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ORIGINAL RESEARCH REPORT

A retrospective study on the clinical efficacy of the intense pulsed light source for photodamage and skin rejuvenation

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ABSTRACT

Objective: The objective of this retrospective review is to investigate the long-term effect of skin rejuvenation by the intense pulsed light (IPL) source for the treatment of photoaging. **Methods:** From 5300 clinical cases that our department has treated with the IPL, the first 2534 were chosen for this study. Each patient received a minimum of 3 IPL treatments during this time—many were yearly treatments. Clinical photographs were taken on a yearly basis for up to 12 years and sent to a blinded independent panel to study the effects of continuous IPL treatments. **Results:** Results showed that the effective rate for the IPL was between 88.24% and 96.45%. **Conclusions:** IPL therapy is an effective treatment for photoaging and can truly have an effect on reversing the signs of photodamage on skin.

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Intense pulsed light (IPL); photoaging; skin rejuvenation

Introduction

Intense pulsed light (IPL) technology has been used for the treatment of photoaged skin and for skin rejuvenation for over 15 years, adhering to the principles of selective photothermolysis that was described by Anderson and Parrish (1). Based on this theory, and through years of study, the IPL has shown to be effective in treating the vascular components of photoaging and the pigmented concerns of photoaging, and, over time, has an effect on the collagen itself which improves the overall skin texture (2). The use of the IPL has been studied for many years, and numerous manuscripts and reviews have been written which clearly document their effectiveness in the treatment of photodamage and in skin rejuvenation. Recently, some very interesting reports have been published which looked at the long-term effects of multiple IPL treatments over time and at the beginnings of the molecular basis for the improvement that has been noted with these long-term treatments and their documented benefits (3,4).

The descriptions presented by the long-term evaluations of IPL treatments in several patients (3) prompted us to evaluate our own experience with the IPL. In our department of plastic surgery, we have been using and studying the IPLs for the past 12 years and therefore we decided to review patient records and charts as well as photographs to evaluate our experiences and see if they collaborated with those previously discussed, but now on a much larger scale. Our clinic has treated 5300 patients since we received our IPL and these patients have undergone 23,400 IPL treatments over this time period.

We will present here a retrospective analysis of 2534 patients treated with and followed with the IPL over a 12-year period. Each of the 2534 patients had a minimum of three IPL treatments

and were photographed at every visit, and the photographs were used for comparisons to the baseline photographs to evaluate the effectiveness of the IPL on the skin over time—this being followed up to 12 years. We will show the improvements seen with these patients in reversing the signs of photodamage and in skin rejuvenation in general with IPL used as the light source.

This is the largest review ever performed with the IPL and also is the longest follow-up of any article with the IPL. The article has very important and useful information that collaborates with previous reports and shows its effectiveness on a much larger scale. The limitations with what will be presented are that this is a retrospective analysis, not a prospective clinical trial. There was no formal Institutional Review Board (IRB) used in this process. There were no set inclusion and exclusion criteria for which to base treatments such as is done in an IRB-approved clinical study. The patients who were followed had signs of photodamage according to the clinicians who were evaluating them. For this evaluation, patients were included if they had any of the following concerns: wrinkles, vascular skin concerns, pigmented skin concerns, and worsening of the skin texture. Treatment with IPL was started to eradicate the signs and symptoms of photodamage, and each patient was chronicled in such a manner so that we now have invaluable information which we felt important to share in this report.

Materials and methods

All of the 5300 IPL-treated patients who were followed for this report were treated in the Department of Plastic Surgery of The First People's Hospital of Foshan, in Foshan, Guangdong, China.

The treatments were performed between October 2002 and June 2014. Of the patients who were treated, 4674 were female and 626 were male with age ranges between 0.5 and 84 years. Eighty-two patients in the group were noted to have received treatments for hemangiomas on the skin, for 0.5–16 years. The Fitzpatrick skin types of the patients in the review were noted to be between II and V. As noted, 2534 of the patients underwent more than three IPL treatments and form the basis of this retrospective review.

For those who were treated with the IPL for photodamage and for skin rejuvenation, the primary skin concerns were noted to be: pigmentary concerns, mainly hyperpigmentation; coarse skin with an increase in pore size; and wrinkles and rhytids.

The IPLs used in this review were the Lumenis Quantum and the Lumenis M22. Lumenis, Yokneam, Israel, manufactured both of the IPLs. The Lumenis Quantum was used from 2002 until the beginning of 2010, and the remainder of the treatments performed was with the Lumenis M22. Both of these IPLs utilize cut-off filters and for the Quantum the cut-off filters used were either 560 nm or 640 nm; for the Lumenis M22, the cut-off filters used were 515 nm, 560 nm, 615 nm, 640 nm, and 695 nm. The filters used were determined from the criteria listed below.

