Spot size (mm)	Mode	Fluence	Frequency (Hz)
Protocol 1						
Step 1	1064 nm	R28	4	MaQX-1	4.5 J/cm²	2
Protocol 2						
Step 1	1064 nm	R28	8	MaQX-1	1.3 J/cm²	10
Step 2	1064 nm	R28	7	MaQX-1	3.0 J/cm²	10
Protocol 3						
Step 1	1064 nm	R28	8	MaQX-1	1.6 J/cm²	10
Step 2	1064 nm	R28	7	MaQX-1	2 J/cm²	10
Step 3	1064 nm	R28	4	MaQX-1	5-6.5 J/cm²	5
Step 4	1064 nm	FS20A	9x9	MaQX-1	4.0 mJ/px	2

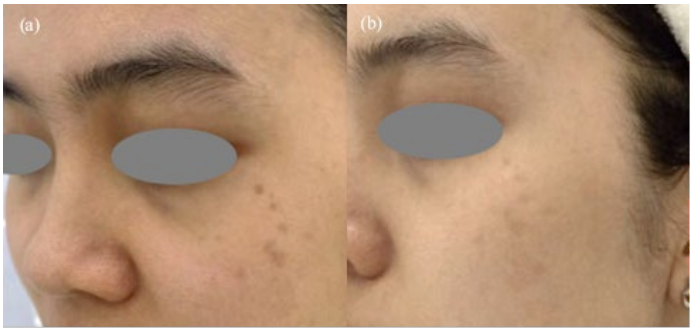

Fig. 5: Hori's nevus at baseline (a) and 12 months after 10 session of protocol 1 (b). Courtesy of Dr. Pham Minh Truong.

g) Nevus of Ota

Three cases of Nevus of Ota showed on average a clearance level of 3 and patient satisfaction of 2.7 (Table 8). One case was treated in 30 sessions with a one week interval, one with 8 sessions with 1–2 months interval and one case was treated in one session (Fig. 6).

Table 8: Treatment parameters for Nevus of Ota

	Wavelength	Handpiece	Spot size (mm)	Mode	Fluence	Frequency (Hz)
Protocol 1						
Step 1	1064 nm	R28	3–7	MaQX-1	2.2–9 J/cm²	10

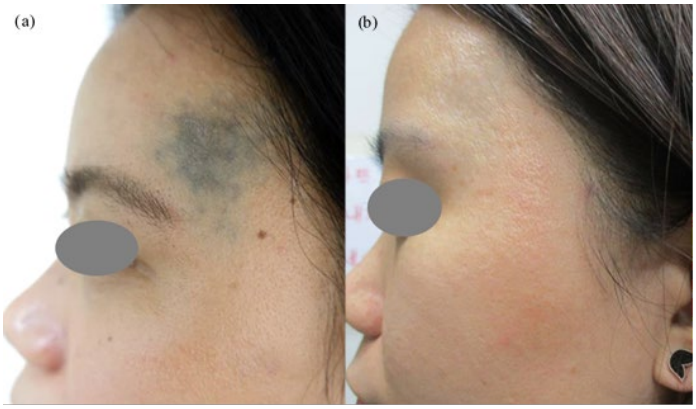

Fig. 6: Nevus of Ota at baseline (a) and 12 months after 30 sessions (b). Courtesy of Dr. Hoon Hur.

h) Dark lips

One case of dark lips was treated with a two-step protocol: in the first step with FRAC3 and 12 J/cm² and in second with MaQX-5 and 3 J/cm² (Fig. 7, Table 9). 4 sessions were performed. Clearance was 3 and patient satisfaction was 2.

