REVIEW ARTICLE

Photodepilation

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Abstract. Unwanted hair is a common problem for which different types of light therapy have been developed as the treatment of choice. Since 1996, when the American Food and Drug Administration approved the first laser therapy for depilation, much progress has been made in light-based technology and lasers. Lasers and intense pulsed light sources with red or near infrared wavelengths (600 to 1200 nm) are the most widely used for removing hair as they target the melanin of the hair shaft, hair follicle epithelium, and hair matrix. The aim of this review is to describe and compare the different photodepilation methods currently available.

Key words: laser, photodepilation, hair removal.

FOTODEPILACIÓN

Abstract. Los pelos indeseados son un problema frecuente para el cual se han desarrollado diferentes tipos de luz como tratamiento de elección. Desde que en 1996 la *Food and Drug Administration* (FDA) aprobó el primer láser para depilar, se han hecho muchos avances en la tecnología basada en la luz y los láseres. Los láseres y las fuentes de luz intensa pulsada (IPL) con longitudes de onda en el espectro del rojo o casi el infrarrojo (de 600 a 1.200 nm) son los más utilizados para eliminar el pelo, ya que tienen como diana la melanina de la vaina del pelo, la del epitelio del folículo piloso y la de la matriz. El propósito de esta revisión es describir y comparar los diferentes métodos de fotodepilación disponibles actualmente.

Resumen: láser, fotodepilación, eliminación del pelo.

History of the Laser

In 1959, Maiman[1] used the concept of stimulated emission introduced by Albert Einstein[2] in 1917 to develop the first ever laser. However, L. Goldman was the real driving force behind the dermatological applications of this revolutionary technology, first proposing various uses for the ruby laser in different skin diseases in 1963.[3-5]

In 1984, Anderson and Parrish[6] introduced the concept of selective photothermolysis—a principle that revolutionized the underlying physical concepts for the medical application of light sources, and that has allowed for major advances in this technology over the past 2 decades.

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Physical Principles of Light-Tissue Interaction

Light is electromagnetic radiation that covers a broad spectrum of wavelengths (from x-rays to radio waves).

When we irradiate tissue—in this case the skin—with a light source, several significant physical phenomena occur (Figure 1). Because of the difference in refraction coefficients between air and the corneal epithelium, some of the radiation is reflected. Another part of the radiation transmitted or penetrating the tissue becomes dispersed. Finally, the radiation that reaches the target tissue can then be absorbed by this structure. Any target tissue or structure must contain a substance or molecule with the appropriate physical and chemical characteristics to absorb this radiation. A molecule that absorbs a given wavelength is known as a chromophore.

All of the medical applications of light sources are built upon the basic physical principle of absorption. Absorption of the radiation by the chromophore must take place in order for a biological reaction to occur. The

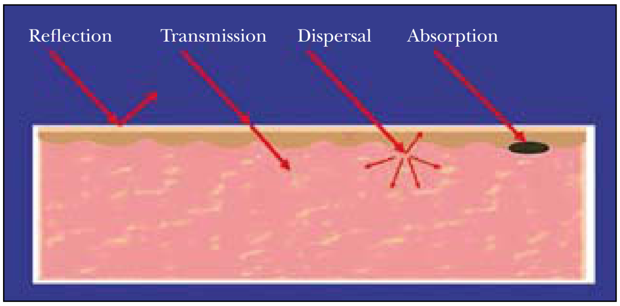

Figure 1. Diagram showing the different physical phenomena that occur when skin is irradiated with a light source.

