Laser hair reduction in the hirsute patient: a critical assessment

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Hirsutism affects 5–10% of unselected women, depending on ethnicity and definition. The past two decades have seen the development of lasers for the removal of unwanted hair, using selective destruction of the hair follicle without damage to adjacent tissues. Selective photothermolysis relies on the absorption of a brief radiation pulse by specific pigmented targets, which generates and confines the heat to that selected target. In general, laser hair removal is most successful in patients with lighter skin colours and dark coloured hairs. Some studies have documented the results of laser hair removal in a controlled setting, although few have extended their observations beyond 1 year. In general, treatment with the ruby, alexandrite or diode lasers, or the use of intense pulsed light results in similar success rates, although these are somewhat lower for the neodymium:Yttrium–Aluminum–Garnet (nd:YAG) laser. Overall, laser hair removal should not be considered ‘permanent’, at least when considering the current data available. Repeated therapies are necessary, although complete alopecia is rarely achieved and it is unclear at what point the maximum benefit is achieved from multiple therapies. While larger prospective, controlled, blinded and uniform studies are still needed, laser hair removal appears to be a useful adjuvant in the treatment of the hirsute patient.

Key words: hirsutism/laser hair reduction/lasers/unwanted hair removal

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Introduction

Hirsutism is defined as the presence in women of terminal hairs in a male-like pattern, and affects between 5–10% of women surveyed (Ferriman and Gallwey, 1961; McKnight, 1964; Hartz et al., 1979; Knochenhauer et al., 1998). The presence of hirsutism is generally a sign of an underlying disorder, principally androgen excess. While hormonal therapy is generally successful in stopping further progression of the disorder, it has only modest effects in reversing the hair growth process (Azziz et al., 2000). Thus, the optimum treatment of the hirsute patient should incorporate the use of methods to permanently destroy unwanted hairs. To date, electrolysis has been the primary method used for the destruction of these hairs. In fact, and consistent with the large number of affected women, it has been estimated that electrolysis-assisted hair removal accounts for a ~$1 billion market in the USA alone, with $1000 per year on the procedure (Moretti and Miller, 1996). The worldwide market has been estimated to be >$3 billion. An additional 80 million women spend $500 million on depilatory products.

During the past two decades we have seen the development of lasers for the removal of unwanted hair. The main objective of laser therapy for hair removal is to selectively cause thermal damage of the hair follicle without destroying adjacent tissues, a process termed selective photothermolysis. Unfortunately, the numbers of lasers available for hair reduction multiply daily, many different treatment protocols are utilized and results are unclear, which has only served to confuse both practitioners and patients regarding the value and limitations of these techniques. In this review we will briefly discuss the physiology of hair growth...
and the differential diagnosis and hormonal treatment of hirsutism. More extensively, we will address the physics and mechanisms of action of laser hair reduction, and the reported success and complications of these procedures.

A brief physiology of hair

The physiology of hair growth and development has been recently reviewed (Azziz et al., 2000). In brief, there are ~50×10^6 hair follicles, generally associated with a sebaceous gland (i.e. forming the pilo-sebaceous unit) covering the body, of which 20% are in the scalp. The only areas free of hair follicles are the soles of the feet, the palms of the hands, and the lips. Few new hair follicles are formed after birth, and their numbers begin to decline after the age of 40 years. Hence, a generalized thinning of the hair is normal with ageing. There are no differences in follicle numbers between genders within each racial/ethnic group, and the visible difference in appearance between men and women does not relate to differences in the number of hair follicles, but rather to the type of hairs arising from these follicles.

Hair is composed of a column of compressed keratinized melanocytes that grow towards the skin surface within the outer hair sheath, from the dermal papilla (Figure 1). In general, there are three types of hair (Montagna and Van Scott, 1958; Uno, 1986; Hashimoto, 1988; Randall, 1994; Paus and Cotsarelis, 1999). Lanugo is a dense, soft hair over the surface of the fetus which is shed sometime late in gestation or early post-partum. Vellus hairs are the soft, short, fine and usually non-pigmented hairs that cover the apparently hairless areas of the body. They usually measure <2 mm in length. Terminal hairs are long, coarse hairs that cover the apparently hairless areas of the body. They are formed after birth, and their numbers begin to decline after the age of 40 years. Hence, a generalized thinning of the hair is normal with ageing. There are no differences in follicle numbers between genders within each racial/ethnic group, and the visible difference in appearance between men and women does not relate to differences in the number of hair follicles, but rather to the type of hairs arising from these follicles.

