

The Efficacy of Intense Pulsed Light in the Treatment of Keloids and Hypertrophic Scars



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Abstract

Introduction: Different therapies have been applied to keloids and hypertrophic scars. Intense pulsed light (IPL) has recently been used but the evidence is limited. This study was to evaluate the effectiveness and safety of IPL as monotherapy for keloids and hypertrophic scars.

Methods: This was a before-and-after interventional study on 16 patients with 50 scars who underwent IPL. Seven scars receive one IPL session, seven received two sessions, and 36 received three sessions. Outcomes were evaluated by the Vancouver Scar Scale (VSS), Patient and Observer Scar Assessment Scale (POSAS), scar ultrasound, colorimeter for pigmentation and erythema, and side effects.

Results: After the treatment, most outcomes significantly improved except that the pigmentation of the scars did not change. Scar thickness significantly reduced by nearly 10% after the first IPL session, 15% after the second session, and >20% after the third session. All side effects were mild with crust (33.3-46%), blisters (8.3-40%), and hyperpigmentation around the scar (0-14%); the pain was moderate as assessed by the patients.

Conclusion: IPL is a safe and effective treatment for keloids and hypertrophic scars. More studies are required to confirm our results.

Keywords: Keloid; Hypertrophic scar; Intense pulse light; VSS; POSAS.

Introduction

Keloids and hypertrophic scars are excessive responses of tissues to injury. They are caused by fibroblast proliferation and collagen overproduction at the injury site. Hypertrophic scars usually do not exceed the site and recede over time, whereas keloids often spread beyond the original wound boundary and do not recede.¹ Keloids and hypertrophic scars are benign, but they can immensely affect patients' quality of life.² Lasers and light have been used to treat keloids and hypertrophic scars. Previously, the 585-595 nm pulsed dye laser (PDL) was widely used in scar treatment, but its drawbacks were the high cost and high risk of purpura. Recently, intense pulsed light (IPL) has been used more often.³ The effectiveness of IPL and PDL was shown to be similar in reducing the appearance of hypertrophic scars, whereas IPL reduced the risk of purpura.⁴ Some studies found that IPL was also effective in the treatment of scars caused by burns, surgery, and after suture removal.⁵⁻¹⁰ The advantages of IPL include minimal invasiveness, reduced long-term side effects, and low cost. The mechanism of IPL has yet to be fully explored. It probably affects the angiogenesis of scars by

the selective absorption of hemoglobin through selective photothermolysis and the coagulation of microvessels of the scar, which causes a lack of oxygen, thereby breaking down the collagen in scars.¹¹

Nevertheless, evidence of the effects of IPL on keloids and hypertrophic scars is still limited and can be improved. Therefore, we conducted this study to evaluate the effectiveness and safety of IPL in treating keloids and hypertrophic scars.

Materials and Methods

Study Design and Patients

This was a before-and-after interventional study of all patients who underwent IPL treatment for keloids or hypertrophic scars with a longitudinal follow-up. The study was performed at the Dermatology - Skin Aesthetics Department of the University Medical Center at Ho Chi Minh City, a tertiary hospital in Southern Vietnam, from November 2020 to October 2021. All patients were informed of the purposes, steps, and possible risks of all procedures, and they agreed with the treatment by written informed consent.

We included patients over five years of age presenting with a clinical diagnosis of keloids or hypertrophic scars. Exclusion criteria were (i) previously receiving any treatment for scars during the last six months, (ii) contraindications to IPL (including lupus erythematosus, herpes simplex, and photosensitivity), (iii) skin infections, (iv) Fitzpatrick skin type VI, and (v) pregnancy.

Treatment Protocol

All patients were treated with IPL M22 (Lumenis Be Ltd., Yokneam, Israel) with the Optimal pulse technology. Each IPL session was done with a vascular filter (530-650 & 900-1200 nm), fluence of 22-24 J/cm², pulse duration of 4-5 ms with double-pulse, and pulse delay of 30-40 ms. The procedure was completed when the scars became darker such as dark red or light gray. The IPL sessions were done at 4-week intervals.^{5,8,10,12,13}

The potential adverse events of IPL are pain, crust, blister, and hyperpigmentation around the scar. We applied several approaches to minimize and solve these adverse events. We performed topical anesthesia before and used a cold compress after the treatment to prevent pain. In cases of the blister, we used topical corticosteroid twice a day, covered the treatment area, and reduced the energy of IPL in the following treatments. In cases of hyperpigmentation around the scar, we shielded the skin around the scar more carefully in the following IPLs and used topical therapy by Tri-Luma® (fluocinolone acetone 0.01%, hydroquinone 4%, and tretinoin 0.05%) cream once a day.