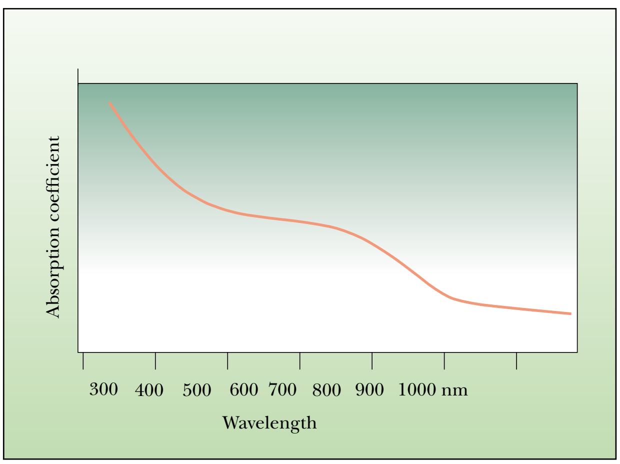

Figure 2. Diagram showing the relationship between wavelength and the absorption coefficient of melanin.

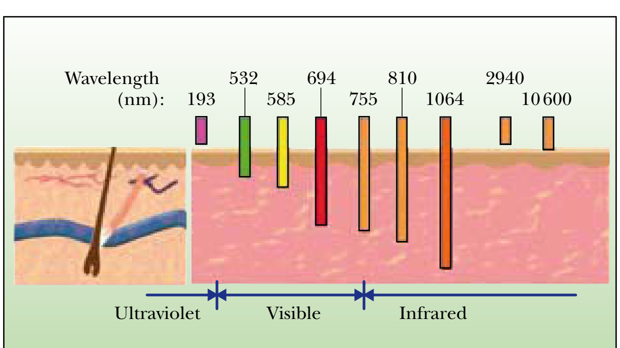

Figure 3. Diagram showing the relationship between wavelength and capacity for penetration into the skin.

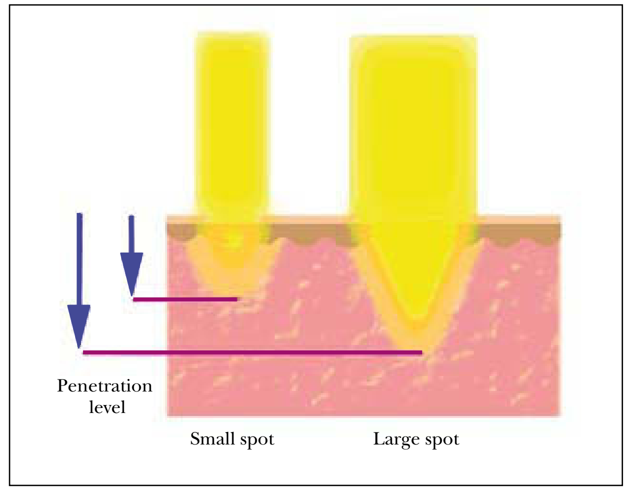

Figure 4. Diagram showing the relationship between spot size and the capacity for penetration into the skin by the same given wavelength.

energy provided in the radiation absorbed by the target tissue undergoes a transformation with several possible outcomes: photothermal (increase in temperature), photochemical (change in the molecular structure), photomechanical (thermal expansion producing sound waves), or fluorescence (emission of photons at another wavelength). In photodepilation, a photothermal effect is sought in order to raise the temperature of the follicular structure and thus destroy it.

Each chromophore has the capacity to absorb certain wavelengths. This is a very important fact as it is the absorption profile of the chromophore that will determine which wavelengths must be used to treat it. We therefore need to know at which wavelength the absorption peaks of each chromophore occur. Melanin is the target chromophore in photodepilation. This intracellular pigment is characterized by high absorption coefficients for all wavelengths in the visible spectrum but in an inverse relation to the wavelength, meaning the absorption coefficient decreases as the wavelength increases (Figure 2).

The wavelength of the radiation used is important not only because it determines the specificity for a given chromophore, but also because penetration depth is dependent upon this. At wavelengths within the low absorption index of water (400 to 1000nm), as the wavelength increases, dispersal within the dermis decreases, increasing the depth of penetration at that wavelength (Figure 3).

Although wavelength is the main factor determining the penetration depth of the radiation used, the size of the target area or spot is another parameter that may also impose limitations: the larger the spot, the deeper the penetration at any given wavelength (Figure 4). This is a result of the conical attenuation of the beam of light due to dispersal.