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A number of hormones affect hair growth, with thyroid and growth hormone producing a generalized growth in hair (Randall, 1994; Deplewski and Rosenfield, 2000). For example, hyperthyroidism results in a fine friable hair which is easily lost, while hypothyroidism produces a course, brittle hair which is also easily broken, and which is often associated with hair loss from the lateral eyebrows. Progesterone and estrogens have only minimal effects on hair growth. Androgens are the most important determinant of the type of hairs distributed throughout the body (Uno, 1986; Randall, 1994; Paus and Cotsarelis, 1999). The principle circulating androgen, testosterone, is converted in the hair follicle by 5α-reductase to dihydrotestosterone (DHT). Testosterone, and the more potent DHT, stimulate the dermal papilla to produce a terminal medullated hair. Other weaker androgens, such as androstenedione and dehydroepiandrosterone (DHEA), can also be metabolized in the skin to testosterone and DHT to produce excessive hair growth.

The effect of androgens on hair growth is skin area-specific, due to local variations in androgen receptor and 5α-reductase content (Randall, 1994; Azziz et al., 2000). While the effect of androgens on hairs (i.e. terminalization of vellus hairs) will be more readily apparent in skin areas with a greater number of hair follicles, hair follicle density does not correlate with follicular sensitivity to androgens. Some areas of the body, termed non-sexual skin (e.g. that of the eyelashes, eyebrows, and lateral and occipital aspects of the scalp), are relatively independent of the effect of androgens. Alternatively, other areas (i.e. ambosexual skin) are quite sensitive to androgens, and hair follicles are terminalized even in the presence of relatively low levels of androgens. These include the pubic area and the axilla, which begin to develop terminal hair even in early puberty when only minimal increases in adrenal androgens are observed. Finally, other areas of skin respond only to high levels of androgens (i.e. sexual skin) and include the chest, abdomen, back, thighs, upper arms and face. The presence of terminal hairs in these areas is characteristically masculine, and if present in women is considered pathological, i.e. hirsutism.

The differential diagnosis and evaluation of the hirsute patient

It should be noted that hirsutism, above all else, should be principally considered a sign of an underlying endocrine or metabolic disorder, and these patients should undergo a thorough evaluation as soon as possible. The vast majority of the causes of hirsutism are androgenic (Azziz et al., 2000) (Table I). Non-androgenic causes of hirsutism are relatively rare. For example, 10–15% of acromegals initially present with hirsutism. Since hair is designed to protect the skin, chronic irritation of the skin

![Figure 1. Anatomy of a pilosebaceous unit containing a terminal hair follicle.](image-url)
The hormonal evaluation of the hirsute patient has been reviewed (Azziz et al., 2000). The laboratory evaluation of the hirsute patient should be targeted to excluding related disorders (NCAH, thyroid dysfunction, hyperprolactinemia) and evaluating ovulatory function (e.g., by obtaining a measurement of circulating androgen levels, including total testosterone, free testosterone and DHEAS are useful primarily in the minimally or non-hirsute oligo-ovulatory patient, to exclude the presence of androgen excess as the cause of the ovulatory dysfunction. However, these measurements have limited diagnostic utility in the patient who is frankly hirsute, and have a low positive predictive value for adrenal or ovarian ASNs (Waggoner et al., 1999).

### Table I. Androgenic causes of hirsutism

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Approximate prevalence among hirsute women (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCOS</td>
<td>70–85</td>
</tr>
<tr>
<td>IH</td>
<td>5–15</td>
</tr>
<tr>
<td>HAIRAN</td>
<td>2–4</td>
</tr>
<tr>
<td>21-OH NCAH</td>
<td>1–10</td>
</tr>
<tr>
<td>Drug-induced</td>
<td>1–3</td>
</tr>
<tr>
<td>ASN</td>
<td>1/300–1/1000</td>
</tr>
</tbody>
</table>

PCOS = polycystic ovarian syndrome; IH = idiopathic hirsutism; HAIRAN = hyperandrogenic insulin resistant–Acanthosis nigricans syndrome; 21-OH NCAH = 21-hydroxylase deficient non-classic adrenal hyperplasia; ASN = androgen-secreting neoplasm.

