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Lasers and light sources for the removal of unwanted hair☆

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Abstract The long-term removal of unwanted hair has become one of the most common and popular cosmetic laser treatments being performed around the world. This manuscript will review a variety of lasers and light sources that have been and are currently being used for epilation of the skin. All of the lasers and light systems currently available do work for long-term hair removal; it is the responsibility of the treating clinician to understand the varying technologies and what the limits of each device is and, most importantly, to be able to handle any untoward effects that might arise during the coarse of treatment. Then, hair removal can be successful for both the patient and the physician using their particular medical device.

Introduction

The long-term removal of unwanted facial and body hair by the use of lasers and nonlaser light sources such as the intense pulsed light (IPL) source has become one of most common cosmetic surgical procedures now being performed by dermasurgeons and laser physicians on a worldwide basis. According to the American Academy of Plastic Surgery, laser hair removal ranked as the second most common outpatient cosmetic procedure performed after Botox injections in a number of procedures performed.[1] A variety of laser systems have been used over the past 10 years or so to treat people with unwanted hair. These laser systems have included the normal mode and long-pulsed ruby lasers (694 nm), the long-pulsed alexandrite lasers (755 nm), the diode laser systems (800-810 nm), the Q-switched Nd:YAG laser system (1064 nm), and the long-pulsed Nd:YAG lasers (1064 nm). The IPL systems, a nonlaser light source, have evolved steadily over this period and, today, remain one of the most common and dependable epilation modalities available. The purpose of this monograph is to review the basic principles involved in the hair removal process and to review the different lasers and light sources involved in the long-term removal of unwanted hair. The author has a bias toward the IPL, although he does use most of the other laser systems on a regular basis in his clinical practice of dermatology.

All of the lasers and IPL light sources thus far developed for the long-term removal of unwanted hair adhere to the principle of selective photothermolysis, conceived by Anderson and Parrish in 1983.[2] This principle states that through the use of lasers (or the IPL), a thermal injury can be confined to a specific chromophore within the skin and to a specific target, leaving other structures with different chromophores untouched. The principle chromophore for hair removal has been determined to be the melanin in the hair follicles. Melanin is found in the hair shaft, the outer root sheath of the infundibulum, and in the matrix area of the hair bulb. Original hair removal devices were developed to treat dark hairs on light skin, using the effects of the light

☆ Dr Gold is a consultant, speaks on their behalf, and received honorarium from Lumenis Inc, Santa Clara, Calif; he also owns stock in Cynosure.

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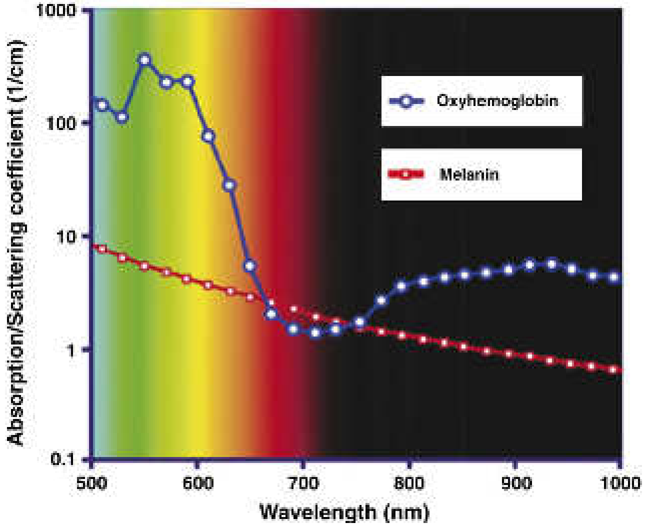

Fig. 1 Absorption curve of oxyhemoglobin and melanin.

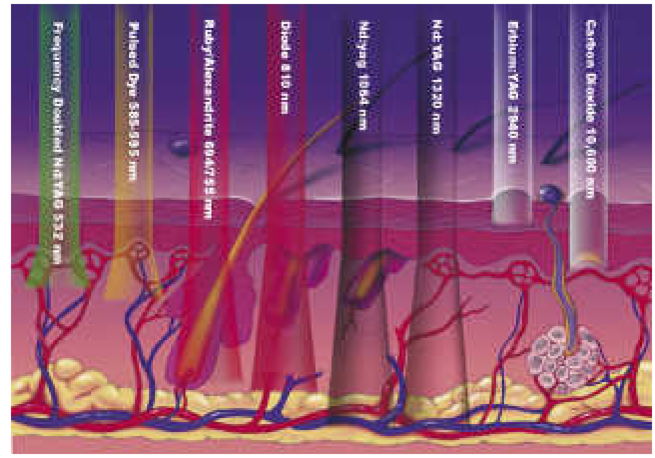

Fig. 2 Energy penetration of commonly used cutaneous lasers, wavelengths, and depths.

on the target of melanin in the hair follicles. A vascular component has been suggested by some to play a role in long-term epilation.[3] The absorption curves for both melanin and hemoglobin are shown in Fig. 1.

