

Intense Pulsed Light: A Brief Overview

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Abstract- Intense Pulsed Light(IPL) has been used in treating many medical conditions such as the removal of unwanted hair, pigmented lesions, and vascular lesions. A systemic database search was made, Principles and Physics behind the IPL and its clinical applications were understood. Earlier studies were carried out to establish its role and clinical safety. A Flash Lamp is used to emit light in the wavelength of 400-1400nm. Different cut-off filters are used to produce a light of a specific wavelength targeting specific chromophores. Spot size, pulse duration, thermal relaxation time, density, and fluence are important concepts to understand. These concepts are used in a scientific manner to address different clinical conditions effectively. Overall IPL is a useful tool for managing many dermatological conditions.

Key Words: Intense Pulsed Light, Fluence, Density, Spot size, Pulse duration, Chromophore

Introduction

We have been reading about light and its properties from the early years of education. However, the use of light in the management of diseases is fascinating. The use of Laser is common in medical sciences but what about Intense Pulsed Light? Not many of us have heard about this. The study aims to understand the science behind using Intense Pulsed Light (IPL) in treating many skin conditions.

Material and Methods:

A systemic electronic database search was performed and the articles were selected in which the basics of the IPL were explained. Treatment of the specific conditions and protocols were kept out of the purview of the study. This study is focused on the concept, history, development, and common uses of IPL. Multiple visits were made to a high volume Laser Centre to understand the clinical utility of IPL.

Results:

Intense Pulsed Light (IPL): IPL uses a flash lamp to produce intense light in the range of 400-1400 nm wavelength. (1) This is the basic difference between Laser and IPL. Laser light has three basic properties. First, they are monochromous which means they have the same wavelength. Second, they run parallel to each other. Third, they are in the same phase which is called coherent. (2) None of these properties are found in IPL. However, this broad spectrum provides IPL with a wider range of applications. Since the light is polychromatic cut-off filters are used to provide the light of a specific wavelength. The most commonly used filters are 515, 560, 590, 615, 640, 695, and 755nm. The skin contains different chromophores. A chromophore is an atom or group whose presence is responsible for the color of the compound or tissue. (3) Each chromophore absorbs light of different wavelengths which is responsible for the desirable effects of the Laser.

History:

By the 1990s Laser was established treatment for many skin conditions and eye diseases. Goldman, Fitzpatrick, and his team conducted experiments on the veins of rabbit ears and successfully photocoagulated the veins by the intense light of wavelength of 585 nm, in 1990. (4) He published his study in a journal in the same year. However, in humans, it produced collateral damage to the skin and led to pigmentary changes. They modified the design of their pulsed light device with the help of an aerospace engineer, Echouse. This modified design could protect the epidermis. They again conducted experiments on the veins of the rabbit ear in 1992. The results were encouraging; they were able to photo-coagulate the veins of rabbit ears. (5) This was a major step in the development of IPL. Later on, they used it in human subjects to treat leg veins and port wine stains with cut-off filters of 550, 570, and 590 nm wavelengths. Which effectively blocked superficial wavelengths. They started using external cooling in the form of cold USG jelly. IPL started getting wider acceptance and more cut-off filters were added to the armamentarium to treat more clinical conditions.

Mechanism of Action:

IPL has different tissue reactions depending on the cut-off filter and chromophore. Most of the desirable results are due to photothermal effects. It is vital to understand a few more concepts to understand the involved science in treating skin conditions.

Wavelength: Emitted spectrum in IPL ranges from 400-1400 nm.

Cut-Off Filter: Different filters are available which can block the shorter wavelength spectrum. Commonly used filters are 515, 560, 590, 615, 640, 695, and 755nm.

Chromophore: Chromophore is an atom or group whose presence is responsible for the color of a compound or tissue for example Melanin is a dark-colored compound that gives black color to skin and hair follicles. Hemoglobin gives red color to the blood.

Thermal Relaxation Time: It is the time required for the temperature in a heated tissue to decrease to 37% of its peak. (6) TRT is typically kept at 10-40 ms. Higher TRT is kept for darker-skinned people.

Pulse Duration: The duration in which energy is absorbed by the chromophore. Pulse duration is based on the thermal relaxation time (TRT) of the chromophore. To minimize the thermal damage to the adjoining tissues Pulse duration should be less than TRT.

Fluence: It is the energy delivered in a unit area. The unit is Joule per square cm (J/cm^2). Clinically used IPL can deliver energy up to $40 J/cm^2$. Deeper tissues are targeted with higher fluence.

Cooling Methods: The flip side of using higher energy is the thermal damage to the upper layer of the skin i.e. epidermis. To avoid this side effect internal or external cooling device or method can be used. Internal cooling devices include using chilled tips. External devices can be using cool ultrasound gel or ice packs.

Spot Size: It is the diameter of the light emitted from the IPL. Smaller spot-sized light scatters more hence higher energy has to be used to get deeper penetration.

Density: It is the number of beams per square cm. It ranges from 50-350 / cm^2 . Higher density delivers higher energy.

IPL Machine: It has the following parts:

- Capacitor Bank
- Cooling System
- Handpiece
- Flash Lamp
- Cut-off filter

Light guide

- Control Panel

Figure 1 shows the IPL machine with Hand Piece. Figure 2 shows the hand piece with cut-off filter. Figure 3 shows the control monitor.