Table 9: Treatment parameters for dark lips

	Wavelength	Handpiece	Spot size (mm)	Mode	Fluence	Frequency (Hz)
Protocol 1						
Step 1	1064 nm	R28	4	FRAC3	12 J/cm²	3
Step 2	1064 nm	R28	5	MaQX-1	3 J/cm²	4

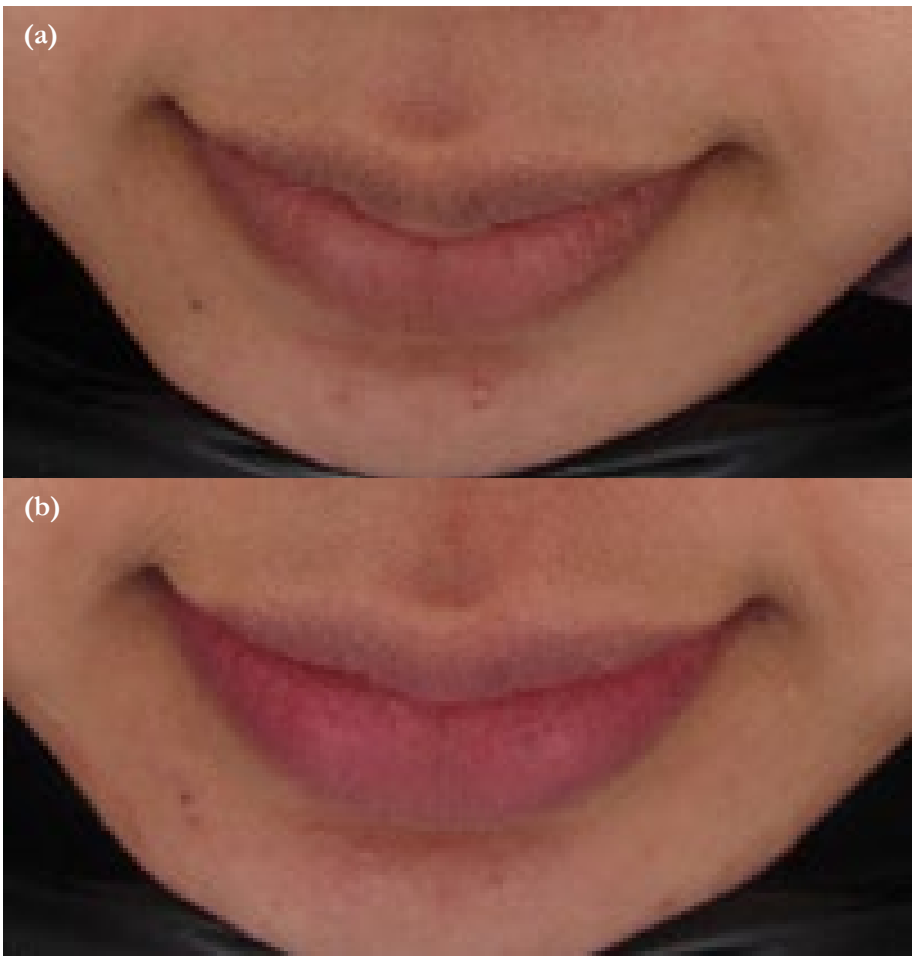

Fig. 7: Dark lips at baseline (A) and 1 month after the second session (B). Courtesy of Dr. Nazelia Thibroni & Dr. Ku Shahira.

i) Café au Lait spot

A case with Café au Lait spot had two treatment sessions (Fig. 8, Table 10). Clearance was rated 3 and patient satisfaction was 3.

Table 10: Treatment parameters for Café au Lait

	Wavelength	Handpiece	Spot size (mm)	Mode	Fluence	Frequency (Hz)
Protocol 1						
Step 1	532 nm	R28	6	MaQX-1	0.6–0.7 J/cm²	3

