White Paper

Elite MPX™: Combining Single and Sequential Emissions of Wavelengths for Photoepilation of Hair

Raminder K. Saluja, MD
Presbyterian Cosmetic Laser Center, Cornelius, NC

Summary

Laser hair destruction was first observed by Dr. Leon Goldman in the 1960s[1] but it was not put to use for decades until the first photoepilation was attempted on human subjects in 1996.

Photoepilation was made possible by the theory of selective photothermolysis.[2,3] By following the tenants of selective photothermolysis and understanding the science of optical irradiation and tissue interaction, the structures responsible for hair growth (bulge and the bulb) can be targeted without damage to the epithelium.[4]

The primary goal of laser hair removal is to target the hair bulge, bulb, and entire follicular epithelium while sparing the epidermis.[5]

Anatomy and Biology of Hair

The three primary components of the hair follicle are the infundibulum, isthmus and hair bulb. The hair bulb is located approximately 4 mm from the skin's surface and therefore the wavelength of the laser or light source selected must traverse this distance to effectively deposit energy in the follicle.[6]

The ability of the wavelengths within the optical spectrum of 600-1100 nm to damage the hair follicle is related to the type and amount of melanin located in the follicle. Melanin is found in the hair shaft, the outer root sheath of the infundibulum, and the matrix area.[7] Pheomelanin is primarily found in red hair and does not absorb the wavelengths of energy as effectively as eumelanin, which is found in darker hair. If the follicle has diminished amounts of melanin, as seen in blonde or grey hair, then absorption within the optical spectrum of 600-1100 nm will be negligible.

Follicular melanocytes differ from epidermal melanocytes in that they contain more melanosomes. Keratinocytes in the epidermis have a ratio of one melanocyte per 25 keratinocytes, while the hair matrix has a ratio of 1:5.[8]

The increased ratio of melanocytes within the hair follicle is advantageous for laser hair removal.

Hair Cycle

The hair cycle is characterized by cyclical periods of growth and rest. The growth phase is termed anagen and the rest phase is telogen. The transition between growth and rest is catagen.[8] During the different growth periods, the histological appearance of the hair follicle differs dramatically.[9] The presence of melanin is highest during the anagen phase. During this phase, the follicle also penetrates the deepest in the skin, typically to the level of subcutaneous fat. Depending on the thickness of the skin, this depth can vary from 2 to 7 mm.[8]

If shorter wavelengths are used solely during this period, the energy may not be delivered to the bulb, which would result in a lack of germinative cell damage, correlating clinically to inefficient hair removal.[9]

Mechanism of Hair follicle Destruction

There are three basic mechanisms by which light can induce destruction in tissue.

1. Thermal destruction which causes coagulation and vaporization due to local and preferential heating. This method of destruction is based on the principle of selective photothermolysis.[2,3]
2. Mechanical destruction which is a result of shock waves that cause violent cavitation, due to extremely rapid thermal expansion. This involves the application of an external chromophore such ASM carbon in a topical suspension. [11, 12]
3. Photochemical injury is due to destructive oxidation by singlet oxygen or free radicals.[2,3,11,12] This involves the administration of a photodynamic agent followed by exposure to light.

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The primary target for the above mechanisms of destruction are the multipotential cells located in the bulge region of the follicle, which play a vital role in the formation of new anagen hair follicles.[6]

The Role of Wavelengths

The Cynosure Elite MPX laser system includes the 755 nm Alexandrite wavelength and 1064 nm neodymium yttrium aluminum garnet (Nd:YAG) wavelengths, which can be deployed separately or titrated in a multiplexed fashion to deliver optimal photoepilation to the hair follicle. It has the ability to deliver high fluences (up to 300 J/cm^2) and short or long pulse duration (up to 300 ms) that can be selected on the touch screen interface.

This system allows effective laser hair reduction for all patients with Fitzpatrick skin types I-VI.

Although melanosomes are vaporized at 694 nm through thermal confinement with low fluences, Ross et. al. suggested that melanosome should be heated in a slower fashion to allow for greater thermal diffusion to the follicle, while still minimizing heat diffusion to the epidermis.

The 755 nm Alexandrite wavelength is less absorbed by epidermal melanin therefore the risk of epidermal damage is less than that seen with the 694 nm wavelength. The epidermis is further protected by an integrated air cooling device within the Elite MPX system. The effectiveness of the 755 nm wavelength for photoepilation has been substantiated by many studies.[13,14,15,16]

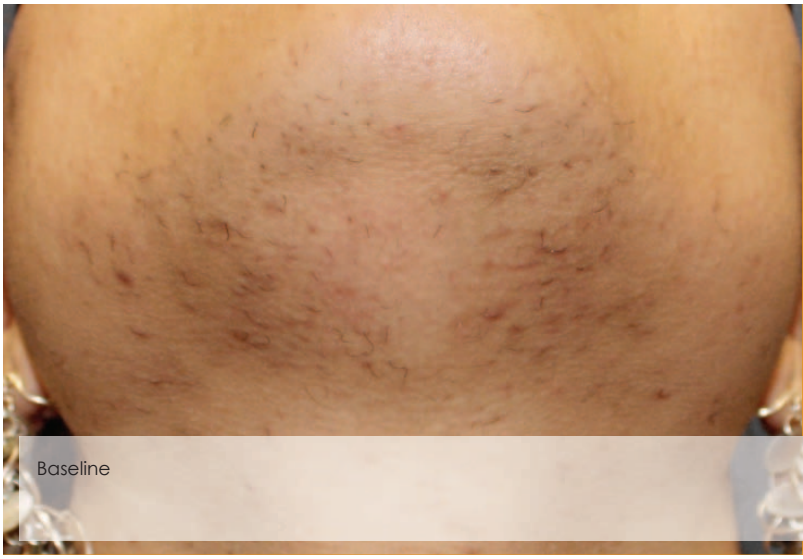
Color contrast between the epidermis and the hair shaft and bulb are critical in determining the optimal wavelength.[8] For high contrast (dark hair, light skin), the 755 nm wavelength can be used with minimal risk of damage to the epidermis. For lower contrast patients (lighter hair and darker skin), the obvious choice would be the 1064 nm Nd:YAG wavelength.

