Intense Pulsed Light (IPL) in Aesthetic Photomedicine

By Matthew Redding February 2004

In the last issue we looked at the principles of Photomedicine, in particular the nature and properties of light and how light interacts with the chromophores or targets in the skin.

This article looks at two of the most common applications for IPL in Aesthetic Practice:

- Permanent Hair Reduction &
- Resolution of superficial vascular lesions

Photo-epilation – Hair Removal

Cultural norms in many countries throughout the world dictate that excessive or visible hair on certain areas of the body is problematic at worst and unattractive at best. Many institutions concern themselves with the removal and management of hair using variety of techniques which range from very short term to long term.

There are various methods of hair removal which include shaving, waxing and electrolysis. In recent years however, laser hair removal has grown in popularity. Photo-epilation (hair removal using light) has been shown to be very effective, arguably resulting in the most long lasting clearance of any hair removal treatment. The ruby laser was one of the first lasers to be utilised for this application but other systems such as Alexandrite or Nd:YAG have also shown good results. Intense Pulsed Light systems, have also proved to be very successful in this area of dermatology. Long term hair removal using IPL systems has been reported to be relatively pain free and have minimal side effects whilst achieving excellent results. Also the much larger treatment area offered by IPL systems makes the treatment less time consuming and more cost effective for both the practitioner and client.

Principles of Photo-epilation

In order to achieve long term hair loss the hair follicle itself must be damaged or destroyed in order to inhibit or prevent re-growth. Irreversible thermal damage to the hair follicle is sufficient to prevent re-growth and is the goal of photo-epilation. The method utilised to heat the hair follicle relies on the absorption of light in the chromophore, melanin. Melanin is present in most hair shafts and, to a certain extent, the hair follicle itself. Melanin absorbs a broad range of wavelengths of light as shown by the absorption curve depicted in Figure 2.

Light directed at the skin is absorbed by the melanin in the hair shaft and produces heat which then conducts down the shaft and outwards into the surrounding follicle (Figure 1).

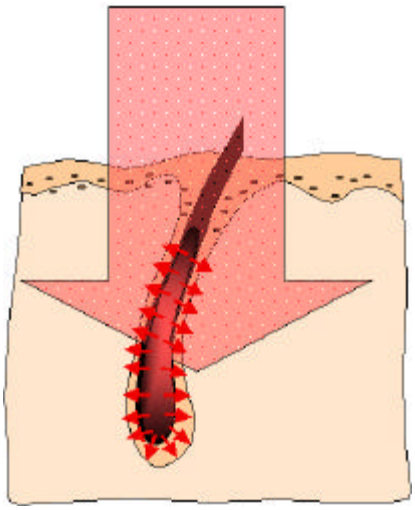


Figure 1

If the heating effect is sufficient then the hair follicle is damaged to the extent that re-growth is inhibited or prevented and long term hair removal is achieved. The key parameters of the light we manage for successful photo-epilation are the wavelength, pulse duration and fluence.

The ideal wavelength choice is derived from Figure 2 and as the graph indicates, there is a broad range of suitable wavelengths. The wide absorption band of melanin means that the broad band spectral output of an IPL system is ideally suited for this application. The main consideration is to avoid unwanted absorption in blood or water and to have wavelengths that are long enough to penetrate deeply enough to be absorbed in the follicle. Most IPL systems utilise wavelengths in the range between 600nm to 1100nm for hair removal.