Selective Photothermolysis

As was stated above, this term was introduced by Anderson and Parrish[6] in 1984—a name that clearly indicates the objective of the selective destruction of a tissue structure by an increase in temperature induced by a light source. There are 3 significant parameters to be taken into account in achieving selective photothermolysis.

1. Suitable wavelength. The wavelength must be absorbed by the target chromophore and must have the capacity to penetrate to the depth at which the chromophore is found.
2. Pulse duration. The duration of exposure of the chromophore to the light beam must be lower than its thermal relaxation time (TRT). The TRT is the time it takes for the temperature of the chromophore to decrease to 50% of peak following exposure to radiation. The chromophore cools by heat dispersal to the surrounding tissue, meaning that the TRT really indicates when the radiation applied will induce a raised temperature in the surrounding tissues by transmission of the heat generated within the target area. As we aim to avoid damage to the surrounding tissue, we must ensure that the pulse does not exceed the TRT. The TRT is generally directly proportional to the size of the target tissue.
3. Sufficient fluence. The energy density administered in the exposure time (measured in J/cm^2) must be sufficient to result in destruction of the target tissue.

Types of Light Source in Dermatology

There are 2 fundamental types of device used in treatment with light sources:

Laser

The term "laser" is an acronym for "light amplification by stimulated emission of radiation." These devices use a solid, liquid, gas, or diode medium that is stimulated by a given energy source to generate photons. The main characteristics of the light emitted by these devices are that it is monochromatic (emitting only one or a few wavelengths), coherent in time and space (all the peaks and troughs of the waves coincide in time—meaning they are in phase), and collimated (all the waves emitted are parallel and travel in the same direction).

Intense Pulsed Light

Intense pulsed light is differentiated from laser light in that it is polychromatic (the radiation emitted includes various wavelengths, that commonly range from 400 to 1500 nm) and is not spatially or temporally coherent (the waves are neither in phase nor parallel).

Physical Principles of Photodepilation

Unwanted hair growth can be caused by factors ranging from hereditary conditions and hormonal abnormalities to the use of certain drugs. Traditional forms of depilation, including shaving, plucking, waxing, and depilatory creams can cause irritation and do not result in any permanent reduction in the number of follicles.[7,8] Before photodepilation systems were introduced, electrolysis was the only method capable of achieving this type of reduction, although there was some inherent risk of scarring or pigmentation problems.[9,10]

In 1996, the American Food and Drug Administration approved the first system for permanent photodepilation. Since then there have been a great many improvements made in both the equipment and treatment protocols.

Photodepilation is an effective system for the progressive and long-term reduction of unwanted hair. However, the term "definitive depilation" is an overstatement, as this implies the permanent elimination of 100% of the hair in the treated area. Current technology is unable to achieve this objective because it is statistically impossible to eliminate 100% of the hair, and there may also be undeveloped follicular structures—especially on the face—that can be activated by hormonal changes or the use of certain drugs. In such situations "new" hair may be seen to appear in previously depilated areas. Hence terms such as "long-term" or "semi-permanent" depilation are preferable.

As was said before, the radiation must be absorbed in order for a biological response to occur. In photodepilation the target chromophore is the melanin within the follicle. For a permanent reduction of the follicular structures to be achieved, the germinal matrix (bulb and dermal papilla) of the follicle must be damaged, although these are by their nature unpigmented structures. The melanin that absorbs the radiation is found in the hair shaft, follicular epithelium, and hair matrix. These are the structures that will absorb the radiation applied. The heat generated must be conducted to the germinal matrix from the pigmented structures in order to cause damage. The germinal matrix and pigmented structures must be in close proximity or contact for the heat to conduct, a situation that only occurs during the anagen phase of development. Hence, only those follicles currently in this growth phase will be definitively eliminated in any given photodepilation session. The remaining follicles will show delayed regrowth in comparison with other untreated areas.

The percentage of hairs in the anagen phase can vary depending on the anatomic area, resulting in differential responses according to the area involved and a variation in the number of sessions needed to achieve similar outcomes.

