Intense Pulsed Light for the Treatment of Facial Freckles in Asian Skin

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BACKGROUND. Freckles are melanotic lesions frequently seen on the face and other sun-exposed areas. Previously evaluation of the severity of freckles has relied on the ultimately subjective assessment of the doctor or patient. Intense pulsed light (IPL) is newly introduced to treat facial freckles in Asian skin.

OBJECTIVE. To determine the effectiveness of IPL treatment for Asian patients with freckled skin and to assess a new and objective method for evaluation of the severity of freckling and post-therapy improvement using an ultraviolet (UV)-sensitive camera and film.

METHODS. Thirty-six patients with freckles were enlisted. IPL treatment was administered to patients with freckles in 4-week sessions. Irradiation wavelength was controlled using cutoff filters ranging from 550 to 590 nm, with a fluence of 25–35 J/cm^2, with single- or double-pulse illumination and a pulse width of 4.0 msec. The assessments of the physician and patient were compared with the objective dermatologic evaluation with black-and-white and UV photography used to derive two treatment parameters, cosmetic density of freckles (CDF) and freckles area and severity index (FASI), which are applicable in a clinical setting.

RESULTS. By the end of the study, two attending physicians assessed the results for 86.1% of the subjects as excellent or good, with 91.7% of the patients reporting that they were extremely or very satisfied. A statistically significant improvement in mean FASI score was demonstrated at 6 months after treatment compared with baseline ($n = 36$, $p < .005$; paired t-test). Mean overall improvement rate ($n = 36$), as determined from the difference in mean FASI score, was 63% at 12 weeks and 58% at 6 months.

CONCLUSION. IPL is an effective and safe treatment for facial freckles in Asian skin, with relatively few adverse effects and high satisfaction levels.

Y.-L. HUANG, MD, Y.-L. LIAO, MD, S.-H. LEE, MD, AND H.-S. HONG, MD, PHD HAVE INDICATED NO SIGNIFICANT INTEREST WITH COMMERCIAL SUPPORTERS.

FRECKLES, OR ephelides, are light-brown macules most frequently observed in fair and red-haired individuals, however, they are also common to Asian people.[1] Histopathologically freckles reveal epidermal melanosis.[2] Treatment may be requested for cosmetic reasons. Before the advent of lasers, however, the traditional treatment and preventive modalities for freckles included sun protection, covering the skin with makeup, chemical bleaching and peeling, dermabrasion, and electrodesiccation/fulguration. More recently it has been reported that freckles respond completely and quickly to the Q-switched 532 nm Nd:YAG, Q-switched alexandrite, and Q-switched ruby lasers.[3–5] The skin types of Asian people are almost exclusively type III–V, and the most important consideration with respect to the use of laser therapy for these skin types is pigment changes, such as hypopigmentation or postinflammatory hyperpigmentation.[6] Intense pulsed light (IPL) is a noncoherent, filtered, broad-spectrum light (500–1200 nm) emitted from a pulsed flashlamp. We used IPL as an effective and safe freckle treatment for Asian patients. Further, we designed a novel, objective method for evaluation and quantification of the severity of freckling.

Materials and Methods

Patients

Seventeen Taiwanese patients with freckles who presented at the Department of Dermatology, Chang Gung Memorial Hospital, Taipei, Taiwan, were enrolled in this study. All the patients were women ranging in age from 20 to 60 years (mean 35.2 years), and the skin phototypes were type III or IV ($n = 18$ and $n = 18$, respectively). None of the patients had undergone other laser treatment or used any chemical bleaching or peeling products before, however, sunscreen had been used on a regular basis. Informed consent was obtained from each patient and our study was approved by the Medical Ethic and Human Research Committee of Chang Gung Memorial Hospital.

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Equipment

The Vasculight (ESC/Sharplan, Yokneam, Israel), a light emission apparatus of the IPL family, was used for all treatments.