All patients received consultations on the benefits of IPL therapy and the nature of the procedure that they were undergoing. The clinicians made certain that there were no contraindications to performing an IPL study on the patient and an appropriate informed consent was signed prior to the IPL treatment. Three standardized clinical photographs (frontal view, and right and left 45 degrees) were performed on each patient at each and every visit.

As this was not set up to be a prospective clinical trial, there was no predetermined inclusion and exclusion criterion. Patients were not treated if they did not exhibit the signs or symptoms of photodamage based on the clinical findings of the treating physician.

Prior to the treatment with the IPLs, each patient received a spot test based on the settings that were selected and observed for a period of up to five minutes, the treatments were continued with appropriate adjustments being considered to the pulse width and the pulse delay, all based on the tissue response of the test spots performed.

Post-treatment care consisted of application of moisturizing creams and sunscreens immediately after the IPL treatment. These varied over the course of the time, but generally were similar in scope during this period of time.

All patients who were included in this review received a minimum of 3 IPL treatments within the first year and then at least one IPL per year from the time they were selected for evaluation for maintenance. Serial photographs were taken at each visit and were the basis for the evaluations reported here.

Three blinded clinicians evaluated the clinical photographs that were taken of these patients over the time course of this project. The blinded evaluators were asked to score the photographs on the basis of clinical findings, these being: A – Excellent; B – Good; C – Moderate; D – Poor; and E – Very Poor. These scales and evaluations also add a limitation to this review in that there were no clinically validated photographs to use as a guide, and we are dealing with the clinicians' findings.

Table 1. Statistical analysis of 1734 patients in April 2014.

Grade before treatment	Grade after treatment	IPL %	IPL combination %
E	E	2.84%	1.95%
E	D	2.65%	2.36%
E	C	11.23%	7.50%
E	B	10.12%	8.69%
E	A	1.28%	12.75%
D	D	2.56%	1.53%
D	C	14.78%	8.15%
D	B	26.69%	12.36%
D	A	2.70%	20.91%
C	C	2.13%	1.69%
C	B	8.54%	5.20%
C	A	9.80%	10.9%
B	B	0.80%	1.60%
B	A	2.25%	3.35%
A	A	1.63%	1.06%

Results

In this retrospective review, we are able to show two different time points in which the evaluations of the effectiveness on the skin with the IPLs are given. This was in April 2014, where 1734 patients were evaluated (Group 1) and then again in June 2014, where 2534 patients were available for evaluation (Group 2). The blinded evaluators were tasked on evaluating the skin quality as: A = Excellent; B = Good; C = Moderate; D = Poor; and E = Very Poor. This correlates to various improvements (or not) in photodamage after IPL therapy over time. The blinded evaluators did not know the time points of any of the IPL sessions and were grading the appearance of the skin based on the photographs under evaluation.

Table 2. Statistical analysis of 2,534 patients in June 2014.

Grade before treatment	Grade after treatment	IPL %	IPL combination %
E	E	2.63%	0.92%
E	D	4.15%	1.58%
E	C	9.36%	6.55%
E	B	9.62%	8.25%
E	A	3.25%	13.66%
D	D	4.98%	1.05%
D	C	11.68%	9.62%
D	B	24.38%	13.49%
D	A	4.70%	19.01%
C	C	1.39%	1.58%
C	B	8.21%	6.10%
C	A	10.55%	12.02%
B	B	1.34%	1.36%
B	A	2.58%	4.22%
A	A	1.18%	0.59%

The total effectiveness of the IPL therapy was based on addition of the calculated scores of the IPL treatments. For a positive effect, the totals of scores A, B, and C were added. From the scores given by the blinded evaluators, the total effective rate for Group 1 was 77.71% and the effective rate of more than two combination treatments was 94.16%. These results are shown in Table 1. When the same criterion was used for the patients in Group 2, the total effective rate of the IPL treatments was 88.24%, and the effective rate for combination treatments was 96.45%. This is shown in Table 2.

Clinical examples of the effectiveness of IPL therapy on photodamaged skin are shown in Figures 1–4.

Discussion

IPL therapy has been widely accepted and acknowledged by plastic surgeons and dermatologists all over the world to be effective in treating photodamage, or photoaging of the skin. It has shown to be increasingly popular among the aesthetic community thanks to its continued efficacy in improving the aging state of the skin with minimal downtime, and consistent improvement in the signs of photodamage (5–7). Photoaging, or photodamage, is manifested by changes that include increases or decreases in pigmentation, angiotelactasis, dry skin, and prominent pores in the skin.