The 1064 Nd:YAG has a long wavelength which bypasses the epidermal melanin and delivers higher bulb to epidermal temperature ratio. This provides effective, yet safe, treatment options for Fitzpatrick skin types V and VI. This wavelength has also been shown to be effective in many studies.[17,18,19] A larger spot size and longer pulse duration increases the effectiveness by increasing depth of penetration and heat diffusion. Although quite effective for Fitzpatrick skin types V and VI, this wavelength can at times be painful to patients due to the increased depth of penetration.

Multiplex Technology

The Elite MPX features Cynosure's patented multiplex technology allowing the sequential emission of the 755 nm wavelength with the 1064 nm wavelength, which can be delivered from an array of handpieces. The integrated air cooling system protects the epithelium during treatment. The computerized panel allows for easy parameter changes, as well as for storing regularly used settings.

The multiplex system can deliver the 1064 nm wavelength first, which preheats the follicle and coagulates the deep vasculature feeding the follicle, while the 755 nm targets the melanin within the follicle. The proper combination allows for all Fitzpatrick skin types to be treated.



Note that the order of the wavelengths can be reversed, for example when treating leg telangectasia the 755 nm is delivered first to coinvert oxyhemoglobin to methemoglobin. This is followed by the 1064 nm with greater absorption coefficient for greater effect.

Advantage of MPX

The ideal phase for effective laser hair removal is during anagen. During this phase melanin concentration is the greatest for strong absorption characteristics with the 755 nm wavelength. The depth of the bulb during anagen starts as superficial but quickly moves deep in the tissue to the level of subcutaneous fat. The longer wavelength of the 1064 nm wavelength has the ability to penetrate the tissue and deliver energy to the deep seated follicle. During the anagen phase the hair follicle is well vascularized and therefore provides an additional target for the 1064 wavelength.

For these two reasons (melanin content and depth of penetration) it was hypothesized that the most effective laser treatment to destroy the follicle would be a combination of two wavelengths which could be selectively titrated, based on the patient's underlying skin type, to maximize melanin absorption (Alexandrite) and minimize patient discomfort, while also ensuring that adequate energy is delivered to the depth of the bulb (Nd:YAG). Thus, the Elite MPX was created.

Treatment Pearls

Taking into consideration the differing attributes of the 755 nm and 1064 nm wavelength, the multiplex mode can be tailored to target pigmented hair on patients with Fitzpatrick skin types I-IV.

(As a disclaimer, the Nd:YAG wavelength alone is still used to treat patients with Fitzpatrick skin type VI.)

On Fitzpatrick skin types I-III patients, the 755 nm wavelength is very effective for treating pigmented hair.[20] However, the multiplex may provide an added benefit when treating light brown hair that is minimally pigmented. The minimally pigmented hair will require additional fluence to be destroyed. Due to the high absorption of the 755 nm by melanin, caution must be used to spare the epidermis while destroying the follicle. When trying to increase the bulb temperature in patients

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with minimal melanin (very light brown hair), at times the epidermal temperature may supercede 70 degrees Celsius and adversely affect the epidermis. Minimally pigmented hair could therefore benefit from the addition fluence of 1064 nm, which is not as highly absorbed by melanin, to help increase the bulb epidermal heat ratio.

A 12 mm spot size is typically selected for the first treatment. A multiplex (MPX) setting is selected with the 755 nm, slightly below the level that would be used for a single-wavelength 755 nm treatment. That fluence is then supplemented by adding 10-12 J/cm^2 of the Nd:YAG wavelength. Both wavelengths' pulse durations are set at 10-30 ms. Settings are titrated depending on patient skin type and skin response..

If the patient is a Fitzpatrick skin type III, the complexion will be used to establish the blend of the two wavelengths. For skin type III a 50/50% blend is used (based on the Alexandrite settings) and the Nd:YAG wavelength is increased accordingly.

For subjects with Fitzpatrick skin type IV, the 1064 nm fluence is calculated and then the corresponding Multiplex fluence adding the 755 nm wavelength is set using a 50/50% blend or a 75/25% blend. At subsequent treatments, the fluence can be titrated by increasing the 1064 nm energy. The target endpoint is the visualization of slight perifollicular edema.

Fitzpatrick skin type V patients are treated cautiously with a small test pulse to see if the epidermis is able to accept a minimal fluence of the 755 nm in conjunction with the predominant 1064 nm settings. Multiplex settings are generally introduced on the third visit, when the hair diameter has reduced.

Large Treatment Zones

For patients with large treatment zones (male back), the 18 mm handpiece is generally used with one wavelength delivered with 2 Hz repetition rate. This decreases the treatment time significantly and allows for good penetration of the delivered energy due to the large spot size. Lower fluences are used with the large spot sizes as the depth of penetration is greater when using larger spot sizes.

Conclusion

The Elite MPX provides the ability to use either the 755 nm Alexandrite or the 1064 nm Nd:YAG wavelengths alone or to titrate the wavelengths and fire them sequentially to provide more efficient and effective hair removal on all patients including those with finer hair and darker skin.

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