Outcome Evaluation

We used the Patient and Observer Scar Assessment Scale (POSAS) to assess each scar. The POSAS has two scales, one for patients and the other for observers. In this study, we only used the POSAS scale for patients to rate the scars, including pain, itching, color, stiffness, thickness, and distinction.¹⁴ For the physicians, the Vancouver Scar Scale (VSS) was used to assess the scars' pliability, height, vascularity, and pigmentation.⁶ The maximum total score for each scar is 13. The scars were then classified into mild (0-3), moderate (4-7), and severe (8-11), according to the VSS.¹⁵

We used a tristimulus reflectance colorimeter to evaluate scar erythema and pigmentation. The colorimeter measures color through three broad wavelength filters: brightness, redness, and pigmentation. This system is suitable for measuring any color in the standard color space defined by the Commission Internationale de l'Eclairage (CIE), where the output in L*a*b coordinates is defined as CIELAB (CIE L*a*b) color space values. The outputs L* and b* are generally a combination of melanin (pigmentation), and output a* is for erythema.

We used manual measurement calipers to assess the VSS score for scar thickness. Additionally, we used ultrasound

with probe L3-12A to evaluate the thickness at the center of the scar (marked on the scar and re-imaged) at each visit. The patients reported procedural complications at each visit, including pain (evaluated using the visual analog scale [VAS]), itch, crust, ulcer, bulla, and purpura.

Statistical Analysis

Summary statistics were done using mean ± standard deviation for numeric variables and frequency and percentage for categorical variables. Outcomes, including the POSAS assessed by patients, VSS score, and assessments by colorimeter and ultrasound, were compared before and after the treatment by the paired *t* test for numeric variables and McNemar's test for categorical variables. The linear regression model was used to evaluate factors associated with improving the VSS score and scar thickness. All tests were two-sided. Statistical significance was defined when the *P* value was <0.05. All analyses were performed using the statistical software R version 4.1.0.

Results

Between November 2020 and October 2021, 16 patients with 50 scars who underwent IPL for keloids or hypertrophic scars in our hospital were included in this study. The female gender was predominant (81.2%). The mean age was 29.4 years. The most common problem of the patients was aesthetic issues (75%). Most of the patients had type-IV skin (93.8%) and had 2-5 scars that required treatment (68.8%) (Table 1).

The mean age of the patients at the onset of the scars was 26.1 years. Most of the scars (50%) occurred 1-3

Table 1. Participants' characteristics

All Patients (N = 16)	
Gender	
Female	13 (81.2)
Male	3 (18.8)
Age (year)	29.4 ± 11.0
Aesthetics issues	12 (75.0)
Itching	7 (43.8)
Concern of disease progression	6 (37.5)
Pain	4 (25.0)
Family history with keloids	4 (25.0)
Type of skin	
IV	15 (93.8)
III	1 (6.2)
Number of scars	
1	3 (18.8)
2-5	11 (68.8)
>5	2 (12.5)

Summary statistics are n (%) for categorical variables and mean ± standard deviation for numeric variables.

years before treatment, and most of them (90%) were keloid. The most common cause of the scars was acne (50%), followed by burns (20%) and post-surgery (14%). The most frequent site was in front of the sternum (34%), followed by the shoulder (20%) and arm or leg (14%). Most of the scars (72%) were located in the skin-stretching or movable area (Table 2). Thirty-six scars from 11 patients received three IPL sessions, seven scars from three patients received two IPL sessions, and seven scars from two patients received one IPL session. Among the two patients who received one IPL session, one did not want another session because of the pain in the first session, and another had a personal issue and could not follow the treatment. Three patients received two IPL sessions because they were satisfied with the outcome of the treatment.

