

RESEARCH ON THE COMBINED TREATMENT OF DEEP
PIGMENTED DISEASES USING Q-SWITCHED LASER AND
INTENSE PULSED LIGHT, ENHANCED BY THE
PHOTOACOUSTIC EFFECT

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Abstract

Pigmentation skin disorders are common skin diseases, among which facial yellow brown spots are more common. The causes are complex, and the etiology is currently not fully understood. The histopathological classification of melasma is of great significance in guiding clinical treatment. Different methods are adopted for the treatment of melanin deposition sites in the skin in order to achieve better therapeutic effects. This article explores the impact of Q-switched laser combined with intense pulsed light on the aesthetic effect of skin in patients with melasma. Seventy-eight female patients with melasma admitted to the hospital from January 2023 to January 2025 were selected as the research subjects. They were randomly divided into an observation group and a control group using the sticky note method, with 39 cases in each group. The control group was treated with intense pulsed light therapy, while the observation group was treated with Q-switched laser combined with intense pulsed light therapy. After 6 months of treatment, the skin melanin index (MI), erythema index (EI), and adverse reactions were compared between the two groups. The melasma area and severity index (MASI) and skin barrier function were recorded before and after 6 months of treatment. After 6 months of treatment, the MASI, MI, and EI indices of the observation group were significantly lower than those of the control group ($P < 0.05$). There was no statistically significant difference in skin barrier function indicators between the two groups of

patients before and after 6 months of treatment ($P > 0.05$), and there was no statistically significant difference in the incidence of adverse reactions between the two groups during treatment ($P > 0.05$). Q-switched laser combined with strong pulsed light can effectively improve facial melasma in patients, which is safe and effective. It can effectively reduce the level of melanocyte stimulating hormone, reduce oxidative stress damage, brighten the patient's skin colour, and has a good aesthetic effect without significant adverse reactions. It can significantly shorten the treatment time, promote rapid recovery of the condition, and is worthy of clinical promotion and application.

Key words: pigmentary diseases, melasma, skin melanin index, photoacoustic effect, Q-switched laser

Introduction. Deep pigmentation conditions, as a prevalent skin disorder, exert a significant adverse impact on the physical and mental health of affected patients. These conditions not only induce obvious cutaneous pigmentation that impairs appearance but also tend to trigger negative emotions such as inferiority and anxiety, thereby reducing patients' quality of life [1–3]. Relevant studies have indicated that the incidence of deep pigmentation diseases is remarkably high in certain regions and exhibits an annual upward trend. Traditional therapeutic approaches, including chemical exfoliation and cryotherapy, despite demonstrating a certain degree of efficacy, are associated with several limitations such as incomplete treatment outcomes, high recurrence rates, and multiple complications [4–7].

In recent years, the combined therapy of Q-switched laser and intense pulsed light (IPL) has been widely adopted in the clinical management of pigmentation diseases as an emerging therapeutic strategy [8–10]. Q-switched laser can instantly release high energy to fragment pigment particles, rendering them susceptible to phagocytosis and clearance by macrophages. In contrast, intense pulsed light possesses broad spectral characteristics, which enable it to target various types of pigments; meanwhile, it can stimulate the proliferation of cutaneous collagen and improve skin texture [11–13]. However, the current combined therapy still has certain deficiencies. On the one hand, for deep pigmentation diseases, the penetration depth of Q-switched laser and intense pulsed light is limited, making it difficult to completely destroy deep-seated pigment particles and thus leading to unsatisfactory therapeutic effects [14–18]. On the other hand, during the implementation of combined therapy, there is a lack of systematic research on the parameter matching and treatment sequence of these two therapeutic modalities, which may not only affect the therapeutic effect but also increase the risk of adverse reactions.

As an emerging physical phenomenon, the photoacoustic effect has exhibited tremendous application potential in the biomedical field. When light irradiates tissues, a portion of the photon energy is absorbed and converted into thermal energy, causing instantaneous tissue expansion and the generation of elastic waves, namely photoacoustic signals. Utilizing the photoacoustic effect can enhance the

depth and effectiveness of light-tissue interaction, providing a novel approach for the treatment of deep pigmentation diseases. Combining the photoacoustic effect with Q-switched laser and intense pulsed light therapy is expected to improve the efficiency of deep pigment particle destruction, enhance therapeutic efficacy, and reduce the number of treatment sessions as well as the incidence of adverse reactions. Therefore, in-depth research on the efficacy and mechanism of photoacoustic effect-enhanced combined therapy of Q-switched laser and intense pulsed light for deep pigmentation diseases holds important theoretical significance and clinical application value.

Materials and methods. General information. Seventy-eight female patients with melasma admitted to our hospital from January 2023 to January 2025 were selected as the research subjects. They were randomly divided into an observation group and a control group, with 39 patients in each group, using the sticky note method. There was no statistically significant difference in general information between the two groups of patients ($P > 0.05$).

Inclusion criteria: ① Meets the diagnostic guidelines related to melasma in the 2010 “Efficacy Criteria for melasma”; ② Female patients; ③ Age range: 18–65 years old; ④ Both the patients and their family members are aware of the content and direction of this study and have signed an informed consent form.