Light sources and lasers commonly used in photodepilation emit radiation in the red or near infrared spectrum (600-1200 nm).

Melanin presents adequate absorption coefficients[11-14] and dermal penetration capacity at these wavelengths.[15]

Recent Changes to the Traditional Concept of Photodepilation

Photodepilation of Nonpigmented Hair

As has already been stated above, the main target chromophore in photodepilation is melanin. As treatment is based on selective photothermolysis, only hair pigmented with melanin can be successfully treated by photodepilation. The absence of melanin in unpigmented hairs or the presence of other pigments (pheomelanin) that are unable to absorb the radiation will result in a lack of biological response to this treatment. A series of recent reports examined the use of other sources of light and radio frequency devices to eliminate unpigmented hair.[16-18] Many of these studies present excessively short follow-up periods or are funded by companies marketing the equipment—a point that implies a potential lack of objectivity in the evaluations. Only time will tell if these observations will lead to new treatments for patients with little or no pigment in their hair who are unable to benefit from the current technology.

Super Hair Removal

A new photodepilation technique has been developed recently applying a different principle than selective thermolysis. The effectiveness of this technique is based on raising the temperature of the hair follicle and dermis in a nonselective manner to sublethal temperatures of around 45°C. Maintaining this lower temperature for longer periods of time than those used for conventional photodepilation should cause damage to the follicular structures leading to their progressive destruction. The prototype equipment for this method uses an 810 nm diode laser. This emits pulses of short duration and low fluence (10 J/cm^2), but at a high frequency (10 Hz). The application of successive sweeps with these pulse trains induces a progressive increase in temperature until the desired levels are reached.

Diffuse heating of the dermis and the thermal equilibrium established with the follicle could provide a new approach to the treatment of small follicles with little pigment—these were notoriously difficult to treat with traditional technologies that depend on the presence of a chromophore in the follicle for their success. Although some apparently good outcomes have been presented to date, the validity of this new technology has not been confirmed as none of the trials have followed scientific protocols or provided sufficient follow-up times.

Extended Theory of Selective Photothermolysis

Apart from wavelength, another determining parameter of the effectiveness of photodepilation is the pulse duration.[19,20] In order to reduce thermal damage to surrounding tissue, the pulse duration must be lower than the TRT of the hair follicle—a time that varies between 10 and 60 milliseconds depending on the diameter of the follicle.[6,13,19] Hence most photodepilation systems are capable of emitting pulse radiation in the range of 10 to 100 milliseconds.

As was stated above, the germinal structures responsible for follicle regrowth are some distance from the pigmented structures that are the true targets of the radiation applied. Some authors propose the use of longer pulse durations than the follicle TRT in order to allow for thermal transmission from the pigmented targets to the germinal matrix and to thus achieve more effective depilation.[20] This concept forms part of an extended theory of selective photothermolysis that considers the possibility of destroying follicular targets through heat diffusion from the pigmented zones of neighboring structures rather than by the direct application of heat to the targets themselves.[21] Some published reports use pulse durations of more than 100 milliseconds, and these have achieved long-term depilation with no side effects.[22,23]

Other Prior Considerations

Photodepilation and Dark Phototypes

The presence of melanin in the epidermis implies the possibility of the absorption of radiation used at this level and consequently implies a risk of burning, scarring, and alterations in pigmentation. This risk increases as the amount of epidermal pigment increases, with a higher risk of side effects in dark phototypes or tanned skins. Consequently, these treatments are traditionally not recommended at times of year when the patient is likely to experience intense exposure to ultraviolet radiation. This risk is also directly proportional to the affinity of the melanin for the form of radiation employed. Thus, shorter wavelengths (intense pulsed light [ILP], ruby laser, alexandrite laser) are not recommended in dark phototypes and during summer seasons when longer wavelengths (diode laser and neodymium: yttrium-aluminum-garnet [Nd: YAG] laser) are safer.