In order for the principle of selective photothermolysis to work, the chromophore being targeted must have a light source with an appropriate wavelength, proper pulse duration, and sufficient fluence or energy delivered to the target. Proper epidermal cooling and appropriate spot sizes to deliver the energies are also important for the epilation process to be successful. As noted earlier, a variety of laser systems have been developed, which have been used in long-term epilation. These are summarized in Table 1. All of the systems reported have had scientific documentation in the medical literature for adequate hair removal, but it appears, at least at the time of this writing, that those laser systems with longer wavelengths are more effective in removing unwanted hair, especially in those individuals with darker skin types and those who are tanned. Ruby lasers have, for the most part, disappeared from the epilation scene, and most research today focuses on the diode laser systems and the long-pulsed Nd:YAG lasers (1064 nm). This is because, in part, the longer wavelength laser systems penetrate deeper into the skin, allowing a deeper destruction to the level of the hair bulbs. This is depicted in Fig. 2. The IPL systems are able to cover virtually all of the wavelengths of light in question and have withstood the test of time for the long-term removal of unwanted hair.

Table 1 Lasers for epilation

Long-pulsed ruby lasers
long-pulsed alexandrite lasers
Diode lasers
Long-pulsed Nd:YAG lasers
IPL sources

The pulse duration in laser systems has also varied and changed over the years. The first commercial hair removal laser system, a Q-switched 1064-nm Nd:YAG laser, used an exogenous carbon suspension applied to the skin and then nanosecond pulse duration to cause a photoacoustic effect to destroy the hair in the hair follicle. This proved to be a temporary phenomenon (up to 3 months' duration), and so the next laser systems moved to microsecond pulse duration (some ruby lasers) and finally into millisecond pulse duration, the preferred pulse duration used by most laser systems today, including the IPL systems. This produces the desired photothermal effect now known to be important for successful long-term epilation.

The fluence, or energy delivered to the target, is also a very important contributing source to ensure proper epilation. Each of the laser systems and IPL devices on the market today provides enough energy to ensure proper penetration into the skin for the removal of unwanted hair.

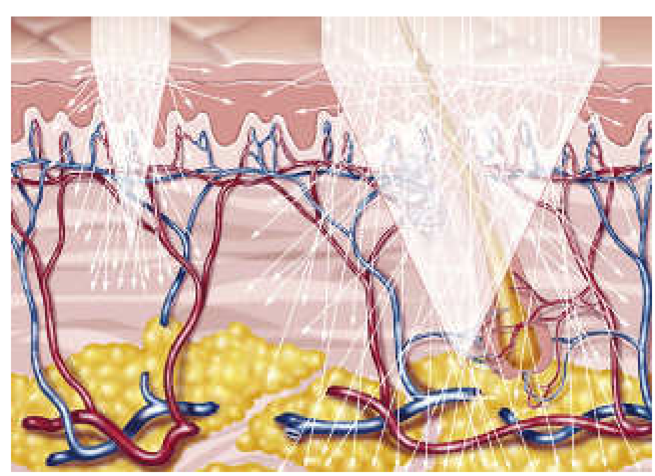

Fig. 3 Factors of depth penetration, spot sizes.

Table 2 Types of ruby lasers

EpiTouch Ruby (Sharplan, Santa Clara, CA, USA)	not available
EpiLaser (Palomar, Burlington, MA, USA)	not available
Chromos 694 (SLS Biophile, Ltd, Carmarthenshire, UK)	not available
Palomar (Palomar, Burlington, MA, USA)	E2000

Table 3 Types of alexandrite lasers

Adept Medical Concepts (Rancho Santa Margarita, CA, USA)	UltraWave Alexandrite
Candela (Wayland, MA, USA)	GentleLase
Cynosure (Westford, MA, USA)	Apogee 5500
WaveLight Lasers (Sterling, VA, USA)	Arion

One of the most important considerations that have become more evident over time includes the concept of epidermal cooling. Laser companies have developed several useful modalities to assure proper epidermal cooling. These include (1) dynamic cooling devices, (2) cryogen cooling, (3) coupling gels, and (4) cool air-cooling. All of these cooling systems protect the epidermis and allow the light from the lasers or IPLs to successfully reach their specific targets while minimizing potential epidermal injury. Finally, larger spot sizes have evolved over time to help deliver the light energy deeper into the tissue where the targets are located. This is seen in Fig. 3.