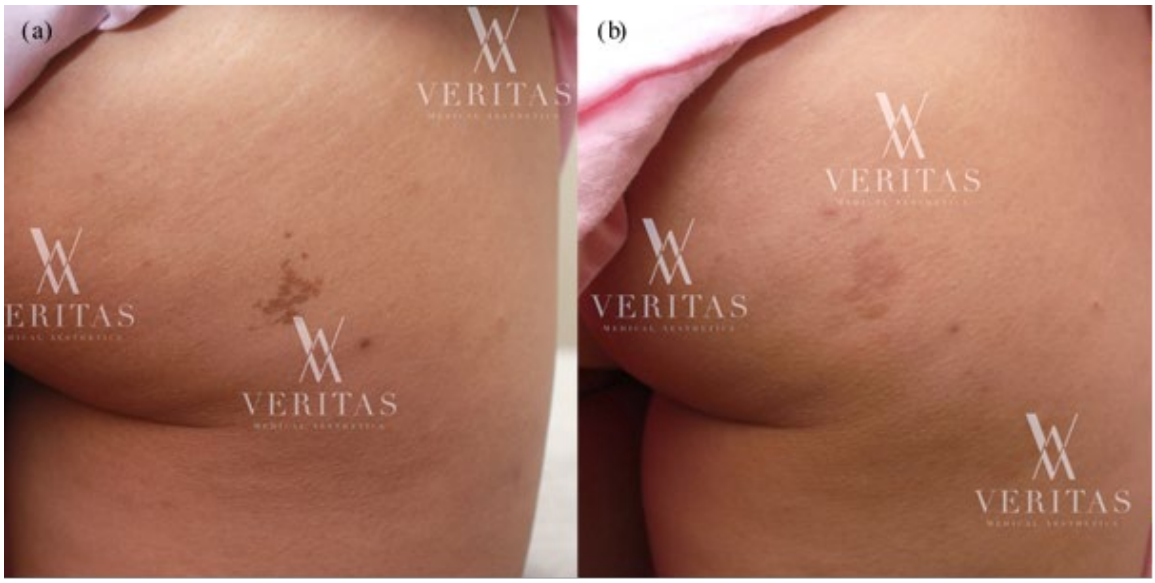

Fig. 8: Café au lait at baseline (a) and 1 month after 2 sessions (b). Courtesy of Dr. Lena Fan.

j) Acanthosis nigricans

A case with Acanthosis nigricans was treated with a three-step protocol in 6 sessions (Fig. 9, Table 11). Clearance was 3 and patient satisfaction was 3.

Table 11: Treatment parameters for Acanthosis nigricans

	Wavelength	Handpiece	Spot size	Mode	Fluence	Frequency
Protocol 1						
Step 1	1064 nm	R28	8 mm	MaQX-1	1.4 J/cm²	10 Hz
Step 2	1064 nm	R28	6 mm	MaQX-1	2.4 J/cm²	10 Hz
Step 3	1064 nm	FS20A	9x9 mm	MaQX-1	7.5 mJ/px	5 Hz

Fig. 9: Acanthosis nigricans at baseline (a) and 1 month after 6 sessions (b). Courtesy of Dr. Lena Fan.

k) Multiple lesions

This category included cases in which one set of parameters was used for various indications (Table 12). Three cases were treated for melasma and lentigines (Fig. 10) with overlapping parameters, two cases for pigmentation and scars, and one with melasma and PIH.

Table 12: Treatment parameters for combinational treatment of multiple lesions

	Wavelength	Handpiece	Spot size (mm)	Mode	Fluence	Frequency (Hz)
Melasma + solar lentigines or lentigines						
Protocol 1						
Step 1	1064 nm	R28	8	MaQX-1	1.4 J/cm²	10
Step 2	1064 nm	R28	4	Frac3	15 J/cm²	3.5
Protocol 2						
Step 1	1064 nm	R28	8	MaQX-1	1.2 J/cm²	10
Step 2	1064 nm	R28	6	MaQX-1	1.8 J/cm²	10
Protocol 3						
Step 1	1064 nm	R28	8	MaQX-1	1.2–1.6 J/cm²	10
Step 2	1064 nm	R28	6	MaQX-1	2.6 J/cm²	10
Step 3	1064 nm	FS20A	9x9	MaQX-1	5 mJ/px	7
Pigmentations + scars						
Protocol 1						
Step 1	1064 nm	R28	4	MaQX-1	5–6 J/cm²	10
Protocol 2						
Step 1	1064 nm	R28	4	MaQX-1	4–6 J/cm²	10
Step 2	1064 nm	FS20A	9x9	MaQX-1	4.5 mJ/px	6
Step 3	1064 nm	FS20A	9x9	MaQX-2	5.5 mJ/px	6
Melasma + PIH						
Protocol 1						
Step 1	1064 nm	R28	5	MaQX-1	2 J/cm²	2