Photodepilation equipment uses cooling systems based on the application of transparent conductive gels, cryogen sprays, cold air flows, or contact cooling systems to minimize the risk of epidermal damage. Apart from reducing the skin temperature and minimizing the risk of burning, the anesthetic effect of cooling reduces the pain associated with the treatment[24,25] and allows for the administration of higher fluences to optimize outcomes.

The use of longer pulses is another mechanism that helps reduce the risk of burns in patients with a dark phototype. The TRT of the epidermis is approximately 10 milliseconds. Emission of radiation in pulses of a duration above this limit allows the heat to disperse into neighboring structures, and, when applied in conjunction with cooling systems, excessive concentration of heat is avoided.

Light Sources in Photodepilation

There are currently several lasers and IPL systems that emit energy at wavelengths and with pulse durations suitable for use in photodepilation. The systems approved for photodepilation by the FDA include long-pulsed ruby (694 nm), long-pulsed alexandrite (755 nm), diode (800-810 nm), and Q-switched and long-pulsed Nd:YAG (1064 nm) lasers; and IPL sources (590-1200 nm).

Long-Pulsed Ruby Laser (694 nm)

The first controlled clinical trial to use the long-pulsed ruby laser for photodepilation was published by Grossman et al.[26] This team treated 13 dark-haired patients with a spot size of 6 mm and fluences of between 20 and 60 J/cm^2 on the back and thighs. Biopsies taken immediately following treatment showed the presence of selective thermal damage in the pigmented hair follicles, and biopsies taken 2 years later showed an increase in the number of follicles that had reduced in size, similar to findings in androgenetic alopecia.[27] Since then many studies[11,28-31] have shown reductions of between 20% and 60% in hair 3 months after a single treatment using different pulse durations and fluences. This percentage increases with the number of sessions. The side effects described with this type of laser include the appearance of blisters, crusts, purpura, transitory hypo- and hyperpigmentation due to heating of the epidermal melanin—an element more common in dark phototypes or tanned skins.

Although this wavelength was initially amongst the most popular options used, it is not commonly offered for permanent hair removal in the present market.

Long-Pulsed Alexandrite Laser (755 nm)

The alexandrite laser has a wavelength of 755 nm that offers a slightly better penetration capacity and a lower melanin absorption coefficient than the ruby laser. Several studies have obtained reductions of between 20% and 50% after a single treatment session using this wavelength.[32,33] Pulse durations recommended by the marketed equipment tend to range from 5 and 20 milliseconds. The use of longer pulses helps minimize the risk of burns, which reduces side effects.[34] Although some studies have shown the safety of this laser,[35-39] absorption by melanin at this wavelength is still relatively high. Consequently, conservative use is recommended in patients with dark phototypes or tanned skins due to the risk of blisters or secondary hyperpigmentations.

Although it has traditionally been considered the most effective laser for photodepilation procedures, more recent prospective and randomized studies have found no significant differences in effectiveness between the various wavelengths available—as will be explained further on.

Diode Laser

The semiconductor diode laser emits radiation between 800 and 810 nm in the electromagnetic spectrum. Melanin has a high enough absorption coefficient at this wavelength to warrant use in photodepiliation, although the absorption coefficient is lower than that of lower wavelengths—such as the ruby or alexandrite lasers. This is responsible for a somewhat better safety profile in patients with dark phototypes. Several studies[38-42] have shown its effectiveness in these cases. In a prospective study with 50 patients with phototypes II and III, Lou et al[41] showed follicle growth ranging between 47% and 66% at 6 months after 2 sessions of treatment. Other studies have shown this laser to provide effective photodepilation in patients with dark phototypes and in specific conditions such as pseudofolliculitis barbae.[43] Despite proven safety in patients with darker phototypes, the still relatively high absorption of this wavelength by melanin could be the cause of some reports of transitory hypo- or hyperpigmentation in these patients.

Nd:YAG Laser

There are less cases of purpura, blisters, crusts, and alterations in pigmentation with the Nd:YAG laser precisely because the 1064 nm wavelength is absorbed less effectively by the endogenous melanin.