An important issue that comes up over and over again when discussing laser and IPL hair removal with your patients and your colleagues is the issue of permanency. Most of the lasers and the IPLs available for epilation have been cleared by the Food and Drug Administration for the permanent reduction of hair. Does this means permanent hair removal? In fact, it does not, and it is a major point for discussion beyond the scope of the manuscript. Suffice it to say, we as physicians owe it to our patients and clients to be realistic regarding the permanence issue. Lasers and IPLs provide the long-term removal of unwanted hair; in some, this may mean forever, and in others, it just may mean time off in between shaving or other depilatory methods and still results in a positive impact for that individual. There are salons and other nonphysician companies promoting permanent/lifetime hair removal from their services. This is simply not always going to happen, and we need to be above that type of rhetoric.

Lasers for hair removal

Ruby lasers

Grossman et al[4] first introduced the concept of laser hair removal in 1996. The report used a normal mode ruby laser system (694 nm). Thirteen patients were entered into their clinical protocol to evaluate this laser system. All the patients were light skinned individuals and had dark hairs. Fluences of 20 to 60 J/cm^2 were used, and patients had one treatment and were evaluated at 1 and 3 months after the therapy. Hair growth delay was observed in all subjects at the 1- and 3-month follow-up visits. At 6 months, 5 of the 13 patients had complete hair regrowth and 4 had less than 50% regrowth. Skin biopsies obtained from the study subjects demonstrated selective thermal damage to pigmented hair follicles, vaporization of hair shafts, patches of follicular epithelial necrosis, and some perifollicular injury. Transient pigmentary changes occurred in all of the patients, but none scarred. At follow-ups of 1 to 2 years, Dierickx et al[5] found that 4 of 7 patients had persistent hair loss. Biopsy results showed reduction in the number of terminal hairs and increase in the number of vellus hairs, but there was no evidence of fibrosis or hair follicle destruction. The conclusion from the 2 studies was that the normal mode

Fig. 4 Apogee hair removal. Before and after 9 months after one treatment. Reprinted with permission from McDaniel et al[9] (Cynosure, Westford, MA, USA).

Table 4 Types of diode lasers

Alderm	HR Force
Iridex	VariLite
Lumenis	Light Sheer, Lumenis One
Opusmed	F1 Diode Laser
Orion	Sonata
Syneron	Comet DS

ruby laser results in miniaturization of the hair follicle bulb and papillae, thus, promoting long-term hair removal.

Studies by others confirmed the results presented above. Lask et al[6] and Williams et al[7] looked at various ruby laser systems and found that hair counts decreased by approximately 30% after a single treatment. Sommer et al[8] found that by using multiple treatments,[3,4] efficacy for ruby laser hair removal increased to approximately 60% hair reduction.

A variety of ruby laser systems have come and gone over the years. They are illustrated in Table 2. They were best used in light skinned individuals with dark hairs. This limited their use in many clinics and paved the way for other systems to emerge.

Alexandrite lasers

Alexandrite laser systems have longer wavelengths than their ruby laser counterparts (755 vs 694 nm). They have the ability to penetrate deeper than ruby lasers and are less absorbed by epidermal melanin; they have had great staying power in treating many skin types, especially skin types I to IV. Clinical trials have shown the effectiveness of these long-pulsed laser systems in permanent hair reduction. McDaniel et al[9] showed that with a variable-pulsed alexandrite laser, hair reductions of 40% to 56% could be achieved at 6 months after a single treatment. Goldberg and Ahkami[10] as well as Nanni and Alster[11] performed work on the long-pulsed alexandrite lasers and showed similar efficacies with minimal adverse effects.

The 2 main long-pulsed alexandrite lasers currently available are the Apogee System from Cynosure (Cynosure, Westford, MA, USA) (Fig. 4) and the Gentlelase System from Candela (Candela, Wayland, MA, USA). The Apogee provides pulse duration of 5 to 40 milliseconds and fluences up to 50 J/cm^2. It uses cool air in a special handpiece that provides for epidermal protection. The Gentlelase uses a 3-millisecond pulse duration, 8- to 18-mm spot sizes, fluences of 10 to 100 J/cm^2, and its own specially designed cryogen spray system for epidermal cooling, known as the dynamic cooling device. The complete list of alexandrite lasers is shown in Table 3.

Diode lasers

Diode lasers are solid-state laser devices that have been very well received over the past several years because of their reliability and their ability to penetrate even deeper into the skin, thus, allowing even darker and perhaps tanned individuals to be successfully treated for epilation of unwanted hair. These devices also use sophisticated cooling apparatus, thus, assuring increased safety for our patients.