Exposure Method and Parameters

IPL treatment was administered for 36 freckled outpatients using cutoff filters of 550–590 nm, with fluences of 25–35 J/cm^2, single or double-pulse illumination, between-pulse intervals of 20.0 or 40.0 msec, and a pulse width of 4.0 msec. The cutoff filters and fluences utilized in this study were arbitrarily selected from those detailed in analogous reports.[10,11,13,18] A chilled, colorless ultrasonic gel was applied directly to the light guide of the filter prior to application to the skin. The filter was kept parallel to and at about 2–3 mm from the skin, with the gel layer between the filter and skin to prevent overexposure, purpura, or blister formation. Perilesional erythema with graying and/or darkening of freckles are the three indicators that treatment is complete and, in this study, the irradiation was concluded when these appeared. Duration for the procedure was in the range of 10–15 minutes.

Where more than one session was required, treatments were administered at 4-week intervals under a doctor's supervision. All of the affected areas of the face, including the lower eyelids but excluding the upper, were treated at every session. The patients were asked to return for regular follow-ups at 2-week intervals for 6 months. All patients were treated without topical or local anesthesia, with no postoperative wounds requiring topical antibiotics or dressings noted a little later after treatment. Patients were advised to use sunscreen products daily. Patients requiring one, two, or three sessions of IPL therapy were assigned to session 1, 2, and 3 groups (n = 21, 13, and 2, respectively).

Evaluation Methods

Before and after treatment, the results were evaluated on five- and four-point scales by both the patients and the two attending physicians at 2-week intervals. The physician's scale consisted of a qualitative assessment combined with an estimate of percentage improvement as follows: excellent, 76–100%; good, 51–75%; fair, 26–50%; poor, 0–25%. In addition, all patients completed a questionnaire using a grading system to assess subjective satisfaction as follows: extremely satisfied, very satisfied, satisfied, slightly satisfied, not satisfied.

Color and black-and-white photographs and UV exposures of all patients enrolled in our study were taken at each visit. The conventional and UV images were taken using a UV-sensitive camera on a fixed-stage table with standard film (400 ASA) under the same conditions (light source, dark room, and camera) with and without the use of a UV filter. On the UV film, the hue of the epidermal melanotic hyperpigmentation was enhanced, as in Wood's light examination (Figure 1).[19]

Three parameters are proposed as the most important determinants of cosmetic outcome: the darkness of the freckles and resultant contrast with the facial skin, the extension and distribution of the macules, and the density of the freckles (number per unit facial area). Two measures/indicators, "cosmetic density of freckles" and "freckles area and severity index", were derived using the following considerations, criteria, and equations.

Contrast: the darkness of the freckles was assessed on a five-point gray scale (0, 1, 2, 3, 4) based on a comparison with the shading of specific facial features as determined from a regular photograph. The contrast referents were the skin, 0 points; a shade midway between that of the skin and the shadow of the nasolabial fold, 1 point; the shadow of the nasolabial fold, 2 points; a shade midway between the nasolabial fold shadow and the eyebrows, 3 points; the eyebrows, 4 points.

Area: the extension and distribution of freckles was defined within nine facial areas (R1, L1, R2, L2, N3, R4, L4, O5, and C6) based on the concept of the six facial cosmetic units (Figure 1). The number of the involved areas was scored from 1 to 9 points.

Density: It is difficult to count all the macules on the face of a patient with freckles. The more critical distribution areas are the bilateral cheeks (R4 and L4) and nasal ridge (N3), which impact cosmetic outcome more significantly. Thus the number of macules per square centimeter on R4, L4, and N3 on the UV photograph was used to derive the number of freckles per unit area (Figure 1), with the following formulas:

$$\text{Cosmetic density of freckles (CDF)} = (R_4 + L_4 + N_3)/3$$

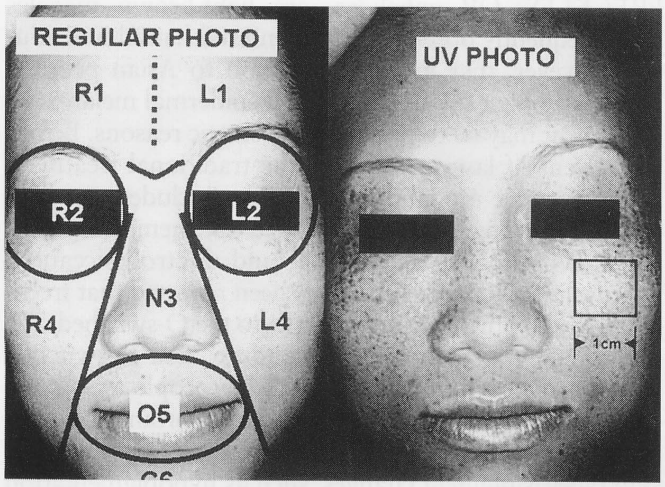

Figure 1. Regular photograph: The distribution of freckles on the face into nine areas (R1, L1, R2, L2, N3, R4, L4, O5, and C6) based on the concept of six cosmetic units. The darkness of the freckles is defined on a five-point gray scale (0–4) on a conventional photograph. UV photograph: The hue of the freckles is enhanced on the UV film. The number of freckles is counted on three 1 cm^2 areas on R4, L4, and N3 and the cosmetic density of freckles is calculated using the equation: CDF = $(R_4 + L_4 + N_3)/3$.

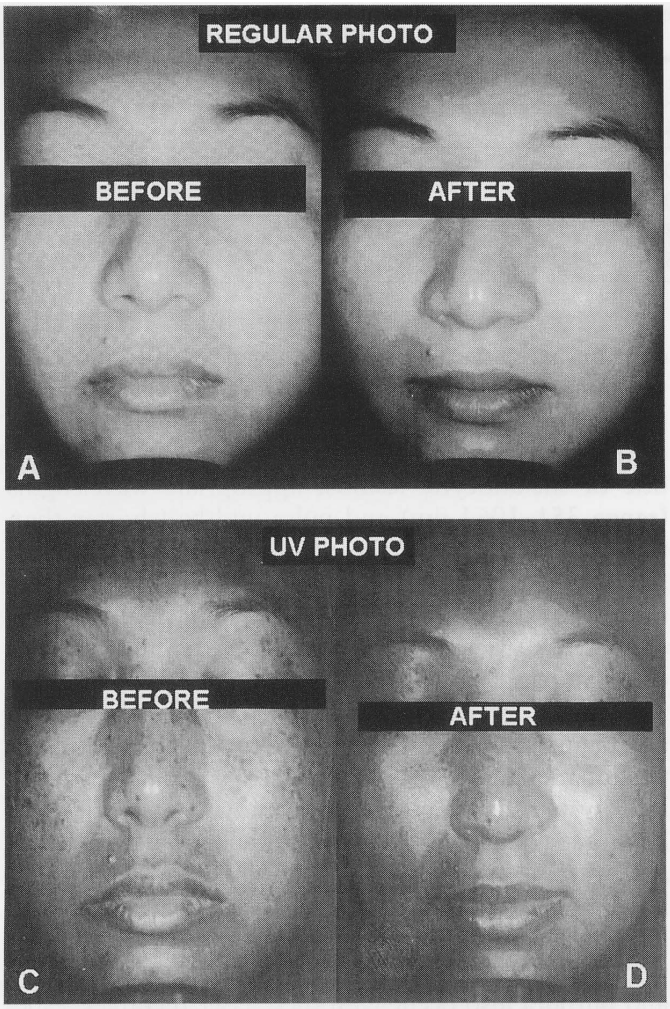

Figure 2. A,B) Regular and C,D) UV photographs of patient 10 were taken before and after IPL treatment. The patient shows marked improvement of facial freckles B) after one session of IPL treatment at 12 weeks, with improvement more apparent on D) the UV image.

Freckles area and severity index (FASI) = contrast + area + density (CDF)

Improvement rate at time of evaluation = $(FASI_{pretreat} - FASI_{posttreat})/FASI_{pretreat}$

Thus the severity of freckling and improvement after treatment can be measured objectively from a comparison of FASI score.