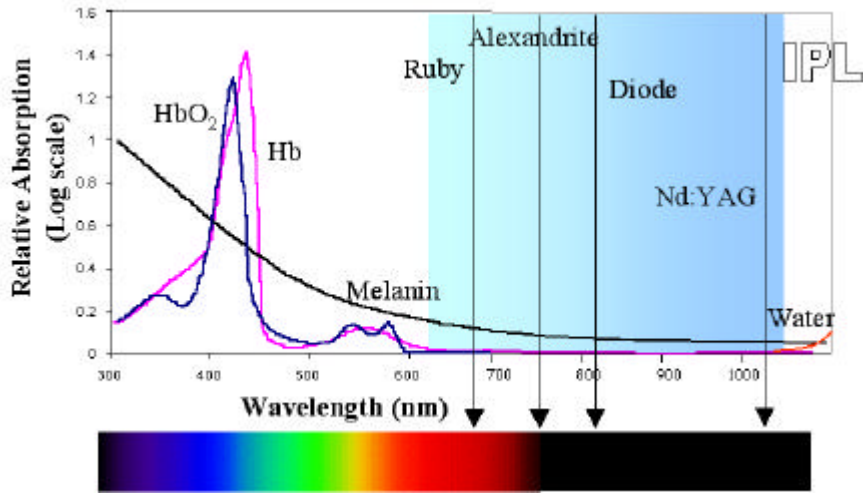


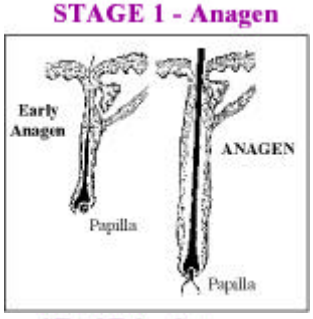
Figure 2

The pulse duration (pulse width) should be equal to or less than the thermal relaxation time for the hair follicles. The exact thermal relaxation time for a population of hair follicles is impossible to calculate as there will be variations in sizes and shapes of the follicle (the physical size of an object is used to determine it's thermal relaxation time). However, it is generally thought that a pulse length of the order of tens of milliseconds is suitable. The majority of lasers and Flashlamp systems used for epilation have pulse lengths which vary between 1 – 100 ms. The fluence required to achieve follicular damage is largely determined from experiment and will often vary significantly depending upon various factors. The skin type (Fitzpatrick scale) and the colour of hair are major factors in determining a suitable fluence. However, there are also variations due to the parameters of a particular IPL system.

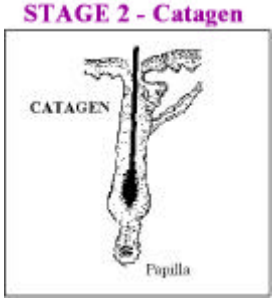
The process of photo-epilation is faced with a conflict between light absorption in the melanin found in the hair shaft and melanin existing around the epidermal/dermal boundary which varies in concentration depending upon the skin type. Dark skinned people (skin type V or VI on the Fitzpatrick scale) have a high melanin content in the skin whereas pale skin (skin type I or II) contains very little melanin. Absorption of light in the epidermal region will cause a heating effect that may result in undesirable tissue damage. The delivery of light from the IPL system should utilise a multiple pulse which aims to reduce the heating effect in the epidermis. The epidermis is able to cool more rapidly than a hair follicle in other words, the epidermis has a shorter relaxation time. The light is delivered in a pulse train which consists of a succession of short pulses with a delay between each one. The delay time is long enough to allow the epidermis to cool but it is short enough to have little cooling effect on the hair follicle. Thus over the entire pulse sequence (typically 3 – 5 pulses) the hair follicle increases in temperature yet the epidermis is able to remain cooler and a temperature differential is established which will damage the follicle without damaging the epidermis.

In order to understand this process it is important to understand the normal hair growth cycle which occurs in three distinct phases.

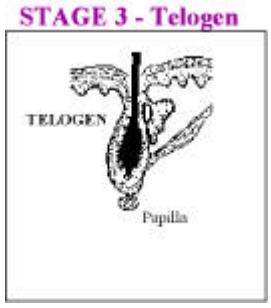
1. **Anagen** – the stage at which hairs are in active growth and attached to the papilla. (Figure 3)



2. **Catagen** – the stage at which the hair growth is arrested but the hair continues to be nourished from the papilla. (Figure 4)



3. **Telogen** – the stage at which the hair growth creases altogether, the hair detaches from the papilla and contracts to almost one-third its original depth. The hair then falls out and the process begins once more with early anagen phase. (Figure 5)



The most important phase for laser assisted or IPL hair removal is early anagen, at this time the hair is connected to and nourished by the papilla and is still relatively close to the surface. At this time it is possible to deposit sufficient energy into the hair shaft, the papilla and the hair bulb to cause permanent damage which will delay or prevent future hair re-growth. It is because of the need to treat hair in this early anagen phase that several treatments are always required to successfully target an entire area. The use of lasers and IPL sources to remove hair depends on the absorption of laser light by the melanin contained in the hair in preference to absorption by melanin in the skin, for this reason only hair containing melanin can be treated.