Hirsutism is not only cosmetically disfiguring, but can also be a significant handicap to a young woman’s social life and emotional stability. Hence, treatment should be undertaken as soon as the diagnosis is established in order to minimize the number of terminalized hair follicles. Nonetheless, these patients require long-term follow-up counselling and emotional support since this problem can be particularly distressing.

The hormonal therapy of hirsutism consists of medications that either suppress androgen production or free androgen levels, or block androgen action. Ovarian androgen suppression can be accomplished with combination oral contraceptives, long-acting GnRH analogues, ketoconazole or insulin-sensitizing drugs. However, the transient suppression of ovarian androgens achieved using surgery, such as laparoscopic ovarian drilling, has little effect on hair growth. Furthermore, adrenal androgen suppression using glucocorticoids also has a limited effect, if any, on hirsutism. Overall, the impact of androgen suppression alone on unwanted hair growth is relatively modest, and most women with clinically significant hirsutism will require the addition of medications to block androgen action. These drugs include androgen receptor blockers such as spironolactone, flutamide and cyproterone acetate (which is also a progestin that can inhibit ovarian androgen secretion by suppressing pituitary gonadotrophins). Androgen blockers also includes finasteride, which decreases androgen-dependent hair growth by inhibiting 5α-reductase and the peripheral conversion of testosterone to DHT. Overall, all drugs that block androgen action provide similar results, such that side-effects will be the most important feature in determining patient preference (Venturolo et al., 1999; Moghetti et al., 2000).

Therapy for hirsutism may take 6 or 8 months before a difference is observed. Furthermore, we need to emphasize that the main purposes of hormonal therapy are to correct the underlying problem, stop new hairs from growing and potentially slow the growth of terminal hairs already present. Although hormonal therapy alone will sometimes produce a thinning and loss of pigmentation of terminal hairs, it generally will not reverse the terminalization of hairs.

In addition to hormonal suppression and androgen blockade, hirsute patients require the removal by mechanical means of any remaining unwanted terminalized hairs. While many patients resort to shaving, bleaching or depilating with satisfactory results, the use of plucking and/or waxing in androgenized skin areas should be discouraged. These latter techniques not only do not kill the hair follicles, but also may induce folliculitis and damage of the hair shaft with subsequent development of in-grown hairs and further facial damage. What hirsute patients require is the permanent destruction of those follicles producing the unwanted terminal hairs. Techniques to accomplish this include electrolysis and, potentially, laser hair reduction.

Lasers in hirsutism
The physics and mechanism of action of lasers for hair removal

The generation of laser (light amplification by the stimulated emission of radiation) light begins when a lasing medium (i.e. a gas, crystal, liquid or semiconductor) is excited (energized). Various sources of excitation are available, including light from a flashlamp, continuous light, radio frequency, high voltage discharge, diodes and even light from another laser. As the lasing medium is excited, the medium’s molecules are stimulated to a higher energy level. These excited molecules tend to spontaneously decay to their original lower energy level (ground state) releasing a photon, and the laser light generated in the process has various properties including monochromaticity, coherent, collimated and high irradiance. Laser light is concentrated in a narrow range of wavelengths, producing the purest (most monochromatic) light available. All emitted photons bear a constant phase relationship with each other in both time and phase, such that the light is said to be coherent. In turn, all laser light photons travel in the same direction with low divergence, such that the light is considered to be collimated. Finally, laser light has high irradiance, since all the light is concentrated into a narrow spatial band resulting in a high radiant power per unit area.

The main mechanism of laser therapy for unwanted hair is the selective destruction of the hair follicle without damage to adjacent tissues. Selective photothermolysis relies on the selective absorption of a brief radiation pulse by specific pigmented targets, which generates and confines the heat to that selected target. It is absolutely necessary that the target has greater optical absorption, at least at some specific wavelength, than the surrounding tissues. This requirement can be met either by choosing endogenous pigmented targets (e.g. those containing melanin) or by using stains or dyes to label the target. Specifically, selective thermal damage of a pigmented target structure will occur when sufficient fluence is delivered at a specific wavelength (and which is preferentially absorbed by the target tissue) during a time equal to or less than the thermal relaxation time of the target (Anderson and Parrish, 1983). We should note a few common terms used in describing laser light. Energy refers to the amount of photons delivered and is measured in joules (J). Power is measured in watts (W) and refers to the delivery rate of energy (1 W = 1 J/s). Fluence is the total energy delivered per unit area and is measured in J/cm². Pulse duration is the amount of time the laser energy is applied (generally in nanoseconds (ns)). The pulse frequency is measured in hertz (1 Hz = 1 pulse/s). Wavelength is measured in nanometers (nm) and refers to the distance between the peaks of the light waves (light having the peculiarity of having both waveform and particulate properties). Overall, wavelength is used to characterize the type of light.