Exclusion criteria: ① Pregnant and lactating women; ② Patients with combined dysfunction of important organs throughout the body; ③ Individuals with combined mental and neurological disorders; ④ Combining allergic skin diseases and other diseases and medical histories that affect this study; ⑤ Individuals with photosensitivity; ⑥ Individuals with combined immune system diseases; ⑦ Individuals with language communication barriers; ⑧ Those who have not received treatment for melasma within six months.

Treatment method. The control group used Q-switched laser to treat the patient’s facial melasma area, which involved facial cleansing and local skin disinfection. Then, the patient was treated with a Q755 nm laser (American Cynosure Q755 nm Emerald Laser, model: PicoSure) at a distance from the patient’s face, with the hand attached to the skin surface until the skin appeared slightly red, and immediately stopped treatment. Cold compress was applied for 30 min after each laser treatment, with a treatment interval of 4 weeks. The observation group was treated with intense pulsed light on the basis of the above, that is, after the patient’s face was cleaned, the patient was put on an eye mask, and the special photon gel was evenly applied on the patient’s face for 1–3 mm. The operator wore goggles, and then the intense pulsed light therapeutic apparatus (American Lumenis, model: M22) was used for treatment. When the skin was slightly red, after the treatment, the face was immediately cleaned, and then cold compress with ice bags was applied for 30 min, with an interval of 4 weeks. During the treatment, both groups were strictly sunscreensed, and the treatment lasted for 6 months.

Observation indicators.

– Melasma Area Severity Index (MASI): The area, colour depth, and colour uniformity of melasma were measured in two groups of patients before and after 6 months of treatment, with a total score ranging from 0 to 48 points. The higher the score, the more severe the melasma.

– Skin Melanin Index (MI) and Erythema Index (EI): After 6 months of treatment, MI and EI were measured using a melanin analyzer and hemoglobin analyzer in the two groups of patients.

– Skin barrier function: Before and after 6 months of treatment, a multifunctional skin tester was used to measure the sebum content, stratum corneum water content, and loss of epidermal water flow in the two groups of patients.

Statistical analysis. SPSS 26.0 statistical software was used to analyze the data, and the quantitative data was expressed in the form of ($\bar{x} \pm s$), all of which were analyzed using *t*-test; The count data is represented as [example (%)], and the comparison between groups is conducted using the chi square test. A $P < 0.05$ is considered statistically significant.

Results. Comparison of MASI scores between the two groups of patients. After 6 months of treatment, the MASI score of the observation group of patients was significantly lower than that of the control group ($P < 0.05$), as shown in Table 1.

T a b l e 1

Comparison of MASI scores before and after treatment between two groups ($\bar{x} \pm s$, points)

group	Before treatment	after treatment	<i>t</i>	<i>P</i>
Observation group ($n = 39$)	19.84±2.62	10.26±3.01	22.315	< 0.001
Control group ($n = 39$)	20.08±3.76	13.76±4.06	10.633	< 0.001
<i>t</i>	0.372	4.541		
<i>P</i>	0.710	< 0.001		

Comparison of aesthetic effects between two groups of patients. After 6 months of treatment, the MI and EI indices of the observation group were significantly lower than those of the control group ($P < 0.05$), as shown in Table 2 and Fig. 1.

Comparison of skin barrier function between two groups of patients. Before and after 6 months of treatment, there was no statistically significant difference in skin barrier function between the two groups of patients ($P > 0.05$), as shown in Table 3.

Adverse reactions in the two groups of patients. After 6 months of treatment, only 2 patients in the control group showed mild local erythema, which was relieved after using medical cold compress patches, and no other obvious adverse reactions were observed, as shown in Table 4.

T a b l e 2

Comparison of aesthetic effects between two groups before and after treatment
($\bar{x} \pm s$)

group	Number of cases	MI/%	EI/degree
Observation group ($n = 39$)	39	15.84 ± 4.14	1.26 ± 0.54
Control group ($n = 39$)	39	19.18 ± 5.35	1.68 ± 0.60
t		3.211	3.512
P		0.002	0.001