As it is usual for melanin to exist in the epidermis, at the junction between the epidermis and the dermis, within the dermis as well as within the hair then the process can become quite complex. It is essential however that the hair is darker than the skin for preferential absorption to occur. The best results will normally be seen in patients with dark hair and fair skin, Fitzpatrick type VI should not be treated using IPL. Cooling the skin before, during and after treatment can reduce damage to the epidermis.

The percentage of hairs in each stage of the cycle, as well as the duration of each phase will vary for different body sites and for different people. As only a portion of the follicle population is treated in each session it is critical that the client understands that between 6 and 10 treatments may be necessary for good clearance and that the treatments must be spaced adequately to allow untreated follicles time to move into the anagen phase. Different areas of the body have different cycles and individuals vary considerably. As useful guide to treatment spacing is:

- Face Area = 3 to 4 weeks
- Bikini/under arms = 4 - 6 weeks
- Legs/backs = 6 - 8 weeks

However spacing is only approximate, if in doubt advise 4 - 6 weeks.

IPL Treatment of Vascular Lesions

What is a vascular Lesion?

Vascular lesions are characterise by red discolouration of the skin and are caused by vessels or capillaries that are either too large, too near the skin surface or both. Different lesions are formed by different vascular "arrangements" and may present as a diffuse, general redness or discrete vessels may be visible.

Important factors in treatment with light are the 3 D's

Depth How deep below the surface of the skin is the lesion. Superficial lesions are very responsive to IPL however deeper vessels may respond better to laser treatment.

Diameter What is the size of the vessels. IPL treats smaller vessels well but larger vessels may need to be treated with either laser, chemicals or surgery.

Density How many vessels make up the lesion and how close together are they. Some lesions such as Port Wine Stain lesion are quite dense and can be resistant to treatment, or need multiple treatments.

The various forms of vascular lesions, including rosacea and telangiectasia, are some of the most common cosmetic concerns for clients. In recent years, a vast array of pulsed and continuous lasers such as the KTP laser, the pulsed dye laser and the frequency-doubled Nd:YAG laser have been used to treat these vascular lesions. Although these laser treatments have been successful to varying degrees, depending on the type of laser used and the clinical indication, at times patients find results disappointing and the various side effects, such as pronounced purpura or bruising (associated with vessel rupture) and pigmentary changes, to be disturbing – especially with facial treatments. Recently, intense pulsed light (IPL) treatment has proved highly successful in the treatment of facial vascular lesions.

IPL systems operate on the principle of selective photothermolysis in which target vessels are selectively damaged with minimal damage to surrounding healthy tissue. IPL systems target the absorption peaks of haemoglobin and oxy-haemoglobin by including wavelengths from around 550nm (see Figure 2). In addition, the IPL should provide a multiple pulsing facility with variable inter-pulse spacing allowing the user to select appropriate parameters to treat vessels of different sizes and at different depths Hence, the IPL system, predominantly targets blood vessels by delivering sufficient energy to thermo coagulate the entire vessel while causing minimal damage to the surrounding skin. Following treatment, the damaged vessels are absorbed by the body and little or no trace of the initial lesion remains.

With laser treatment a single wavelength of light (say 577nm) is utilised, whereas IPL utilises multiple wavelengths. As different wavelengths have different penetration there is a more even absorption of light across the vessel. A Monte Carlo numerical analysis (Figure 6) performed to describe the absorption of different types of light sources within blood vessels, shows that light absorption across the vessel (plotted on the vertical axis) is more uniform for broadband radiation than for a 577nm laser source. This feature means that there is more even thermo-coagulation and less vessel rupture. Associated purpura, are less likely with treatments using IPL systems than with lasers.