Table 3 shows the results after each IPL session. In

Table 2. Characteristics of Scars Before Treatment

	All Scars (N=50)
Age of onset (year)	26.1 ± 11.3
Age of scar	
< 1 year	11 (22.0)
1-3 years	25 (50.0)
> 3 years	14 (28.0)
Type of scar	
Keloid	45 (90.0)
Hypertrophic scars	5 (10.0)
Cause of scar	
Primary	5 (10.0)
Injury	3 (6.0)
Acne	25 (50.0)
Post-surgery	7 (14.0)
Burn	10 (20.0)
Site	
Front of sternum	17 (34.0)
Shoulder	10 (20.0)
Arm or leg	7 (14.0)
Breast	4 (8.0)
Jaw angle	4 (8.0)
Armpit	3 (6.0)
Neck	3 (6.0)
Abdomen	1 (2.0)
Dorsum	1 (2.0)
Skin-stretching or movable area	36 (72.0)
Number of IPL sessions	
1 session	7 (14.0)
2 sessions	7 (14.0)
3 sessions	36 (72.0)

Summary statistics are n (%) for categorical variables and mean ± standard deviation for numeric variables. IPL, intense pulsed light.

general, more IPL sessions better improved all outcomes. After one IPL session, some parameters significantly improved, including scar thickness, pliability, and all POSAS evaluations of the patients. After two IPL sessions, scar thickness, pliability, the POSAS evaluations of the patients, a*, and erythema improved. The VSS score was significantly reduced by nearly 24%. After three IPL sessions, nearly all parameters significantly improved. The average VSS scores decreased by 34% compared to the pre-treatment. The index of pliability had a major decrease of 43%, followed by thickness and erythema appearance. The average a* assessing the erythema of the scar improved by 12% after the treatment. The L* and b* parameters (which represent pigmentation) did not significantly change after three IPL sessions. Scar thickness was significantly reduced by nearly 10% after the first IPL, 15% after the second IPL, and more than 20% after the third IPL. Images of some scars before and after the treatment are shown in Figure 1.

Side effects were mild and decreased over time. The most common one was crust (46%, 37.2%, and 33.3% after the first, second, and third IPL session respectively), followed by blister (40%, 32.6%, and 8.3% respectively) and post-inflammatory hyperpigmentation around the scar (14%, 14%, and 0% respectively). All cases with crust occurred within 2-3 days after the treatment and were resolved without treatment in a week. The cases with blisters were resolved in a week without any ulcers or infections. The cases with hyperpigmentation around the scar were resolved within 1-3 months after IPL. The mean VAS pain scores were 5.2 ± 3.4, 4.6 ± 3.0, and 4.2 ± 2.6 after the first, second, and third IPL sessions respectively (Table 4).

We found several factors associated with the outcomes (Table 5). The scar at the skin-stretching point or movable area significantly decreased the improvement of the VSS score by -1.55 points (95% confidence interval [CI]: -2.67; -0.44) when compared with the scars in other areas. The cause of the scar is associated with a decrease in scar thickness: the scar caused by acne significantly improved the decrease of scar thickness by 0.5 mm (95% CI: 0.14; 0.86) compared to other causes.

Discussion

The study evaluated the efficacy of IPL on hypertrophic scars and keloids. The assessment was based on the reliable clinical and objective colorimeter and scar thickness in ultrasound evaluation. More IPL sessions better improved all outcomes. The average VSS scores, the index of pliability, thickness, and erythema appearance significantly decreased. The thickness improved by 24% on ultrasound compared to the pre-treatment. The average a* assessing the erythema of the scar improved by 12% after the treatment, and L* and b* showed no change.