Table 1. Grading System of Freckles Lightening and Posttherapy Improvement Assessed by Physician (n = 36)

Grade and percent clearance	*Number of patients (%) at 12 weeks*	*Number of patients (%) at 6 months*
Excellent, 76–100%	15 (41.7%)	8 (22.2%)
Good, 51–75%	17 (47.2%)	23 (63.9%)
Fair, 26–50%	4 (11.1%)	5 (13.9%)
Poor, 0–25%	0 (0%)	0 (0%)

Table 2. Grading System of Freckles Lightening and Posttherapy Improvement Assessed by Patients (n = 36)

Grade	*Number of patients (%) at 6 months*
Extremely satisfied	9 (25.0%)
Very satisfied	24 (66.7%)
Satisfied	2 (5.6%)
Slightly satisfied	1 (2.7%)
Not satisfied	0 (%)

Results

A total of 36 subjects completed the treatment course and the cosmetic self-evaluation questionnaire. The mean number of treatments was 1.47. Both patients and physicians assessed the results of the evaluations and ratings. There was excellent to complete resolution of the irradiated sites after one to three treatments for all patients (Figure 2). Further, the excellent/good level was achieved for 86.1% of the patients at the end point of the study, as assessed by the physician's evaluation (Table 1). The irradiated freckles were generally cleared to the patient's satisfaction, with 91.7% of the individuals reporting that they were extremely or very satisfied (Table 2). In order to achieve the excellent/good level of freckle clearance as assessed by the physician's evaluation, patients required one-to-two sessions of treatment, with an overall mean of 1.45 sessions recorded for the sample population (n = 29) (Table 3).

The FASI was used to evaluate the severity and improvement of freckling after IPL treatment, and the results are summarized in Table 4 and Figure 3. The mean FASI prior to the treatment of the group of session 1 (patients required one session of treatment, n = 21) was lower than for the other groups (patients required two or three sessions of treatment, n = 13 or n = 2). Comparing freckle resolution after treatment, the mean FASI for all groups (sessions 1, 2, and 3) was decreased at the 2nd, 6th, and 10th weeks in comparison to baseline with a downward slope revealed (especially the lines of "sessions 3" and "total") for the FASI plot at these time points (Figure 3). The most obvious improvement was demonstrated at the end of

Table 3. Number of Treatment Sessions to Reach the Level of Excellent or Good

Session	*Number of patients (%) at 6 months*
Group 1, treat once (n = 21)	16 (76.2%)
Group 2, treat twice (n = 13)	13 (100.0%)
Group 3, treat triple (n = 2)	2 (100.0%)
Total (n = 36)	31 (86.1%)

Table 4. Mean "Freckles Area and Severity Index" (FASI) Score for Different Session Groups at Different Posttreatment Intervals (See Figure 3)

	Mean Freckles Area and Severity Index (FASI)							
Session	*Pretreat*	*2 weeks*	*4 weeks*	*6 weeks*	*8 weeks*	*10 weeks*	*12 weeks*	*6 months*
1 (n = 21)	54.40	16.62	20.97	22.20	23.33	24.28	26.03	28.50
2 (n = 13)	70.52	19.41	28.57	16.00	15.75	17.33	18.85	22.78
3 (n = 2)	144.67	68.67	96.33	57.33	98.67	48.67	53.33	64.33
Total (n = 36)	67.29	20.99	28.97	21.35	24.19	22.44	24.25	27.91

the second week after treatment, with the lower mean FASI maintained for 6 months (Table 4 and Figure 3). Statistically significant differences were demonstrated comparing mean FASI before treatment and at 6 months after treatment ($P < .005$, paired t-test). Total mean improvement rate, calculated using the mean FASI for each session group, was 63% at 12 weeks and 58% at 24 weeks (Table 5).

One case of hypopigmentation was noted, however, it resolved within 1 month without other additional treatment. Further, no wound infection or scarring formation was noted. Erythema and pain during and after treatment were transient, disappearing after 1 or 2 days. All evidence of crusted facial lesions had disappeared within 1 week.