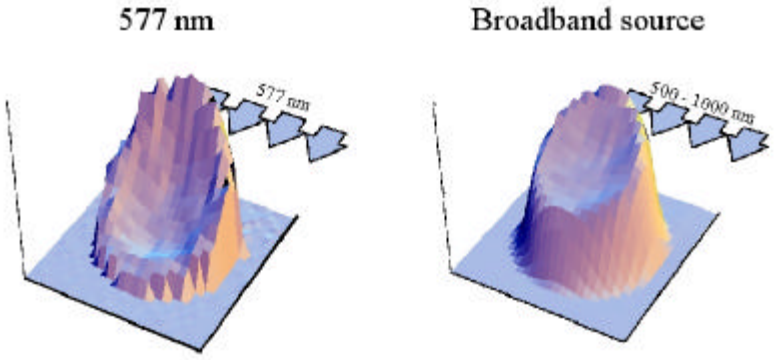


Figure 6

The capillary walls remain intact. (Figure 7)

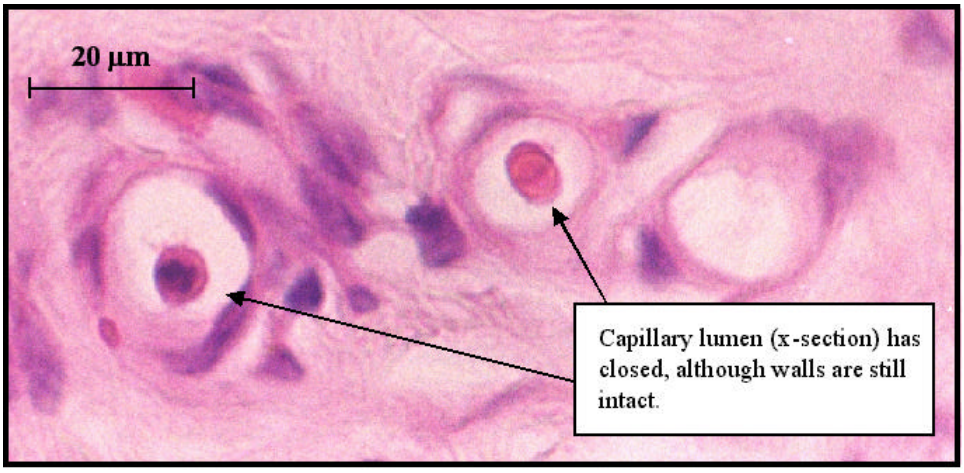


Figure 7

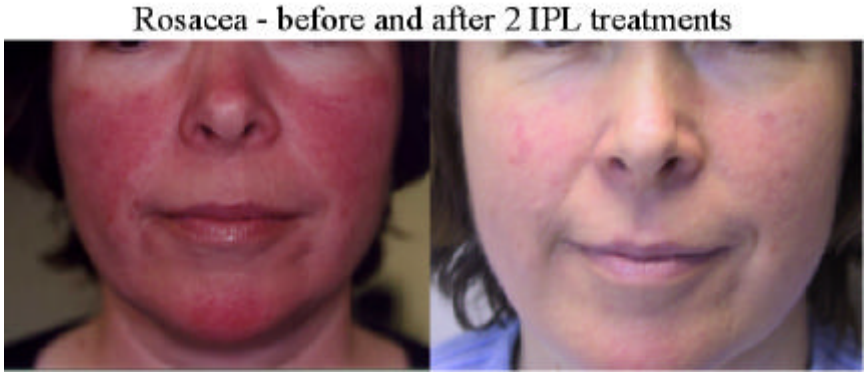


Figure 8

Vascular IPL treatments differ from hair removal in that an immediate effect can often be seen. When the light is absorbed in the vessel the blood immediately thermo-coagulates, resulting in a blanching or greying of the vessel. Over the next few weeks the necrotic tissue is absorbed as part of the body's normal physiological process. The complexity of the lesion (3 D's) will determine how many treatments are necessary. Often good results are achieved with as few as 1 – 3 treatments, however resistant lesions (e.g. PWS) may require more. Treatment spacing should be around 4 weeks to allow the body time to absorb the destroyed tissue.

Revascularisation may occur however usually with smaller and less visible capillaries, which can be re treated.

The next article will look at other applications of IPL in Aesthetic Photomedicine, in particular Skin Rejuvenation, Superficial Pigmentation and Inflammatory Acne. In the future we will cover the practical aspects of IPL treatment and running an IPL clinic.

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Matthew is a qualified Medical Radiographer and has worked extensively within healthcare and engineering environments in clinical, education and senior management roles. He also holds a Bachelor of Business degree with a major in management and a minor in applied science. He is a director of Medical Technologies, a company with over 14 years experience with medical lasers and manages their LightLogic Division. He has studied laser and IPL physics and physiology in the UK.