Once light strikes the skin, the energy can be reflected, scattered, absorbed or transmitted. Approximately 5% of visible light is reflected at the keratinized layer of the epidermis. In turn, because of its high content of collagen, elastin and blood vessel walls, the dermis primarily scatters light (including laser light). Only absorbed light has a direct tissue effect, causing thermal, chemical or mechanical tissue damage. Thermal damage may range from simple protein denaturation to cellular vaporization and carbon formation. Chromophores are substances that preferentially absorb light; they may be endogenous (melanin, haemoglobin or oxyhaemoglobin) or exogenous (tattoo ink). The heating (and destruction) of laser-irradiated tissue due to direct absorption of laser light is a function of various laser (e.g. power, spot size, irradiation time and repetition rate) and tissue parameters (absorption and scattering coefficients, density, heat capacity and thermal conductivity) (Van Gemert and Welch, 1989).

Laser parameters determining the success of laser hair reduction

In general, three characteristics of the laser need to be taken into account when considering hair destruction by photothermolysis: wavelength, fluence and pulse duration. The longer the wavelength, the deeper the laser light penetrates the skin. The epidermis limits the amount of light that passes deeply into the skin, whereas the dermis may allow some penetration. The wavelength of the laser light influences the depth of penetration, and the absorptivity of skin chromophores depends on the wavelength. Absorption of laser light by chromophores in hair follicles is required for selective photothermolysis. The absorption spectrum of melanin, oxyhaemoglobin and water, relative to the wavelengths of lasers currently used for hair reduction, is shown in the figure.
dermis, reducing the effects of lasers on the germinative hair cells (Tong et al., 1987). It is possible to continue to obtain greater tissue depths using longer optical wavelengths, until the laser light reaches a wavelength of ~1500–2000 nm (near infrared spectrum) where adsorption by water (and which is present in all human tissues) begins, diminishing transmittance and increasing the risk of collateral burns. Alternatively, the best wavelengths used to target follicular pigment are in the red and infrared range of the electromagnetic spectrum (600–1200 nm). It should be noted that the absorption of light by melanin decreases with longer wavelengths, and that oxyhaemoglobin and melanin have similar absorption at wavelengths at 750–850 nm (DiBernardo et al., 1999) (Figure 2). In addition, the larger the spot size, the deeper the laser light will penetrate. To avoid epidermal damage due to its melanin content, the skin’s surface is usually cooled during treatment. In general, the fluence of the laser should be greater than or equal to the threshold fluence for tissue destruction.

The laser pulse width plays an important role in determining selective photothermolysis, as suggested by the thermal transfer theory (Anderson and Parrish, 1983). The duration of the laser pulse has to be shorter than the thermal relaxation time of the hair follicle in order to minimize collateral thermal damage. We note that lasers may be continuous mode or pulsed. A continuous mode laser emits a continuous stream of light as long as the medium is excited, resulting in heating and vaporization of the target tissue. Alternatively, a pulsed laser will emit light only in short amounts, which may vary from femtoseconds (quadrillionths of a second) to as long as seconds. High energy, ultra-short pulses of laser light cause extremely rapid heating of the target, with an ultra-rapid expansion of the thermal plasma. As the plasma collapses, the shock wave causes mechanical disruption of the target. The simplest way to pulse a laser is to use a mechanical shutter, similar to that in a camera, which works down to the millisecond (ms) range. Flash lamps (similar to those used in photographic strobe lights) can also be used to produce low millisecond range pulses. Pulses in the micro- to nanosecond range are produced using Q-switching (quality or gain-switching).