Fig. 5 Lumenis One and Light Sheer with Sapphire Tip (Lumenis Inc). A, Hair removal with Light Sheer—Chin. Pretreatment (left), after 46 months after 4 treatments (right), 2 treatments each, 30 J/cm^2, 15 milliseconds, and 40 J/cm^2, 20 milliseconds. Reprinted with permission from V. Campos, MD; C. Dierickx, MD; and R. Anderson, MD (Lumenis, Inc). B, Hair removal with Light Sheer—arm. Pretreatment (left), after 14 months after 2 treatments (right), 40 J/cm^2, 20 milliseconds. Reprinted with permission from V. Campos, MD; C. Dierickx, MD; and R. Anderson, MD (Lumenis, Inc). C, Hair removal with Light Sheer—leg. Pretreatment (left), 24 months after 3 treatments (right), 40 J/cm^2, 20 milliseconds. Reprinted with permission from V. Campos, MD; C. Dierickx, MD; and R. Anderson, MD (Lumenis, Inc).

Clinical studies using diode lasers have shown their effectiveness in permanent (long-term) hair removal. Studies by Dierickx et al[12] as well as by Handrick and Alster[13] showed efficacy rates of almost 90% in their patients studied. Adverse events were minimal, and darker-skinned individuals were successfully treated.

A variety of diode laser systems is available and is shown in Table 4. The most popular of the diode laser systems for hair removal is the LightSheer produced by Lumenis, Santa Clara, Calif. This is an 810-nm diode laser with pulse widths that vary from 5 up to a newly introduced model, up to 400 milliseconds, allowing darker skin types to be easily treated. The spot size is 12 × 12 mm, and it uses a fast repetition rate of 2 Hz, as well as fluences between 10 and 60 J/cm^2. It has its own contact cooling device known as ChillTip in its stand-alone version and Sapphire Cooled Tip in the Lumenis One model (Fig. 5).

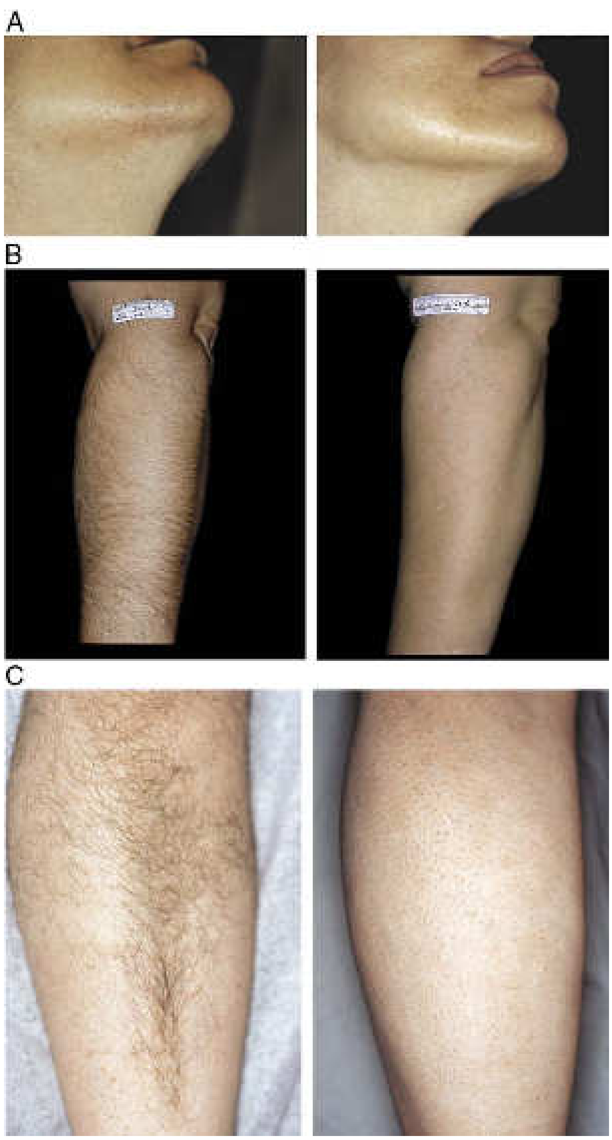

Fig. 5 continued

Q-switched Nd:YAG laser (1064 nm)

Although the normal mode ruby laser was the first described laser system for hair removal, it was the Q-switched Nd:YAG that made it in the commercial arena first. The system was known as the Softlight System, and it was developed by Thermolase, San Diego, Calif. The process used a proprietary suspension of carbon particles onto wax-epilated skin. Upon removal of the carbon suspension, low-energy irradiation of the area was performed. Parameters for the Softlight device usually included 2 to 3 J/cm^2, 10-nanosecond pulse duration, and a 7-mm spot size. Clinical trials by Goldberg et al[14] confirmed its short-term effectiveness with 25% hair reduction at 3 months after a single treatment. A study by Nanni and Alster[15] found that, compared with laser treatments alone, there was no added benefit by waxing or by using the carbon suspension.

Kilmer et al[16,17] studied the other Q-switched Nd:YAG laser for hair removal, a high-powered nanosecond pulsed laser system called MedLite IV, from ConBio, Dublin, Calif. It uses a 4-mm spot size and a repetition rate of 10 Hz. The studies with these devices show that they can delay hair growth but are not capable of permanent hair reduction.