Figure 1. Before and after photographs of a patient treated with IPL 14 times over a 10-year period.



Figure 2. Before and after photographs of a patient treated with IPL 12 times over a 12-year period.

The IPL is a broadband-based light source, with an absorption spectrum between 500 and 1200 nm, with a spectrum of light in the near-infrared region. The pulsed light of this broadband light source acts on the various target tissues of photodamaged skin via the principle of selective photothermolysis that allows the light to target specific chromophores within the skin, not affecting structures within the target chromophore (1). From studies that have been performed in the past, we know that all of the components of photodamage seen on the skin surface can be improved with IPL, including problems with pigments, the vascular components, and the skin texture and tone itself. IPL is an effective therapy and one of the things we have learned and are demonstrating through this article and others that

have been published (3) is that repeat IPL sessions over a long period of time can have a profound impact on one's skin health, creating reversal of skin aging and the signs of photodamage in many patients.

In order for this process to work, one must become very skilled in the use of the IPL system. This is just not a point and shoot device and there are several parameters that must be used and adjusted in many of the patients to make it effective and to continue to show its improvements over time. These subtle, but important, adjustments in the settings of the device are skills that are learned over time, can vary slightly with the type of IPL being used, and needs to be reviewed over and over again for achieving complete effectiveness.



Figure 3. Before and after photographs of a patient treated with IPL 23 times over a 13-year period.

The first parameter that we look at on a regular basis is the IPL cut-off filter that is used. The most common ones used in our series were the 590-nm and 640-nm cut-off filters. The 560-nm filter is ideal when the photodamage being treated is predominantly epidermal hyperpigmentation or angiotelactasis on the skin surface, because 500–600 nm is the wavelength where we see the maximum absorption of pigment and hemoglobin by light. When these lesions are treated with IPL, the pigmented lesions turn dark immediately following the treatment and the vascular response will be graying of the target vessels. When these are seen, one knows that the IPL response for those areas will be obvious. The 640-nm filter is used for

those with enlarged or prominent pores and with more signs of wrinkling, sun damage, and, in general, a more prominent photoaged skin. This longer wavelength allows deeper penetration of the light being used and will have less impact on the epidermis and the more superficial skin concerns. We also recommend that for darker skin types, as seen in many Asian individuals, the wavelength of 640 nm should be used, as it is safer than the others because of the deeper penetration and less attraction for epidermal pigment. This helps reduce the incidence of post-inflammatory hyperpigmentation (PIH), one of the concerns whenever we use energy-based systems on darker skin types.



Figure 4. Before and after photographs of a patient treated with IPL 60 times over a 12-year period.

The IPL's pulse width is another variable that one must know and understand to maximize the IPL treatments. The pulse width depends on the rate at which the epidermis absorbs the photon energy within the unit time of the pulse of light. When the pulse width is short, the energy delivered mainly focuses itself on the epidermis, which can in turn absorb too much energy and, if so, can result in the footprinting that is sometimes seen with IPL use and resultant PIH. In Southern China, where this study was completed, the skin type most commonly seen is skin type IV, and, when footprinting and PIH occur, it can take many months to resolve, which is unfortunate and often leads to discontinuation of therapy by many patients. When the IPLs were first introduced into the market they were mainly set to default parameters as used

in the Western countries, where skin types II and III predominate. When these devices came to China in 2001, many were not aware of the need for adjusting the pulse width of the devices and even with the sophisticated IPLs that were used in our department and clinic, the pulse widths were too short for the darker skin types that are seen in our culture. The pulse width for the Lumenis Quantum was 0.2 msec and the pulse width for the Lumenis M22 was 3.0 msec—all too short for our patient population. Thus, it has been and is imperative that an appropriate analysis of the skin type is performed every time a patient comes to the department for their IPL treatment. From our experience, and what was used in this evaluation, the pulse widths we recommend for our Chinese patients are shown in Table 3.

Table 3. Selection of pulse width.

Equipment	Skin type			
	Type III	Type IV	Type V	Type VI
Quantum™	2.2–2.4/5.0 ms	2.4–2.6/6.0 ms	2.8–3.0/7.0/7.0 ms	5.0/7.0/7.0 ms
Lumenis M22	3.0–3.5/6.0 ms	3.5–4.0/7.0 ms	4.0–4.5/8.0/8.0 ms	6.0/8.0/8.0 ms

The next parameter that is crucial for a successful IPL treatment is pulse delay time. In all efficient IPL systems, there is a pulse delay between the firing of two pulses, which is set for the machine to allow for an increase in the temperature of the epidermis after the first pulse and then cooling sufficiently before firing the second pulse so as to prevent overheating of the epidermis, which again can lead to footprinting, burns, and PIH. Pulse delays for the IPLs used in this review are shown in Table 4, again determined from experience in adjusting the pulse delays to allow for safe treatments in our department.