The ideal laser pulse duration should be between the thermal relaxation time of the epidermis (3–10 ms) and the thermal relaxation time of the hair follicle (40–100 ms for terminal hair follicles measuring 200–300 μm in diameter (Van Gemert and Welch, 1989; Dierickx et al., 1998). Results after treatment of hair follicles are expected to be better with longer pulsed lasers when compared with shorter pulsed ones. However, the therapeutic difference between longer and shorter pulsed lasers may be minimal. For example, Wimmershoff et al. found 50–75% reduction 6 weeks after a single treatment, and a 25% reduction 6 months after two to four treatments using a 5 ms long-pulsed ruby laser. Although a heterogeneous population with different skin types and hair colour was evaluated in this study, these results are similar to those published for shorter wavelengths (Wimmershoff et al., 2000).

**Target tissue and clinical factors determining efficacy of laser hair reduction**

Various tissue and clinical parameters affect the efficacy of laser-induced hair removal, including skin type, hair colour and hair growth phase. To permanently remove hair with lasers we first need to identify which part of the hair follicle needs to be destroyed, and find an adequate site within this structure to absorb the laser light. Two hair structures have been targeted for destruction in order to attempt to achieve permanent hair damage: the hair bulb and the hair bulge (Figure 1). Notably the laser light must penetrate the skin, since the bulge is located 1–1.5 mm and the hair bulb 3–7 mm deep within the skin. For the targeted destruction of hair follicles, surrounding tissues should not be heated to minimize the risk of adverse sequelae, such as scarring.

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**Lasers in hirsutism**

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**Figure 3.** Frequency of side-effects overall among 900 patients assessed retrospectively after hair reduction with either Q-switched neodymium:Yttrium–Aluminum–Garnet, alexandrite lasers or long-pulsed ruby according to Fitzpatrick skin phototype (lightest skin colour studied is type I and darkest skin colour was type V) (modified with permission from Nanni and Alster, 1999).
and hyperpigmentation. Hence melanin in the hair, or an exogenous chromophore, is targeted for laser heating.

**Skin and hair pigmentation**

Laser-induced selective photothermolysis depends on the selective absorption of laser light by the specific structure being targeted for heating, while the absorption by surrounding tissues should be minimized. Hence, the best candidates for laser-induced selective photothermolysis are patients with lighter skin (Fitzpatrick types I–IV) (Fitzpatrick, 1988) and dark brown or black hairs (Williams et al., 1998). While successful hair removal with either lasers or intense pulsed light has been occasionally reported in patients with Fitzpatrick skin types V and VI (Johnson and Dovale, 1999; Adrian and Shay, 2000; Greppi, 2001), it is clear that the incidence of complications such as burns, scarring and hypo- or hyper-pigmentation increases with the degree of skin pigmentation (Liew et al., 1999a) (Figure 3). It should be noted that complications are not limited to patients with genetically determined dark skin, but also to those patients with darker skin due to other reasons, such as sun-tanning and lentiginous photoaging.

In addition to the degree of contrast between skin and hair, the colour or pigmentation of the hair alone, i.e. its melanin content, has also been suggested to be a determining factor in the success rate of laser hair removal. In fact, in clinical studies patients with darker hair respond better after repeated treatments (Williams et al., 1998; Liew et al., 1999b). Nonetheless, conflicting data exists as to whether the melanin content of the hair is a significant determinant of the efficacy of laser damage to the hair (Liew et al., 1999c; Liew, 1999), suggesting that a greater proportion of the viable cells of hairs with higher melanin content will be destroyed every time a laser treatment is administered. To increase the amount of laser light selectively absorbed by the hair follicles, various investigators have resorted to the use of an exogenously applied chromophore. For example, a formulation containing rhodamine-6G-loaded microspheres dispersed into silicone vehicles has been demonstrated to penetrate deeply into the follicular duct (up to 282 m) after ethanol application to the skin (Sumian et al., 1999).