Long-pulsed Nd:YAG laser (1064 nm)

The long-pulsed Nd:YAG lasers are receiving the most attention at this time, and numerous systems are available using this long wavelength of light. At this wavelength of light, melanin absorption is reduced, which require higher fluences (power) to damage the hair effectively. Epidermal cooling devices incorporated into these devices ensure a reduction in the potential for epidermal injury and allow them to be successfully used in patients with dark skin (up to skin type VI). Several clinical trials have demonstrated its effectiveness in long-term hair removal.[18-20] Recently, Tanzi et al showed the effectiveness of the Nd:YAG laser in the long-term removal of hair in patients with all skin types. In their study, hair reduction after 3 Nd:YAG laser treatments was shown to be from 58% to 62% on facial sites at 1 month after the last treatment and 66% to 69% on nonfacial hair at the 1-month follow-up time. At 6 months after the final treatment, hair removal was shown to be 41% to 46% on facial hair and 48% to 53% on nonfacial hair areas.[21]

A variety of 1064 Nd:YAG laser systems are available on the market. These are depicted in Table 5.

Nonlaser light sources for hair removal—IPL

The first commercially available IPL system was developed by Goldman and Eckhouse in 1990 and brought to the market in 1994. Their high-intensity flashlamp system, known as the PhotoDerm VL, was designed to treat vascular anomalies of the skin, including spider and

Table 5 Types of 1064-nm Nd:YAG lasers

Adept Medical Concepts (Rancho Santa Margarita, CA, USA)	UltraWave II, III
Candela (Wayland, MA, USA)	GentleYAG
CoolTouch (Roseville, CA, USA)	Varia
Cutera (Brisbane, CA, USA)	CoolGlide CV, Excel, XEO, Vantage
Cynosure (Westford, MA, USA)	Apogee Elite
Fontana Medical (Ljubljana Slovenia)	Dualis, Plus, Plus II, Fidelis
Aerolase (Tarrytown, NY, USA)	FriendlyLight Nd:YAG
Hoya ConBio (Etinwand, CA, USA)	MedLite C6
Laserscope (San Jose, CA, USA)	Lyra I, Solis
Lumenis (Santa Clara, CA, USA)	Lumenis One
Sciton (Palo Alto, CA, USA)	Profile Console, MP, ClearScan
WaveLight (Sterling, VA, USA)	Mydon

varicose veins, port-wine stains, and hemangiomas. It was manufactured by ESC Medical Systems, Yokneam, Israel. This IPL system emitted polychromatic light in a broad wavelength spectrum from 515 to 1200 nm. A variety of cutoff filters were developed, which were able to block out light below the cutoff filter and allow wavelengths of light above the filter to reach their targets. Wavelengths could then be selected to treat vascular structures, and with proper training and skill, these lesions could be successfully treated. It was found serendipitously that structures containing melanin, such as hair, could also be treated with the IPL device, which eventually led to a specific IPL system for hair removal.

The IPL systems, in general, use millisecond pulse duration that is lower than the thermal relaxation times of the targets being treated and sufficient energies to reach the targets in question. The IPL was developed to deliver their pulses of light in either single, double, or triple pulse modes for vascular treatments and from 1 to 5 pulses for some hair removal devices. This concept is known as multiple synchronized pulsing and is shown in Fig. 6. The pulse modes work with varying pulse delays to assure a "gentler" cooling of the specific target and the epidermis as well. Heat is therefore retained in the larger deeper vessels and in the deeper areas of the hair shaft, resulting in selective thermal damage, a concept that is also known as the principle of thermokinetic selectivity.[21]

The author was fortunate to have received the first IPL device specifically designed for epilation in the world. The device was known as the EpiLight, and research endeavors over time showed its effectiveness in the long-term removal of unwanted hair (Fig. 7). Reports and clinical research trials from this author have appeared in the medical literature showing its effectiveness in (1) 3-month data, (2) 1-year data, (3) 2-year data, (4) epilation treating blond hairs, and (5) treating types V and VI skin. Other investigators throughout the world have corroborated these results and have shown the effectiveness of the IPL in the epilation process. These reports will be briefly summarized further.

In 1997, this author and his associates reported on the first use of a specific IPL system developed for hair removal.[22] The EpiLight system used a computerized software program that aided users in determining default parameters that were to be used for the treatment session. Characteristics entered

Fig. 6 Multiple synchronization pulsing.

Fig. 7 EpiLight, ESC Sharplan.