A study by Salem et al in 2021 evaluated the effectiveness

Table 3. Results After Treatment

	Before Treatment (N=50)	After 1 IPL Session (N=50)	After 2 IPL Sessions (N=43)	After 3 IPL sessions (N=36)	P1	P2	P3
L*	53.55±5.28	53.61±5.45	53.91±5.40	54.49±4.49	0.866	0.503	0.712
a*	18.03±4.46	17.68±4.07	16.58±4.56	16.16±3.65	0.322	0.024	0.002
b*	12.98±2.70	13.27±2.47	13.06±2.48	13.31±2.49	0.582	0.933	0.781
Scar thickness (Ultrasound) (mm)	3.26±1.39	3.03±1.38	2.74±1.24	2.56±1.25	<0.001	<0.001	<0.001
Erythema	1.66±0.96	1.60±1.01	1.26±0.95	1.17±0.97	0.299	0.008	0.002
Pigmentation	1.14±0.99	1.48±0.86	1.00±0.98	0.69±0.92	0.012	0.878	0.029
Thickness (Calipers) (mm)	2.00±0.57	1.88±0.56	1.70±0.71	1.58±0.65	0.020	0.003	<0.001
Pliability	2.94±0.87	2.68±1.02	1.98±1.10	1.69±1.17	<0.001	<0.001	<0.001
VSS score	7.74±2.33	7.64±2.19	5.93±2.75	5.14±2.81	0.526	<0.001	<0.001
Classification based on VSS					0.548	0.002	<0.001
Mild	0 (0.0)	0 (0.0)	10 (23.3)	13 (36.1)			
Moderate	24 (48.0)	28 (56.0)	21 (48.8)	17 (47.2)			
Severe	26 (52.0)	22 (44.0)	12 (27.9)	6 (16.7)			
Patient's assessment							
Pain	2.12±1.88	1.48±1.23	1.28±0.91	1.14±0.42	<0.001	0.003	0.008
Itching	3.92±2.38	2.62±2.07	1.49±1.20	1.25±0.60	<0.001	<0.001	<0.001
Color	7.00±2.19	6.02±2.45	4.77±2.72	4.50±2.62	0.013	<0.001	<0.001
Stiff	6.18±1.80	5.08±1.94	4.07±2.21	3.50±1.95	<0.001	<0.001	<0.001
Thickness	5.48±2.63	4.30±2.22	3.47±2.02	3.25±2.20	<0.001	<0.001	<0.001
Distinction	7.40±1.54	6.08±1.91	5.33±2.35	5.19±2.39	<0.001	<0.001	<0.001
POSAS score	32.10±8.67	25.58±8.11	20.40±8.22	18.83±7.67	<0.001	<0.001	<0.001

Summary statistics are n (%) for categorical variables and mean±standard deviation for numeric variables.

Paired *t* test is used for numeric variables and McNemar's test is used for categorical variables; P1 is to compare the measurements before treatment and after 1 IPL session; P2 is to compare the measurements before treatment and after 2 IPL sessions; P3 is to compare the measurements before treatment and after 3 IPL sessions.

IPL, intense pulsed light; POSAS, Patient and Observer Scar Assessment Scale; VSS, Vancouver Scar Scale.



Figure 1. Images of Scars Before and After Treatment. Upper images are the scars before treatment, and lower images are the corresponding scars after treatment

of IPL in the treatment of hypertrophic scars; the improvement rates of VSS score and scar thickness on ultrasound were 11.5% and 12.5% respectively, which are lower than those in our study.¹⁰ The differences in the effectiveness of the two studies can be attributed to the differences in the wavelength, pulse width, and pulse delay filters. The blood flow of hypertrophic and keloid scars was measured to be much higher than that of normal

skin.¹⁶ Furthermore, the vascular diameter of keloids and hypertrophic scars was estimated to be up to 15 μ m which was higher than the standard capillary diameter - up to 10 μ m.¹⁷ A keloid's blood flow and vascular size play an important role in laser and light thermal effects. With the scar's large blood vessels and high vascular flow, the flow rate is slow. Therefore, choosing a short pulse width is probably better to reduce side effects, and in such

cases, a double pulse should be used. To increase heat accumulation in blood vessels to effectively coagulate blood vessels, we used a 4-5 ms double pulse as the lowest pulse width of the IPL M22. In contrast, Salem's study used a 10 ms single pulse. In an immunohistochemical evaluation of vessel wall damage and selectivity after IPL treatment for capillary malformations, Grillo et al concluded that IPL had great potential in the treatment of capillary malformations and found a large number of combinations of therapeutic parameters that can be used.¹⁸ The influence of changes in treatment parameters could affect the effectiveness of IPL, and the optimal parameters applied to the scar treatment are still questioned.

The average POSAS scores fell by 42% and itching was reduced. This was similar to Erol and colleagues' results in 2008.⁵ During the treatment, approximately 80% of the patients experienced mild and moderate pain, which scored 4-5. To minimize pain, we could apply anesthesia 30 minutes before the procedure and give the patients a cold compress after the treatment. 44.3% of the patients

developed scabs within 2-3 days and peeled themselves off within the first week after the treatment. Also, 36% of the scars blistered within a day after the treatment. We used topical corticosteroids twice a day and instructed the patients to carefully cover the treatment site (maybe with a silicon sheet) and try not to poke the blister. All blisters healed within a week without leaving any ulcers or infections. However, we found that blisters occurred quite commonly. In cases of blisters after the treatment, we reduced the energy density to 4-6 J/cm² without changing the pulse width or pulse delay parameters. Post-inflammatory hyperpigmentation in the skin around the scar occurred in 11.5% of the patients in our study. To minimize this, we shielded the skin around the scar more carefully in the next shots, and no more hyperpigmentation was observed. There were no cases of ulcer, hypopigmentation, or purpura. Therefore, IPL is an effective and safe method for the treatment of keloids and hypertrophic scars.