The first photodepilation devices marketed in the United States used this wavelength, but in the ultra-short pulsed or Q-switched mode (pulse duration in the range of nanoseconds). Despite giving satisfactory initial results[44,45] they proved ineffective in achieving long-term reductions in hair growth. Devices currently using this wavelength apply pulse durations in the range of milliseconds (long-pulsed Nd:YAG), closer to the TRT of the hair follicle. Several studies have shown the effectiveness of long-pulsed Nd:YAG lasers in long-term hair reduction, above all in patients with dark phototypes.[46-48]

Melanin presents lower absorption coefficients for this wavelength than those of the lasers cited earlier. This reduced absorption means a lower risk of burns and consequent secondary hypo- and hyperpigmentation or scarring in high phototypes or tanned skins. In fact, this was the first wavelength approved by the FDA for use in photodepilation in dark phototypes. However, given that melanin is also the chromophore of the target tissue (the follicle), this lower absorption coefficient implies the need for higher fluences than those used at other wavelengths if effective heating of the follicular structures is to be achieved. Although recent studies do not show significant differences in effectiveness between the wavelengths of the lasers mentioned earlier and the Nd:YAG laser, the main shortcoming is that photodepilation procedures undertaken at this wavelength are generally more painful than the others. This problem can partly be resolved by the use of topical anesthetics or additional skin cooling systems. Another problem is that the associated pain limits both spot size and firing frequency, meaning that treatment sessions with this wavelength are generally longer in comparison with alexandrite or diode lasers.

Intense Pulsed Light

Sources of IPL can also be used in photodepilation. They are devices that emit at wavelengths between 550 and 1200 nm. The wavelength emission spectrum is restricted by the use of specific filters in photodepilation applications. Some devices use filters that only eliminate wavelengths lower than those specified on the filter; others incorporate water filters that also suppress radiation from the infrared spectrum; and some use fluorescent filters that convert some of the undesired spectrum back to the recommended wavelength for this application. This variation in the capacity to narrow the spectrum of emission means the fluence required for each device can vary greatly. The narrower the emission spectrum of the equipment, the lower the fluence required for treatment, as there will be less energy "lost" at wavelengths that are not "useful." The most commonly used filters can eliminate wavelengths below 590 and 900 nm. The shortest wavelength filters (590-640 nm) are used in patients with fair skin, fine hair, and little pigment. In these situations it is common for short pulses (2.5-5 milliseconds) to be used, and, where pulse trains are used instead of single pulses, the interpulse intervals will also be short (1-20 milliseconds). Longer wavelength filters (695-755 nm) are used in patients with darker phototypes, and thicker and more heavily pigmented skins. In these cases the pulses and interpulse intervals will be longer (5-20 milliseconds and 30-100 milliseconds, respectively). The first studies on photodepilation with IPL sources showed hair reductions of between 50% and 60% at 3 months after the first treatment.[49] After 3 or 4 sessions, reductions of up to 75% are seen after follow-up periods of 6 months.[50-52] The side effects are similar to those described with alexandrite and diode lasers.

Treatment Procedure

In photodepilation, as in any other treatment procedure, an algorithm must be used to define the optimal conditions for the treatment procedure. Once a thorough medical history has ruled out the absolute and relative contraindications for this treatment, the following points must be considered:

1. Determination of the clinical characteristics of the patient: basic phototype, prior sun exposure, and hair type
2. Preparation for treatment
3. Selection of treatment parameters
4. Application of treatment
5. Expected response
6. Follow-up treatment and monitoring

Clinical Characteristics of the Patient

Phototype and hair type are the main clinical characteristics to consider when selecting the form of treatment. As has been commented above, the shorter wavelengths of the spectrum present higher absorption coefficients for melanin. This means that these wavelengths present a higher risk of burning and side effects in dark phototypes or tanned skins. Therefore, longer wavelengths should be selected (diode or Nd:YAG lasers) over lower ones (ruby or alexandrite lasers, IPL) wherever possible in patients with dark phototype or sun exposure prior to treatment. Where these are not available, more conservative treatment parameters should be proposed on the basis of longer pulses and lower fluences. In the case of IPL sources, longer wavelength filters, longer pulses, and lower fluences should be selected. Where longer wavelengths are not available and where there is any doubt as to the safety of the treatment because of the degree of pigmentation, we recommend that treatment be postponed to those times of year when there is less sun exposure.