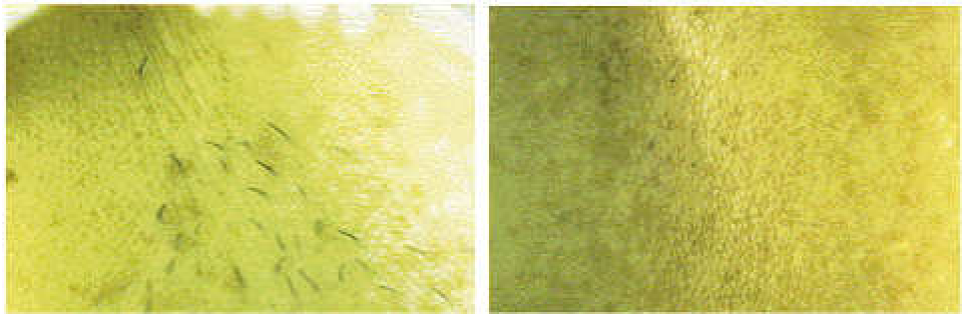

Fig. 8 Intense pulsed light hair removal after 3 months after 1 treatment.

Pre

Fig. 9 Intense pulsed light hair removal before and after 1 year and 1 treatment.

Fig. 10 Intense pulsed light hair removal—blond hair.

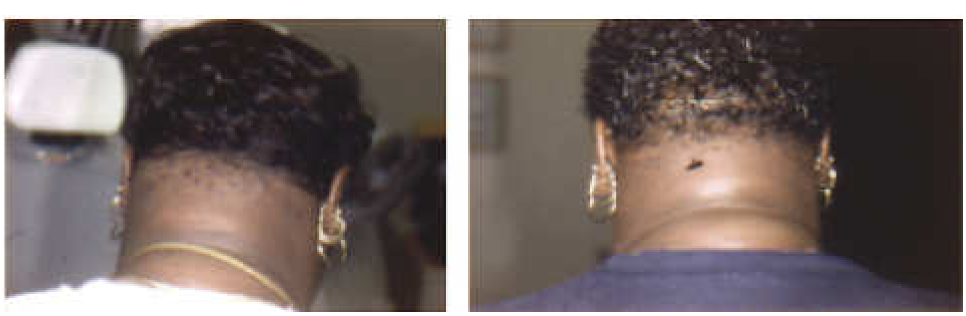

Fig. 11 Intense pulsed light hair removal—skin type V/VI.

Fig. 12 Ellipse Flex. Denmark Dermatologic Development (Candela).

into the computer included the patient's skin type, hair color, area of the body to be treated, and hair type being treated. Thirty-seven treatment sites in 31 patients (predominantly skin types I-IV) were entered into the original EpiLight clinical protocol. Each patient received one treatment, and a target area of 1 × 1 cm was chosen to have hair counts performed. A variety of cutoff filters were used during the clinical trial, including 590, 615, 645, and 695 nm. The longer wavelength cutoff filters were used in darker-skinned individuals. Fluence levels in this trial ranged from 34 to 55 J/cm^2. Double and triple pulsing was used with pulse sequences of 1.5 to 3.5 milliseconds with pulse delays ranging from 20 to 50 milliseconds. An ice-cold coupling gel was used to provide epidermal cooling. Large spot sizes, either 8 × 35 or 10 × 45 mm, were used to enhance light penetration into the skin. The patients were evaluated after their treatment session and at intervals of 2, 4, 8, and 12 weeks. At the end of the 12-week observation period, there was an approximate 60% reduction in hair counts as compared with baseline in the patients studied (Fig. 8). Adverse events showed erythema immediately after treatment in 70% of the patients and edema at the treatment site in 8%. No other significant adverse effects were seen.

From the original cohort, 24 of the 31 patients returned for evaluation of the treatment area at the 1-year interval and were reported on in 1999.[23] This represented 77% of the original patient population. The remainder of the patients, 23%, required more than one treatment session for adequate epilation results to be achieved or was lost to follow-up. In this group of individuals, there was a 75% hair count reduction at the 1-year interval compared with baseline hair counts (Fig. 9). The same group of patients was able to be followed for an additional year and at the 2-year follow-up period; hair reduction was maintained at a 60% level as compared with their baseline hair counts. This trial was published in 2002.[24]

In addition, this author has reported on the successful use of the IPL in treating blond hair (1999) [25] and in dark skin types (2000).[26] The case report described in which blond hair was treated hypothesized that because blond hairs' absorption coefficient falls between 500 and 600 nm, the IPL's unique ability to use cutoff filters allows the use of 590 and 645 nm to be used in these cases. Low fluences, short pulses, and short delay times are necessary to treat blond hairs successfully. Vascular influences were also hypothesized as being an important factor for successful blond hair epilation (Fig. 10). In the year 2000, a new cutoff filter was developed to treat darker-skinned individuals, those with skin types V and VI. This 755-nm cutoff filter was studied in 64 individuals with skin types V and VI. One treatment was performed, and 85 treatment sites were used in this clinical evaluation. Fluences of 24 to 26 J/cm^2 were used; quadruple pulses of 2 to 3 milliseconds were used with long 125-millisecond delays given between the pulses. Follow-up visits at 2, 4, 8, and 12 weeks were performed with hair counts performed at each visit. At the end of the clinical trial, hair reduction of 68% was realized in these darker-skinned individuals (Fig. 11). Adverse effects were noted to be similar to the original 3-month trial. Thus, the IPL was found to be successful in the long-term reduction of unwanted hair in all skin types and in all skin colors, and received Food and Drug Administration clearance as such.