**Hair growth cycle**

In mice, Lin and colleagues noted that the ability of lasers to cause follicle destruction depended, at least in part, on the phase of the hair growth cycle (Lin et al., 1998). Using a ruby laser at fluences ranging from 1.47–3.16 J/cm², these investigators noted that in animals treated during the anagen (active growth) phase there was a heterogeneous, but widespread, injury to the follicular epithelium that extended along its entire length, increasing with increasing fluence. However, no follicular damage was observed in catagen (resting) or telogen (shedding) stage follicles at any of the fluences used. Full hair regrowth occurred 28–56 days after laser exposure administered during the catagen or telogen phases for all fluence levels. In contrast, regrowth after laser treatment in the anagen phase was fluence-dependent, with moderate to full regrowth at 1.47 J/cm² and none to sparse regrowth occurring at 3.16 J/cm². Nonetheless, in a study using human ex vivo scalp skin Liew and colleagues noted that the proportion of hairs in the anagen phase did not contribute solely to the efficacy of ruby laser hair removal (Liew et al., 1999d). These investigators suggested that when re-growth of hair occurs after laser therapy, it is simply from follicles that received inadequate treatment.

The exact effect that lasers have on the hair follicle to cause permanent hair reduction remains unclear. Dierickx and colleagues suggested that laser damage induces a process of miniaturization of the coarse terminal hair-producing follicles, transforming them into hair follicles that produce vellus-like hairs, resulting in a non-scarring alopecia (Dierickx et al., 1998). Histological examination 2 years after laser treatment has demonstrated a decrease in the number of terminal hair follicles and a reciprocal increase in the number of miniature or vellus hair follicles. Since the size of the hair is dependent on the size of the papilla and the bulb of the hair follicle (Van Scott and Ekel, 1958), it has been proposed that laser therapy miniaturizes the papilla and the bulb either by the direct photothermal injury of these structures, or through the injury of other structures in the follicle which control the formation of the bulb with each anagen cycle. Interestingly, the histological changes of the hair follicle after lasers are similar to those described in patients with androgenetic alopecia (Abell, 1984).

<table>
<thead>
<tr>
<th>Author and year</th>
<th>Type of laser</th>
<th>No. of subjects</th>
<th>Follow-up</th>
<th>No. of treatments</th>
<th>Interval between treatments</th>
<th>Hair reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grossman et al., 1996</td>
<td>Ruby</td>
<td>13</td>
<td>6 months</td>
<td>1</td>
<td>–</td>
<td>30±h</td>
</tr>
<tr>
<td>Dierickx et al., 1998</td>
<td>Ruby</td>
<td>7</td>
<td>2 years</td>
<td>1</td>
<td>–</td>
<td>64a</td>
</tr>
<tr>
<td>Polderman et al., 2000</td>
<td>Ruby</td>
<td>30</td>
<td>3 months</td>
<td>3</td>
<td>1 month: face; 3 months: arm/pubis</td>
<td>38–49a</td>
</tr>
<tr>
<td>Wimmershoff et al., 2000</td>
<td>Ruby</td>
<td>74</td>
<td>6 months</td>
<td>1–4</td>
<td>6 weeks</td>
<td>1 Rx: &lt;25 2–4 Rx: 26–50</td>
</tr>
<tr>
<td>Nanni and Alster, 1997</td>
<td>Nd:YAG</td>
<td>12</td>
<td>6 months</td>
<td>1</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td>McDaniel et al., 1999</td>
<td>Alexandrite</td>
<td>22</td>
<td>6 months</td>
<td>1–2</td>
<td>2 months</td>
<td>8–56</td>
</tr>
<tr>
<td>Lou et al., 2000</td>
<td>Diode laser</td>
<td>18</td>
<td>20 months</td>
<td>2</td>
<td>4 weeks</td>
<td>46a</td>
</tr>
</tbody>
</table>

*a*Statistically significant difference compared with control area.

*b*Based on four subjects having ≤50% regrowth of hair.

Rx = treatment.
Results of clinical studies of laser hair reduction

Goldman and colleagues first described the injury of pigmented hair follicles by a ruby laser in 1963 (Goldman et al., 1963). Subsequently, Oshiro and Maruyama noted hair loss after treatment of nevi with ruby lasers (Oshiro and Maruyama, 1983). However, severe epidermal damage in the epilated area was also reported, suggesting that laser technology was not a safe method for the removal of unwanted hairs. The possibility of selectively destroying hair follicles without causing extensive epidermal damage was suggested with the introduction of the concept of selective photothermolysis (Anderson and Parrish, 1983). Selective photothermolysis is possible when the target preferentially absorbs the laser wavelength selected and the light exposure time (pulse duration) is shorter than the time it takes for heat to dissipate from the target into the surrounding tissues.