Discussion

Intense pulsed light sources emit in the 500–1200 nm range and allow variation of pulse length and mode, between-pulse delay, and fluence. This permits the implementation of a wide range of treatment parameters, allowing hair removal,[7] treatment of vascular lesions,[8,9] photorejuvenation,[10,11] and, in theory, removal of either superficial or deep melanocytic lesions.[12,13] Treatment of freckles using IPL has also been reported.[13] Superficial pigmented lesions such as freckles, lentigines, and seborrheic keratoses respond to a variety of pulsed and continuous wave lasers. The target for IPL and laser treatment of melanocytic or melanotic lesions is the melanosome, a natural chromophore of the skin. In order to achieve selective photothermolysis of melanotic or melanocytic lesions, appropriate wavelengths (range 351–1064 nm) and pulse widths (shorter than the melanosome thermal relaxation time of 70–250 nsec) are needed.[14–17] Freckles respond completely and quickly to the Q-switched 532 nm Nd:YAG, Q-switched alexandrite, and Q-switched ruby lasers.[3–5] As the skin types of Asian people are almost always type III–V, the most important considerations for laser therapy of Asian skin are pigmented changes, such as hypopigmentation or postinflammatory hyperpigmentation.[6] All Q-switched laser systems, such as ruby, alexandrite, and Nd:YAG, have been reported to cause both hypopigmentation and, rarely, hyperpigmentation.[3,20] Postinflammatory hyperpigmentation occurs in up to 8% of patients with 532 nm Nd:YAG lasers and occurs more often in darker skin types.[20,21] Further, tissue splatter, punctate bleeding, and purpura also occur with these laser therapies, especially when used at high fluences on deeply pigmented lesions or in patients taking aspirin or anticoagulants.[20,22,23] Pain and postoperative bleeding have been reported to be greater with the 532 nm Nd:YAG laser than with the ruby laser.[24] Thus IPL is an effective, safe, and rapid treatment for facial freckles in Asian skin.

IPL sources permit utilization of cutoff filters at wavelengths as low as 515 nm, fluences of 20–24 J/cm^2, and single-/double-pulse durations of 2–4 msec, effectively eliminating discrete superficial melanin pigmentations such as those which characterize poikiloderma of Civatte.[18] IPL, with a 590 nm cutoff filter, may also remove superficial and deep melanin pigmentation (spilus nevus).[12] Moreno

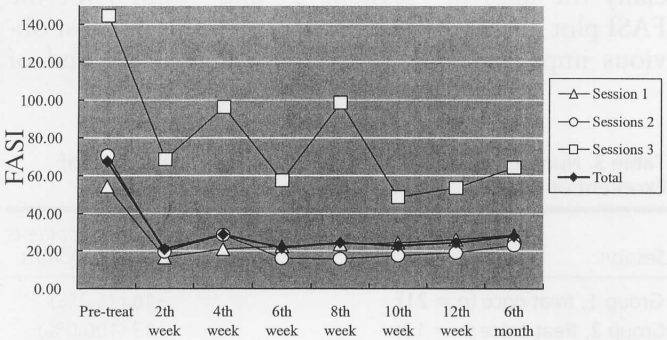

Figure 3. Mean FASI for different session groups at different posttreatment intervals.

Table 5. Mean Improvement Rate Calculated From the Mean FASI at Different Time of Evaluation

Session	*Mean improvement rate at 12 weeks*	*Mean improvement rate at 6 months*
1 (n = 21)	51%	47%
2 (n = 13)	73%	67%
3 (n = 2)	63%	55%
Total (n = 36)	63%	58%

Arias and Ferrando[13] have reported IPL treatment at 4-week intervals for three patients with freckles using a 590 nm cutoff filter, fluence of 34 J/cm^2, double-pulse duration of 3.8 msec, and delay time of 20 msec. A clearance rate of 76–100% was achieved after two treatment sessions. Noninvasive rejuvenation of photodamaged skin using serial, full-face IPL treatments has been reported by Bitter.[10] Thereafter IPL photorejuvenation for Asian skin was reported using 550/570 nm cutoff filters, fluences of 28–32 J/cm^2, and delay times of 20.0/40.0 msec, with excellent or good results for resolution of pigmented lesions achieved for more than 90% of the sample population of 97 patients.[11] Further, few or no adverse effects were noted for superficial pigmented lesions treated with IPL during and after treatment in the above studies.