Preparation for Treatment

The patient must be advised to avoid any traction-based hair removal systems for 2 to 4 weeks before treatment. These forms of depilation also remove the structure that absorbs the radiation, nullifying the therapeutic effect. It is always advisable to shave the area to be treated. Hair follicles that vaporize as the light impulse is delivered can cause superficial burns on the epidermis around the follicles. Shaving can be carried out from several days prior to application of the light source. We personally prefer the shaving to be done immediately prior to the procedure, as this allows us to evaluate the characteristics of the follicles (follicle diameter and degree of pigmentation) and to adjust the treatment parameters accordingly.

Topical anesthetics can be used to improve tolerance to treatment, with applications from 20 to 130 minutes prior to the procedure, in accordance with the given limitations in terms of side effects and maximum recommended dosage.

Selection of Treatment Parameters

The clinical characteristics of the patient (phototype and hair type) are used to select the ideal wavelength for the procedure. Once the wavelength has been selected, some devices allow the size of the spot of light to be adjusted. It must be borne in mind that a larger spot size provides greater penetration capacity for the radiation, and can also allow for the more rapid treatment of large areas. However, this also implies an increase in the level of pain associated with the treatment—due partly to the greater degree of penetration and partly to the simultaneous heating of a larger surface area. We generally use the larger spot size, except in those areas where we want to preserve deep structures or limit the sensation of pain (face, lips, etc). The next parameter to select is the pulse duration. As has been commented before, this must be adapted to the biological characteristics of the follicle, or—more precisely—its size. Fine hairs have lower TRTs, and so the pulse durations should be lower. Thicker hairs will require longer pulse durations. Current recommendations on ideal pulse durations for effective photodepilation range from 10 milliseconds to 60 milliseconds. In certain situations pulse durations of less than 10 milliseconds (very fine hairs) or up to 100 milliseconds can be used. As was mentioned before, longer pulse lengths can be used to ensure greater skin protection in the case of dark phototypes or prior sun exposure. Devices are presently available that can administer pulses of 100 to 400 milliseconds. The last parameter to select is the fluence. This is inversely proportional to the amount of chromophore present in the target. Hence, the larger the size of the follicle and the higher its degree of pigmentation, the lower the fluence required for photothermolysis. Meanwhile, finer or less pigmented hairs will require lower fluences. This fact can mean that certain treatments cannot be carried out. For example: in a patient with a dark phototype but fine, poorly pigmented hair, the biological characteristics of the hair require short, high-energy pulses while the phototype requires the use of short wavelengths and long, low-energy pulses. Such conservative parameters would probably lead to ineffective treatment in such a case.

We must also be aware that treatment parameters must be reconsidered at each treatment session. The progressive reduction in size of the follicles over successive sessions means the initial treatment parameters will not be applicable in subsequent treatment sessions. Also, changes can occur in the degree of skin pigmentation of the patient, and on-going reconsideration of the parameters applied in later sessions is essential.

Application of Treatment

The application of the light pulse varies according to the equipment selected. Most of these devices use skin cooling systems to reduce the risk of burns and side effects, and improve patient tolerance levels. Training is needed in the rate at which to move the hand piece for treatments with high firing frequencies (2-3 per second) in order to avoid overlap between firings and the implicit risk of burning.

Expected Reaction

Different immediate reactions can be seen depending on the type of light used and the nature of the hair treated.

Coarser and more pigmented hairs tend to vaporize, producing smoke and the characteristic smell of burned keratin. This means a good ventilation system is necessary in order to remove smoke from the treatment room. With finer hair the response is not always so evident. The end of the shaved hair may become thickened, or there may be a change in color (whitening) around the follicular ostia due to disappearance of the follicle. It is common for erythema and a transient perifollicular papule to appear 10 to 20 minutes after the procedure—a sign that often indicates a good outcome in terms of treatment efficacy.