Grossman and colleagues reported the first clinical controlled study of laser hair reduction in 1996 using the ruby laser (Grossman et al., 1996). Lasers useful in hair removal may be grouped into three categories based on the type of laser or light source each employs: (i) red light systems (694 nm ruby); (ii) infrared light systems [755 nm alexandrite, 800 nm semiconductor diode, or 1064 nm neodymium:Yttrium–Aluminum–Garnet (Nd:YAG)]; and (iii) intense pulsed light (IPL) sources (590–1200 nm). The currently available clinical data for each of these lasers will be discussed. Studies that are controlled and prospective are summarized in Table II.

Ruby lasers

The ruby laser was first developed in 1956 (Maiman, 1966) and produces a laser beam of 694 nm, using a xenon flashlamp to excite a ruby crystal. There are two different types of ruby lasers available, the normal (continuous) mode and the Q-switched version. In the Q-switched type, the beam of light is amplified before emission is performed. The photon energy output or fluence of the Q-switched ruby laser is equivalent to that of a normal mode ruby system, but it is delivered over nanoseconds rather than milliseconds. The power (energy per unit of time: Joules per second or watts) is therefore a thousand times greater than that of the normal mode long-pulsed ruby laser. However, as indicated above, while the Q-switched laser has a higher irradiant power, it does not allow for adequate heat transfer to the lasered tissue that results in an inadequate kill rate of hair follicles. Currently, hair removal is effected using the long-pulsed (1–5 ms) normal-mode ruby lasers.

The ruby laser is the best studied laser system used in hair removal. In 1996 Grossman and colleagues reported on the first controlled clinical trial using a normal mode ruby laser system in 12 men and one woman volunteer with dark or brown hair (Grossman et al., 1996). Different skin areas were pre-treated by shaving or waxing, and laser treatment was applied to waxed and shaved areas of skin using fluencies of 30–60 J/cm² with 270 μs pulses. Control sites in the same subjects (which had also been shaved or waxed) were left untreated by the laser. The follow-up was performed at 1, 3 and 6 months after laser treatment, during which the number of terminal hairs in the areas (treated and control) were evaluated by counting the number of terminal hairs. At 6 months after a single treatment, 4/13 subjects had <50% of hair regrowth as evaluated by hair counting, but only in shaved areas. At the 6 month evaluation a significant amount of hair loss was observed only in those skin areas that were initially shaven and then treated by laser at the highest fluence (60 J/cm²). Transient hyperpigmentation was observed in three (23%)
subjects. In a subsequent report these same investigators published the results of a 2 year follow-up in seven individuals (Dierickx et al., 1998). At the 1 and 2 year follow-ups there was significantly less hair only in the skin areas that had been initially shaven and then treated with the ruby laser (at all fluences) when compared with the untreated control skin areas. A total of four individuals had laser-induced alopecia in the treated areas, a result evident by the 6 month evaluation.

Subsequently, a number of reports have documented the results of hair removal with the ruby laser, studying patients with varying types of skin and using different laser parameters. The published hair reduction rates have ranged from 37 to 72% 3 months after one to three treatments, to a 38–49% hair reduction 1 year after three treatment sessions (Williams et al., 1998; Liew et al., 1999b; Sommer et al., 1999; Campos et al., 2000a; Polderman et al., 2000; Wimmershoff et al., 2000). In controlled studies, the use of a ruby laser (one to four sessions) proved to be more efficacious for hair reduction than shaving or waxing only (Grossman et al., 1996; Dietrickx et al., 1998; Polderman et al., 2000; Wimmershoff et al., 2000).

As expected, multiple treatments at 3–5 week intervals produce a greater degree of hair reduction than a single session (Sommer et al., 1999). A prospective, controlled study compared ruby laser with hot wax and needle electrolysis for hair removal (Polderman et al., 2000) (Figure 4). Three sessions of ruby laser treatment (25 or 40 J/cm², 0.8 ms pulses) at intervals of 1 month (for face, n = 10) or 3 months (pubic or arm areas, n = 10 each) produced significant hair reduction evident at 6 months (on the face) and 8 months (on the arms and pubis). The same number of sessions with needle electrolysis or hot wax groups did not produce significant changes in hair counts by the 12 month follow-up (or ~3 months after the last treatment session). Nonetheless, it is unclear whether comparing three sessions of electrolysis with three sessions of laser is fair, considering the fact that several treatments with electrolysis are usually needed to obtain a permanent reduction in hair growth (Richards and Meharg, 1995) and the significant differential in cost. In general, higher fluencies have a better success in hair removal, although side-effects logically increase (Dierickx et al., 1998; Campos et al., 2000a; Polderman et al., 2000).