Several treatments have been used for keloids and hypertrophic scars, such as laser and light, cryotherapy, silicone gel, injection at the lesion (e.g., triamcinolone, bleomycin, 5-fluorouracil, botulinum toxin), and surgery. However, no treatment could remove the scars and prevent the recurrence completely.¹⁹ Some even have a higher rate of side effects, such as infection, necrosis, or loss of pigmentation.²⁰ For example, intralesional triamcinolone injection was the first-line therapy for keloids and hypertrophic scars. It can reduce the average VSS score by more than 50%.^{21,22} However, it is commonly associated with multiple side effects in 63% of the patients, such as subcutaneous atrophy, telangiectasia,

Table 4. Side Effects After Treatment

	After 1 IPL Session (N=50)	After 2 IPL Sessions (N=43)	After 3 IPL Sessions (N=36)
VAS pain score	5.2±3.4	4.6±3.0	4.2±2.6
Crust	23 (46.0)	16 (37.2)	12 (33.3)
Blister	20 (40.0)	14 (32.6)	3 (8.3)
Hyperpigmentation around the scar	7 (14.0)	6 (14.0)	0 (0.0)

Summary statistics are n (%) for categorical variables and mean±standard deviation for numeric variables.

IPL, intense pulsed light; VAS, visual analog scale.

Table 5. Factors Associated With the Improvement of VSS and Scar Thickness Before and After Treatment

	Improvement of VSS			Decrease of Scar Thickness		
	Beta	95% CI	P Value	Beta	95% CI	P Value
Age of scar						
<1 year	0	Ref	Ref	0	Ref	Ref
1-3 years	0.12	-1.26, 1.49	0.866	0.39	-0.10, 0.88	0.117
>3 years	-0.65	-2.18, 0.88	0.398	0.09	-0.46, 0.63	0.754
Scar thickness (1st time)						
≤2 cm	0	Ref	Ref	0	Ref	Ref
>2 cm	-0.76	-2.21, 0.70	0.302	0.39	-0.13, 0.91	0.137
Cause of scar						
Acne	0	Ref	Ref	0	Ref	Ref
Other	0.00	-1.08, 1.08	1	-0.50	-0.86, -0.14	0.008
Family history of keloids						
No	0	Ref	Ref	0	Ref	Ref
Yes	-0.67	-2.01, 0.66	0.315	0.23	-0.25, 0.72	0.339
Skin-stretching point; movable area						
No	0	Ref	Ref	0	Ref	Ref
Yes	-1.55	-2.67, -0.44	0.007	-0.10	-0.54, 0.33	0.633

CI, confidence interval; VSS, Vancouver Scar Scale.

and hypopigmentation.²³ Combination therapies offer better results and higher patient satisfaction than monotherapy. Studies showed that a combined therapy of IPL and corticosteroid injection improved the appearance of keloids and hypertrophic scars and increased the recovery of skin hydration.²⁴⁻²⁶ In clinical practice, some scars are hard, red, and firm, with pain and itching, which increases the difficulty of intralesional injection. In these cases, IPL effectively softens the scars, reduces the redness and thickness of the scars, relieves pain and itching, and facilitates intralesional injection.

The main limitations of the study are the small sample size and lack of a comparison group to evaluate better the safety and effectiveness of IPL in the treatment of hypertrophic scars and keloids. The follow-up time is also limited, so we cannot conclude about the recurrence rate and long-term effects of IPL.

In conclusion, IPL is a safe and effective treatment for keloids and hypertrophic scars. The side effects were mild. IPL can reduce scar thickness and improve scar pliability, VSS score, and patient-reported outcomes, according to the POSAS questionnaire. The effectiveness can be improved with more sessions of IPL, and side effects can be well-managed. Studies with larger sample sizes and longer follow-ups are required to confirm our results.

Authors' Contribution

Conceptualization: Le Thai Van Thanh, Tran So Quan.

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Visualization: Nguyen Lam Vuong.

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Competing Interests

The authors declare that there is no conflict of interest regarding the publication of this article.

Ethical Approval

The study was approved by the institutional ethics committee (No. 2952/QĐ-ĐHYD, dated 14-Sep-2020).

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