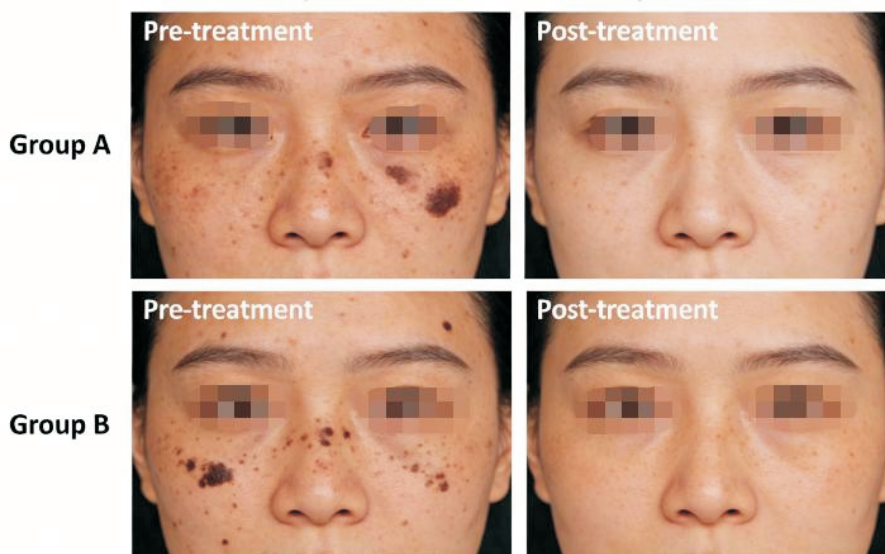


Fig. 1. Some clinical photos “before” and “after” from the two study groups

Discussion. Melasma is a common skin disease in clinical practice, with a complex pathogenesis often related to sun exposure, stress, hormone secretion, and other factors. At present, traditional treatment methods such as the combination of Chinese and Western medicine and microneedling are commonly used. Although they have certain effects on the treatment of melasma, the treatment cycle is long and the effect is unsatisfactory, which increases the economic and mental burden on patients and seriously affects their living conditions. Therefore, exploring effective treatment methods is of great significance for treating melasma.

Intense pulsed light is a broad-spectrum light that can penetrate the skin and use the principle of selective photothermal decomposition to destroy melanocytes and shatter melanosomes. The unique multi pulse technology selects different pulse widths and delay times for effective and safe treatment of different target tissues, comprehensively improving pigmentary, vascular skin problems, and skin texture relaxation skin problems. The treatment also protects normal skin tissue

T a b l e 3

Comparison of skin barrier function between two groups before and after treatment
($\bar{x} \pm s$)

Group	time	Sebum content/(U.C)	Water content of stratum corneum/(U.C)	Loss value of epidermal water diversion
Observation group ($n = 39$)	Before treatment	30.62 ± 4.34	36.32 ± 4.55	16.36 ± 2.11
	after treatment	30.64 ± 4.16	36.33 ± 4.79	16.35 ± 2.13
	t	0.032	0.015	0.032
	P	0.971	0.991	0.971
Control group ($n = 39$)	Before treatment	30.65 ± 4.53	36.36 ± 4.46	16.38 ± 2.10
	after treatment	30.66 ± 4.79	36.35 ± 4.38	16.38 ± 2.14
	t	0.015	0.016	0.063
	P	0.991	0.988	0.946

T a b l e 4

Comparison of adverse reactions between two groups of patients ($n = 78$, cases)

group	erythema	scar	hypo- pigmentation	pigmentation	edema	Total/ n (%)
Observation group ($n = 39$)	0	0	0	0	0	0
Control group ($n = 39$)	2	0	0	0	0	2.6

without affecting sweating, but there is a problem of not being able to instantly hit the peak energy, only acting on the epidermal and superficial dermis layer melanin, resulting in a high recurrence rate after treatment. Q-switched laser has strong penetration ability and utilizes the principle of instantaneous photo induced explosion to release the laser in a very short time (about 10 ns), forming a high energy density giant pulse that effectively destroys pigment tissue while having minimal impact on other tissues in the body. Q-switched laser therapy device, with uniform energy within the spot range, can effectively remove diseased pigments and vascular tissue without damaging surrounding tissues, without damaging the skin or leaving scars, thus achieving the goal of spot removal and beauty. QU et al. [19] found that Q1064 nm modulation combined with tranexamic acid can effectively treat moderate to severe melasma with high safety. This article explores the effects of Q-switched laser combined with intense pulsed light on the skin colour score and aesthetic effect of patients with melasma. It was found that after 6 months of treatment, the MASI score, aesthetic effect, and skin colour score

of the observation group were better than those of the control group, indicating that Q-switched laser combined with intense pulsed light can reduce the severity of melasma, reduce plaque area, improve aesthetic effect, and improve skin colour, which is similar to the above study.

In summary, compared with the treatment with Q-switched laser alone, the combination of Q-switched laser and intense pulsed light can effectively reduce the severity of melasma in patients, shrink plaques, improve patient skin colour, and have higher safety and aesthetic effects.

Conclusion. This article explores the impact of Q-switched laser combined with intense pulsed light on the aesthetic effect of skin in patients with melasma. After 6 months of treatment, the MASI, MI, and EI indices of the observation group were significantly lower than those of the control group ($P < 0.05$). There was no statistically significant difference in skin barrier function indicators between the two groups of patients before and after 6 months of treatment ($P > 0.05$), and there was no statistically significant difference in the incidence of adverse reactions between the two groups during treatment ($P > 0.05$). The combination of Q-switched laser and intense pulsed light can effectively improve the condition of facial melasma in patients, which is safe and effective. It can effectively reduce the level of melanocyte stimulating hormone, reduce oxidative stress damage, brighten the patient's skin colour, and has a good aesthetic effect without significant adverse reactions. It can significantly shorten the treatment time, promote rapid recovery of the condition, and is worthy of clinical promotion and application.

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