The number of pulses can be also considered an important feature of one's IPL treatment. Whether one is using double or triple pulses, we need to keep in mind that there needs to be appropriate pulse delays (one or two), which are set to maximize the protection of the epidermis and allow for appropriate skin cooling in between the pulses that are given. With some of the original IPLs, higher energies were needed to assure efficacy, so even when we were using energies of 30 J/cm², and delivering them in 2–3 pulses, the corresponding mean therapeutic doses of the sub-pulses were 15 J/cm² or even 10 J/cm². With some of the newer devices available, less energy is needed; however, the delivery of that energy is superior and thus safer for our patients. Again, from our study, we have determined the most appropriate IPL pulses for those who were evaluated in this review. These are shown in Table 5.

The selection of the energy density is also crucial for the effectiveness of the IPL treatments. Again, this is also dependent on the IPL that is being used, but from what we have determined, in order to prevent footprinting, burns, and PIH, one must use the energy sub-pulses and not exceed the maximum that can result in those unwanted effects. In a previous unpublished review of 35 patients (out of 700 treated) who developed the adverse events noted above, all of them were found to have skin type V and had energy sub-pulses higher than 10 J/cm². Therefore, we recommend that the mean energy of sub-pulses should not be higher than 8 J/cm² in patients

with skin type V or not higher than 10 J/cm² in those with skin type IV when the Lumenis Quantum IPL is used. When the more sophisticated Lumenis M22 is used, with a squared-pulsed delivery system, we recommend that the mean energy of sub-pulses not be higher than 6 J/cm² for skin type V and not higher than 8 J/cm² for those with skin type IV. We also recommend that for our Chinese patients who have uneven skin tone or in areas that have less connective tissue, such as the forehead, the cheek bone, and the bony prominence of the lower jaw, the energy selected should be 1–2 J/cm² less than what would be used on the other areas of the face, again for the safety of the patient and to lower the risks of any untoward results.

Complications and prevention

The commonly reported complications of IPL therapy are burns, blisters, footprinting, and PIH. In 2004, we conducted a statistical analysis of 700 patients who had received treatments in our department with the IPL up to that time. Of the 700 patients who had been treated, we found that 35, or 5%, of them had experienced an adverse event. Of the complications seen, 31, or 4.43%, of them were burns on the skin that manifested themselves as dot-like eschars (27 or 2.43%), footprinting (12 or 1.71%), and blisters (2 or 0.29%), respectively. Three (0.43%) of the patients developed "photosensitivity," which was manifested as bead-like blisters and papules with pruritus and dotted flushing, and one of our patients (0.14%) developed an acne or folliculitis-type reaction.

We found that all of the patients who suffered from burns had either skin type IV or V and all of them had a narrow pulse width setting on the IPL device with a mean energy of sub-pulses more than 10 J/cm².

We have since conducted an analysis on the remaining 1834 patients receiving IPL treatments (total = 2534 and found that only 21 (1.06%) of the patients experienced a total of 37 adverse events, which included 13 cases of footprinting (0.72%), 9 cases of PIH (0.50%), 8 cases of scars (0.44%), 6 cases of blisters (0.33%), and 1 case of swelling (0.05%). From the above statistics we can see that our complication rate has reduced significantly as we have developed increased experience and appropriate treatment parameters for our patient population.

Conclusion

As one of the therapeutic approaches for reversing skin aging and photodamage, IPL technology has been widely acknowledged and accepted throughout the world (1,2). This evaluation has shown that with IPL therapy which is continued on a yearly basis, one can truly reverse photodamage and skin aging; therefore, it should be considered a major impact player for long-term skin health. We need to use the IPL device wisely by

Table 4. Selection of pulse delay time.

Equipment	Skin type			
	Type III	Type IV	Type V	Type VI
Quantum™	15 ms	20 ms	25/25	30/30
Lumenis M22	20 ms	30 ms	40/40	50/50

Table 5. Selection of the number of pulses.

Equipment	Skin type			
	Type III	Type IV	Type V	Type VI
Quantum™	2	2	3	3
Lumenis M22	1	2	3	3

changing parameters and adjusting settings when needed. But with IPL, we can change lives, which is very important in aesthetic medicine and is something that this series has shown over time and with each IPL treatment.

Declaration of interest

Dr. Gold is a consultant to Lumenis. He received no financial compensation for work on this project. The other authors report no financial compensation for the project. The authors alone are responsible for the content and writing of the paper.

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