Fig. 3: Example of patient with melasma and solar lentigines; baseline (a) and 2 weeks after 11 sessions of protocol 2 (b) for melasma + solar lentigines. Courtesy of Dr. Lucas Chia Liang Choong.

l) Safety

Side effects were minimal and short term. 13 out of 72 patients (18.1%) observed no side effects. The most common side effect was post-treatment erythema, which was observed in 48 patients (66.7%). The overall duration of erythema ranged from five minutes to four days. Scabbing was observed in eight patients (11.1%) and in most cases appeared after treatment with the FS20A fractional handpiece. The scabbing lasted up to seven days. Edema appeared in seven patients (9.7%) and resolved within 72 hours after treatment. Other observed side effects included discomfort, petechiae, burning sensation, dry skin, darkening of pigmented lesions and bleeding (Table 13). All side effects resolved without complications.

Table 13: Frequency of side effects.

Side effect	No. of patients	% of patients
Erythema	48	66.7
Scabbing	8	11.1
Edema	7	9.7
Discomfort	5	6.9
Petechiea	3	4.2
Transient hyperpigmentation	2	2.8
Burning sensation	1	1.4
Dry skin	1	1.4

IV. DISCUSSION

Laser treatment of pigmented skin lesions in patients with darker Fitzpatrick skin types remains challenging, as the highly melanized epidermis contains melanosomes which are larger and nonaggregated[11]. Higher melanin content can better absorb the laser energy and induce thermal injury in neighboring structures. This can result in increased risk of unwanted side effects, such as post-inflammatory hyper-pigmentation (PIH) and scarring if the parameters are not carefully chosen. Melanin in darker skin also acts as a competitive chromophore that absorbs laser energy intended for the treatment of target pigmented lesions, reducing the treatment efficacy. In treating patients with darker Fitzpatrick skin types, unique laser parameters with longer wavelengths, lower treatment fluences and the use of epidermal cooling devices have been shown to reduce the risk of complications[11].

Our case series presents a unique insight into the clinical practice of QS laser treatment of various pigmented lesions in patients with Asian skin types. The presented protocols have been shown clinically effective, with high patient satisfaction and minimal side effects.

The most commonly treated indication among the participating centers was melasma. Although there are still many challenges in the treatment of melasma, laser treatment alone or in combination has shown efficacy in the treatment of this condition[12–14].

Recently there has been increased effort to raise awareness of skin conditions like melasma, particularly in the Asian population[6]. In Asia, laser toning is commonly performed for treating melasma[15]. Although the exact mechanism by which laser toning improves melasma is still unclear, it has been proposed that by delivering repetitive laser energy with sub-photothermolytic fluence (<5 J/cm^2) over a large spot size, melanin granules are fragmented and dispersed into the cytoplasm without cellular destruction. The term "subcellular selective photothermolysis (SSP)" has been proposed to describe the mechanism for improvement of melasma with laser toning[16]. Some early experiences on laser toning for skin rejuvenation demonstrated good clinical efficacy without any significant complications.

As shown in this case series, there appears to be a wide variation in the treatment protocols for melasma used in clinical practice. Regardless of the protocol, the patients achieved a good degree of clearance, as clinically evaluated by the treating physician. 93.3% of patients with melasma achieved more than 50% of clearance at the last follow-up. In all cases, patients were at least "satisfied" with the treatment, except in one case where a temporary darkening of the lesion was observed and the patient was "somehow satisfied". Due to the heterogeneity of the protocol, further quantitative analysis was not possible. Nevertheless, the results suggest that several sessions are likely to be needed for full results. Nine cases with melasma had a follow-up at 6 months or later (up to 12 months follow-up) and none of the cases reported a recurrence of

melasma. Most often the brushing technique was used, with an occasional addition of spot hunting steps.