Follow-up Treatment and Monitoring

Treatment can produce erythema that is generally transient in nature. Where erythema persists, medium potency topical corticosteroids may be recommended for application in the 48 to 72 hours following treatment. Other soothing products, such as those based on *Aloe vera*, can also be recommended.

Successive treatment sessions do not need to be scheduled in advance. There is some delay in follicular growth following a session which makes it difficult to predict when the follicles will be ready for the next treatment. We therefore recommend that our patients wait for follicles to reappear and then book a session for 3 to 4 weeks later in order to give the follicles that are not destroyed time to completely reappear. Once the inflammatory reaction phase has passed, the patient can remove the treated hair by traction depilation methods. Once regrowth has occurred, depilation should be avoided in order to allow the target chromophore to become better established. The skin must be strictly protected from ultraviolet radiation during the period of local inflammation and in the following months, providing time for any burns that should occur during treatment to heal. Ultraviolet radiation should also be avoided in the 4 weeks prior to the following procedure.

Side Effects

The most common side effects of photodepilation systems are pain during treatment, post-treatment erythema and perifollicular edema, blisters, alterations in pigmentation, and scarring.[53,54] Most of these complications occur in tanned patients or those with dark phototypes, and they can currently be avoided by the use of longer wavelengths and better skin cooling systems.

Localized and transient edema can occur depending on the area to be treated and the density of the hair follicles. Topical corticosteroids help minimize the effects and accelerate the recovery process in such cases.

Another, side effect described in rare cases for practically all the wavelengths is that of "paradoxical growth," where new follicles appear in areas surrounding the treated zones.[54-56] This phenomenon translates clinically into a lack of effectiveness of the procedure with an increase in the number of follicles in the treated area or neighboring zones. The mechanism that causes this is unknown, but it is possible that there is some photoactivation of potential follicular structures in these zones. The hair follicles could thus be altering their biological behavior in a manner similar to the mechanism in fibroblasts, lymphocytes, and melanocytes which can be "activated" by wavelengths and increases in temperature caused by these forms of radiation. Another possible cause of this reaction could be the use of excessively conservative treatment parameters with insufficient fluences. Successive sessions with more aggressive treatment parameters could minimize this effect.

Conclusion

Photodepilation is a treatment procedure that is in high demand. This is due to the high social acceptance of the procedure and the on-going development of photodepilation systems. Despite these advances, we must be aware that the technological advances announced are often promoted by companies launching new products in order to ensure their market share. On many occasions the claimed advances have no physical basis and are eventually found to be worthless. Consequently, it is very important that the scientific studies presented by these companies be evaluated and critically assessed in order to check the design and analysis of results.

In general terms, we conclude that all of the available photodepilation systems can be used for photodepilation in patients with pigmented follicles and fair skins (phototypes I-III). The systems most commonly used in these patients are the long-pulsed ruby, long-pulsed alexandrite, long-pulsed diode lasers, and IPL systems.

Patients with dark phototypes (IV-VI) can be treated effectively using longer wavelengths, longer pulse durations, and more effective skin-cooling systems. Although diode and alexandrite lasers can be used in this type of patient, use of the Nd:YAG laser is considered safer for them.[57,35] Comparative studies using these types of photodepilation devices have shown they have similar levels of efficacy.[35,38,39,58-61] Any differences between these are based on elements such as the treatment time required (time taken per area to be treated in each session), the level of pain associated with the procedure, the cost of equipment and perishables, and the possibility of treating dark phototypes. Therefore, any decision on which technology to acquire for these procedures must be based more on these concepts and the characteristics of the treatment center —number of patients, space available, local climate, and phototypes, etc—than on any claims of the greater effectiveness at certain wavelengths.

Conflicts of Interest

The authors declare no conflicts of interest.

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