IPL has been used to treat facial freckles in Asian people using the following treatment parameters: cutoff filters of 550–590 nm, fluences of 25–35 J/cm^2, single- or double-pulse delivery, between-pulse delay of 20.0/40.0 msec, and pulse width of 4.0 msec. Excellent or good results were achieved for 86.1% of patients by the end of our study (at 6 months) as determined by the evaluation of the attending physician; in addition, the irradiated freckles were generally cleared to the patient's satisfaction, with 91.7% reporting that they were extremely or very satisfied. Further, a mean of only 1.47 sessions was required, consistent with the results of previous, related studies.[10,13] In Negishi et al.'s work,[11] they used similar parameters of IPL for full-face rejuvenation in Asian skin with three to six treatment sessions. Fewer treatment sessions were needed in our series because we use IPL for facial freckles not for "pigmented lesions." "Pigmented lesions" may include freckles, solar lentigo, Ota's nevus, and melasma. Melasma needs more sessions (about four sessions) of IPL treatment than freckles, as was also reported in a previous study.[13]

To evaluate improvement in earlier studies, self-report questionnaires were used by patients and photographs were used by physicians, however, these methods are ultimately too subjective to permit any meaningful quantification of improvement. Publication bias of physicians and bias of patients with self-evaluation are impossible to eliminate. In our study, a novel method was used to more objectively and quantifiably evaluate the severity of and improvement in freckling using a derivation of the FASI. This assessment parameter is based on the three most important cosmetic factors, the hue of the freckles, their density, and the area of distribution. Derivation of this parameter permits intra- and interindividual comparison and allows observation of the dynamic changes in the severity of freckles over time and with various treatment protocols. For our study, the mean FASI for different session groups at different post-treatment intervals are presented in Figure 3. In summary, irrespective of the number of sessions, the best response was noted at about 2 weeks after commencement of treatment, with the response maintained for at least 6 months. More treatment sessions were required for patients with a poor initial FASI assessment (Table 4 and Figure 3). A statistically significant improvement was demonstrated at 6 months after treatment in comparison to baseline FASI ($P < .005$, paired t-test), supporting the proposition that IPL therapy is an efficacious treatment for freckles. Mean overall improvement rate, calculated from the mean FASI for each session group, was 63% during week 12 and 58% at 6 months. These results provide quantifiable and statistically validated information with respect to the improvement in and clearance rate of freckles, which differs from the evaluations of the physicians and the patients themselves, ultimately subjective methods, estimating the efficacy of treatment.

The high satisfaction rate reflected in the subjective evaluations of our patients may be due to the associated cosmetic benefits of IPL therapy, treatment parameters which were based on those used in analogous studies where improvement in fine wrinkles, telangiectasia, cutaneous smoothness, and pore size were reported by the subjects. Further, no local or topical anesthetic agents were needed (lesser pain), few side effects (such as only one case with hypopigmentation, no postinflammatory hyperpigmentation, and no postoperative bleeding) were noted, and little wound healing time was required. In addition, the duration of the procedure was relatively short, requiring only 10–15 minutes due to the selection of larger-size probes and filters. All the superior features outlined above constitute important benefits which make the IPL treatment more tolerable for the patient.

We recognize the limitations of our study with small sample size. Further large sample size, comparative, and case-control studies are needed to confirm the cosmetic benefits of IPL therapy for facial freckles in Asian skin.

Conclusion

Treatment of facial freckles in Asian skin using IPL is an effective, safe, and rapid treatment, with relatively few side effects and high patient satisfaction levels. It seems reasonable to suggest that utilization of the derived parameter, freckles area and severity index, is an objective and superior method for evaluation of the severity of and improvement in freckling. Further research is still required, including investigations to establish the optimum treatment parameters, evaluations of long-term results, comparison with other laser equipment, and a histopathologic review of tissue samples

to determine the underlying biological mechanisms in the treatment course for the various procedures. Our own investigations will be continued and the findings compiled in a follow-up report.

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Commentary

This article is interesting as it addresses the use of IPL in Asians. One interesting finding in this study is the mean number of treatment sessions needed to achieve a good result, which was only 1.4. This differs significantly from Negishi et al.'s work[1] as well as our own experience despite the use of similar parameters. It is worthwhile to point out that the mechanism of action for IPL with short-wavelength filters to remove lentigines is to a certain degree due to lack of effective epidermal cooling. Epidermal melanins affected by the photothermal property of the IPL lead to destruction and their subsequent removal. As a result, for Asians to achieve rapid resolution of lentigines with a more aggressive approach using IPL, hypopigmentation (sometimes even a barlike appearance) can occur. Although the complication rate described in this article was low, readers should bear such potential complications in mind.

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