In order to address different physiological mechanisms that are involved in melasma and to maximize the results, a multi-step treatment should ideally be performed. Recently, a new four-step Fotona laser protocol for treating melasma has shown high effectiveness in Latin patients[14]. Each step has been developed to target the complexity of melasma. In the first step, QS Nd:YAG 1064-nm is applied with the purpose to treat the melanocyte, the final effector of the most known symptom in melasma, the pigmentation. The second step with Nd:YAG FRAC3 pulses modulates inflammation and increases the production of collagen. The third step involves the use of a fractional handpiece (FS20A) and specific parameters designed both to further reduce the hyperpigmentation and induce skin remodeling. Both the second and third steps result in a rejuvenation effect. The fourth step with FRAC3 or VERSA pulses is applied to treat the vascular component of melasma.

In a study by Yue 2016[17], the advantages of fractional mode QS 1064-nm Nd:YAG were combined with those of large-spot/low-fluence QS 1064-nm Nd:YAG laser treatment in the hope of achieving prolonged improvement. Multiple scanning passes in each session and multiple treatment sessions were required to achieve the desired clinical outcomes, as we also observed in this case series.

Lentigines were the second-most treated pigmented lesions in this case series. They are extremely common hyperpigmented macules that most often result from chronic sun exposure[18]. They contain melanin within keratinocytes and melanocytes[19]. Histologically, melanocytes in the basal layer are increased in number without nesting and rete ridges are elongated[20]. There was a great variation of protocols used for treatment of lentigines in our case series. All cases (100%) in this study achieved more than 50% of clearance. All patients were "very satisfied" or "satisfied" with the results. Three cases had follow-up longer than 9 months (up to 24 months). Laser application with spot hunting or brushing or a combination of both was used. In two cases a long-pulsed step was used with a focus on lentigines. Three protocols included a step with a fractional handpiece. Previously, a study by Bohnert at al. 2018[21] showed superior results when a dual laser treatment (QS 1064 nm and 532 nm) was used. Low-fluence QS 1064-nm Nd:YAG laser has also been reported to effectively treat partial unilateral lentiginosis in Koreans[22] with no significant side effects. Similar results were achieved for senile lentigines[23].

Freckles were treated with three different protocols, one used only 532-nm QS laser. All of eight patients achieved at least 50% of clearance. Up to 11 sessions were applied with up to 10 passes. Only minimal erythema was reported in some cases after treatment.

PIH is commonly caused by an inflammatory process, such as eczema, acne, trauma, or cosmetic procedures. And among many types of PIH treatment, QS 1064-nm Nd:YAG laser has continually been shown to be effective for this purpose[24–27]. Cases with PIH in this study, which were mostly due to acne, also responded very well to laser therapy. Clearance higher than 76% in all cases was achieved in 3–7 sessions with 4-week intervals in ordered to allow time for maximal healing and lightening. Unfortunately, there was no long follow-up case to confirm the longevity of treatment success.

A high clearance rate was achieved in all cases with Hori's nevus which persisted for up to 12 months. The median number of session was 10 (range 5-16), which is similar to a previous report by Cho S.B et al.[28] As reported by Ee HL et al.[29] a combination with QS 532-nm might further improve clinical outcomes and can be particularly effective in preventing recurrence.

QS 1064-nm Nd:YAG has commonly been used for treating Nevus of Ota and has achieved considerable results[30–35].Three cases in this study were treated with a varied number of sessions and also achieved various levels of clearance. The best clearance was achieved using a protocol with 30 sessions, lower fluence and a 3-second pulse-stacking technique. The outcome persisted after 12-months of follow up. The results support a study with a similar protocol used, where 12 patients with Ota's Nevus achieved complete clearance with no significant side effects[36].

Tailoring the treatment to the specific skin type and patient is the key. The present paper provides the reader with a variety of specific protocols with an excellent safety profile that have been successfully used to resolve the most common pigmented lesions in the Asian population.

CONFLICT OF INTEREST

We declare that two of the authors (JV, ZV) are currently also affiliated with Fotona d.o.o.

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