Personal observations by this author and some published results from other clinical investigators have shown that multiple treatments with the IPL, as with other laser epilation devices, will usually yield longer-term and more consistent results. Other investigatory clinical trials with the IPL device for long-term epilation will also be reviewed.

Fitzpatrick and Goldman[27] reported their findings with the EpiLight device in 1997. Fifty patients received one

Fig. 13 Intense pulsed light hair removal, pre-/posttreatment results, 12 J/cm^2, 10 milliseconds, one treatment.

Fig. 14 Intense pulsed light hair removal, pre-/posttreatment results, 3 treatments, 9.5 J/cm^2, 15 milliseconds; 11 J/cm^2, 20 milliseconds; 12 J/cm^2, 20 milliseconds.

treatment with the IPL device (using 590-, 650-, and 690-nm filters, triple pulsing of 2.5/3.0 milliseconds with a 20- to 30-millisecond delay) and showed a 62% reduction in hair counts at the 3-month time. Zelickson and Flor[28] studied the PhotoDerm VL in removing hair in 1998. They looked at 83 subjects and 2 different settings for their IPL machine: (1) 570-nm filter, 2.4/2.4-millisecond pulse duration with a 10-millisecond delay at 35 to 46 J/cm^2; and (2) 590-nm filter, 3.1/3.1-millisecond pulse duration with a 20-millisecond delay at 42 to 47 J/cm^2. The patients were evaluated after their first treatment at 4 weeks and then had the best treatment parameters used to treat every 4 weeks for up to 5 total treatments. Follow-up at 4, 8, and 12 weeks after the last treatment showed that hair reduction was approximately 60%, 45%, and 40% during the follow-up periods. Smith et al[29] reported EpiLight findings in 90 patients (1998). Four biweekly treatments were given to these subjects using the 590-, 615-, 645-, and 645-nm filters, fluences of 33 to 60 J/cm^2, and 2 to 5 pulses with 2.5- to 3.5-millisecond pulse duration. After the third treatment, there was an 81% reduction in hair. At 4 months after the treatment, there was a reduction of 63% in hair counts, which was reduced to 48% at 6 months.

Weiss et al,[30] in 1999, studied 28 treatment sites on 23 patients using a single treatment and a 3-month follow-up. A second cohort of patients (56 treatment sites on 48 patients) received 2 treatments 1 month apart and was followed for 6 months. Parameters chosen for the IPL used in these trials were fluences of 40 to 42 J/cm^2 with triple pulsing using pulse duration of 2.8 to 3.2 milliseconds and pulse delays of 20 to 30 milliseconds. Results from this trial showed a hair reduction of 63% in the one-treatment protocol and 64% after the second treatment, which was reduced to 33% by the end of 6 months. The IPL system used in this trial program was once again the EpiLight device. Weir and Woo[31] reported their findings with the EpiLight in 1999. A single-treatment protocol showed hair reduction of 42% in skin types IV and 37% in skin types V over a 15-month period.

Troilus and Troilus[32] reported their findings with a different IPL device designed for long-term hair removal in 1999. The IPL system used for their clinical trials was the Ellipse Relax Light 1000 (Fig. 12) manufactured by Danish Dermatologic Development, Hoersholm, Denmark. This IPL system uses a "dual mode filtering" handpiece. This direct contact handpiece consists of a high-energy flashlamp system with a fixed sealed 600-nm filter with a water-filled filter to reduce wavelengths above 950 nm. The water filtering system allows for proper epidermal cooling (enhanced with coupling gels) and for an enlarged therapeutic window without the need for changing filters. The spot size used is large, 10 × 48 mm, to increase the optical depth in the skin tissue. Ten patients were followed

Fig. 15 Intense pulsed light hair removal, pre/posttreatment results, 3 treatments, 10 J/cm^2, 15 milliseconds; 9 J/cm^2, 15 milliseconds; 9 J/cm^2, 15 milliseconds.

in their original clinical trials. Four treatment sessions given at 1-month treatment intervals and follow-up were evaluated at 4 and 8 months. Hair reduction of 74.7% was seen at 4 months, and 80.2% was seen at 8 months. No significant adverse events were seen during this study.

Also in 1999, Schroeter et al[33] reported on their experience with the IPL system for epilation. Forty patients with excessive facial hair were entered into this clinical trial. Using the PhotoDerm VL, the patients received, on average, 6 treatment sessions and showed hair reduction of 76.7%.