Preparation for IPL Treatment:

The diagnosis and treatment plan is discussed with the patient. The individual is explained about the Procedure. Pre-procedure preparations are explained in detail for example for hair removal the individual is asked not to go ahead with waxing at least two weeks before the procedure. Shaving is to be done in the areas to be addressed for hair removal. Local anesthetic cream is applied 30-45 minutes before the procedure. Cream is wiped out and the individual is shifted to the Laser room. Adequate privacy is maintained during the whole procedure.

Protection: IPL has side effects on the eyes and it can affect the retina of the eyes. Hence, protective eyewear is used by both the patient and the person doing the IPL.

How IPL is done:

Once an individual comes to the Laser suite, an appropriate position is made. The IPL procedure is explained. Appropriate settings and the right cut-off filter are used. Cold ultrasound gel is applied. Energy is delivered to the desired areas through the handpiece. At the end of the session, the individual is sent home with the necessary instructions.

Common Conditions in which IPL is used:

1. **Hair Removal:** IPL is widely used for unwanted body hair removal. As discussed earlier, goal is to selectively target the Melanin. Melanin is present in the skin and in hair follicles so to target melanin present in the hair follicles, which is deeper, light of higher wavelength is used. Most frequently used wavelengths are 695nm and 755nm. With this knowledge, it is obvious that black or dark brown dense and coarse hair are more responsive to IPL treatment. Hair shaft and follicle contain higher concentration of melanin. Once Melanin absorb the light, it is converted into thermal energy which lead to the death of the hair follicle. Skin also contains melanin. To protect the skin from thermal damage pulse is delivered in multiple mini pulses with higher thermal relaxation time between these pulses. Generally, 4-8 sittings are required with a gap of 4 weeks. The whole procedure is performed after application of anaesthetic cream. Proper eye protection is taken to avoid any side effects to vision.

2. **Pigmented Lesions:** Pigmentary changes are common due to aging and chronic sun exposure. Target pigment is the melanin and wavelengths of 630-1100nm are used. Thermal energy leads to faster differentiation of the melanin producing cells. They migrate upwards towards the epidermis along with the deposited pigments. In this way these pigmented deposits are removed from the body as crusts.

3. **Wrinkles and Aging Changes:** IPL is a popular non-surgical method of facial rejuvenation. In this thermal changes lead to tightening of the collagen fibres which decreases the laxity and wrinkling associated with aging. IPL also induces the new collagen synthesis by the cells known as fibroblasts.

4. **Vascular Lesions:** The blood vessels in the skin can be targeted by the IPL. Here hemoglobin is targeted. When light of a specific wavelength is absorbed by hemoglobin it leads to thermal changes and photo necrosis of the involved small vessels. Later on, this dead tissue is removed by the body cells.

Conclusion:

IPL is a versatile tool to treat a number of conditions which is based on sound principles of biophysics. It is safe and effective in hair removal and treating pigmented and vascular lesions. Photo rejuvenation is another useful indication of IPL. A better understanding of wavelengths and their biological effects is still an evolving field in which many advancements are likely to be seen in time ahead.

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Figure1: Multi Lasers with IPL

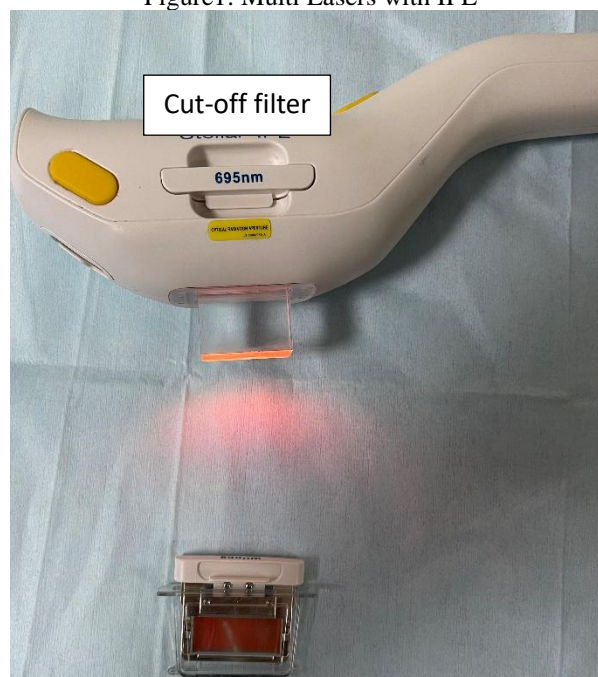


Figure 2 : Hand piece

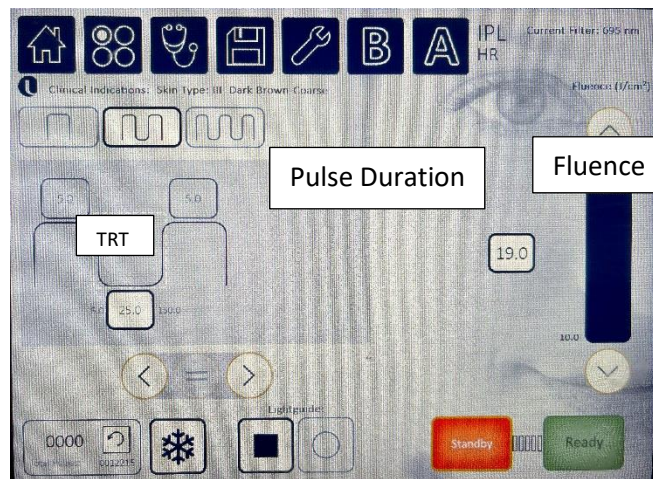


Figure 3: Control Monitor