Sadick et al[35] reported on their findings with the EpiLight device in 1999[34] and in 2000. In the first clinical study, 67 patients received either single (9 patients) or multiple (58 patients) treatments. A variety of cutoff filters were used in this trial; the fluences used were 40 to 42 J/cm^2. Pulse duration was from 2.9 to 3.0 milliseconds with pulse delays of 30 milliseconds. In those subjects who received one treatment with the IPL device, hair reduction was shown to be 61% at 3 months, 58% from 3 months to less than 6 months, and 48% at 6 months or more of follow-up. In those individuals who had multiple therapies (up to 7), results showed hair reduction of 47% at 3 months, 56% from 3 months to less than 6 months, and 64% at 6 months or more of follow-up. In a subsequent report, 34 patients were evaluated with the EpiLight device. Hair reduction of 76% was achieved after a mean of 3.7 treatments and a follow-up time frame of 21.1 months (mean).

Moreno-Arias et al[36] reported on the successful correction of an improperly placed frontal hairline transplantation in 2000. Using an EpiLight device, the following parameters were used: 695-nm cutoff filter, fluence of 38 J/cm^2, 3.5-millisecond pulse duration, triple pulses, and a 30-millisecond pulse delay; 2 treatments were given to this affected area. No hair growth was seen at an 18-month interval in this case report.

In one of the only comparative studies using an IPL device to appear in the medical literature, Bjerring et al[37] compared the IPL device against a normal mode ruby laser for the long-term reduction of unwanted hair in 2000. The IPL system used in their clinical trial was the Danish Dermatologic Development Ellipse Relax 1000, and the normal mode ruby laser uses was the EpiTouch Ruby (from ESC Sharplan, Yokneam, Israel). Thirty-one patients were treated 3 times with the IPL device on one side of the chin, and the neck area and the other side was treated with the normal mode ruby laser. After 6 months, 9 patients received an additional of 3 IPL treatments on the IPL side, and 11 of the ruby laser patients had 3 additional ruby treatments. All treatment sessions were conducted at 2-month intervals. Hair reduction was noted to be 49.3% after 3 IPL treatments and 21.3% after the ruby laser treatments. The authors concluded that the IPL was more effective for hair removal than the normal mode ruby laser (Figs. 13-15).

A number of newer and more sophisticated IPL sources/systems have been developed over the past several years, which have made the IPL devices easier to use, more predictable, and safer for our patients. The list of IPLs is shown in Table 6. Every major laser company in the world has either developed or has entered into an agreement with another company to comarket an IPL. The major IPLs on the market today include Syneron's Aurora and Lumenis One from Lumenis. Syneron's Aurora uses bipolar radiofrequency in coordination with an IPL. Results from several investigations show great promise, including the removal of blond hair with this device.[38,39] The Lumenis One contains 3 devices, an IPL, a LightSheer, and a 1064-nm laser system, all potentially useful in the unwanted removal of hair. Other IPLs of note include the Sciton BBL (Palo Alto, CA, USA), the Alma Lasers Harmony (Buffalo Grove, IL, USA), the Palomar EsteLux and MediLux (Burlingon, MA, USA), the SkinStation from Radiancy SkinStation (Orangeburg, NY, USA), and the PhotoSilk and PhotoLight devices from Cynosure.

Table 6 The different IPLs being used for epilation

Adept Medical Systems (Rancho Santa Margarita, CA, USA)	McCue, SpectraPulse
American Medical Bio Care (Newport Beach, CA, USA)	Omnilight FPL, Novalight FPL
Cynosure (Westford, MA, USA)	PhotoSilk Plus, Cynergy III
DermaMed (Lenni, PA, USA)	Quadra Q4
Laserscope (San Jose, CA, USA)	Solis
Lumenis (Santa Clara, CA, USA)	Lumenis One
McCue (Belton, MD, USA)	Ultra VPL
Novalis (Tampa, FL, USA)	Clareon HR, Solarus HR
OptoGenesis (Austin, TX, USA)	EpiCool Platinum
Palomar (Burlington, MA, USA)	StarLux, MediLux, EsteLux
Radiancy (Orangeburg, NY, USA)	SkinStation
Sciton (Palo Alto, CA, USA)	Profile MP
Syneron (Richmond Hill, Ontario Canada)	Aurora DS, Galaxy DS

Conclusions

The removal of unwanted hair has been one of the most enjoyable studies I have done. It has been a pleasure to be a part of the conceptualization to making it a reality and to be able to truly help someone with legitimate problems. Lasers and IPLs for the removal of unwanted hair have grown into a multimillion dollar business, and we must remember our mission always, that is, to take care of our patients to the best of our ability and for us not to deceive with false practices or promises.

Hair removal is here and is a proven and effective therapy for our patients using lasers and nonlaser light sources. Further advances will be a benefit for our patients.

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