Almost all side-effects demonstrated in the published clinical trials have been temporary, including erythema, pigmentary changes and blistering. Hyperpigmentation in skin types II–II has been observed in up to 12% (Williams et al., 1998); blistering and hypopigmentation may occur in 8–12% of patients with type V skin (Liew et al., 1999b). In one study, a pain rate of 14% was reported (Salomon, 1998). A patient suffering from solar-induced post-inflammatory hyperpigmentation has been described after hair removal with a ruby laser (Hasan et al., 1999); and unfortunately, after 4 months of intense medical therapy most of the affected areas remained hyperpigmented. Cellular carcinoma is a theoretical possibility, since free radicals at the hair shaft produced by the conversion of light into heat may cause DNA damage. However, basal cell hyperproliferation within the skin, thought to be a mechanism of burn wound carcinogenesis, does not appear to occur after exposure to ruby laser radiation at a common clinical dose of 11 J/cm² (Liew et al., 1999e).

Overall, clinical results with the ruby laser have not been as good as theory would predict. The less than expected success may result, at least in part, from the intrinsic variations of skin and hair present in humans. For example, heterogeneous temperature increases were achieved in the hair follicles of skin studied ex vivo within the same area following ruby laser treatment (Topping et al., 2000). This suggests that differences exist even between follicles located in the same general area of skin and that these differences result in an amount of heat transfer. These findings are compatible with the fact that the rate of heat transfer by a specific body affected by the same amount of energy depends on the molecular composition of that body. For hair follicles, it is logical to think that their molecular composition varies even in the same person and in the same area. The heterogeneous heat transfer suggests that the bulge and bulb areas of the hair follicles may frequently not receive enough heat to be destroyed and result in permanent hair removal. In addition, human hair growth is asynchronous, which means that at any one point in time, hair follicles are in different stages of growth in the same area of skin. It is possible that the sensitivity of the hair follicle to laser energy may vary along the hair growth cycle, affecting the rate of permanent hair removal. However, a recent study demonstrated no correlation between the proportion of hairs in anagen at the time of laser administration and the efficacy of laser hair removal (Liew et al., 1999c). Skin pigmentation may also decrease laser effectiveness secondary to absorption of the laser light by skin melanin. However, no decrease in the efficacy of laser hair reduction has been observed in darker skins with repeated treatment.

Use of nd:YAG lasers

The nd:YAG laser has been proposed as an effective method of hair removal for several reasons (Littler, 1999). Firstly, its longer wavelength (1064 nm) allows for better skin penetration of the energy than the ruby laser. Although the deepest hair follicles are often located at 4–5 mm in depth, lasers of shorter wavelength may not penetrate as deeply. Secondly, lasers with wavelengths well above 1000 nm have the inconvenience of being absorbed by water, diminishing transmittance and increasing the risk of side-effects. The nd:YAG laser, with a wavelength of ~1000 nm, results in relatively less absorbed by cutaneous chromophores, potentially diminishing the incidence of side-effects while enhancing skin penetration. Finally, the nd:YAG laser system can treat a large amount of skin surface quickly, with its 7–8 mm beam size.

Because of its lesser absorption by melanin, some protocols call for patients receiving nd:YAG treatment to first undergo wax epilation and the topical application of a carbon-based suspension (Goldberg et al., 1997; Nanni and Alster, 1997). This solution, when massaged onto the skin, fills the follicles with the exogenous chromophore, potentially increasing the absorption of the laser light into the area of the follicle. Because the chromophore may also coat other parts of the skin (e.g. stratum corneum) improved methods of dye delivery have been proposed (Sumian et al., 1999). Most nd:YAG machines are Q-switched, with pulses ranging from 10 ns to 30 ms, although nd:YAG equipment delivering non-Q-switched long pulses is also available (SmartEpil, Deka-MeLa, Calenzano, Italy).

A single prospective controlled trial has demonstrated that one treatment session with a Q-switched nd:YAG laser with topically applied carbon dye results in a greater reduction of hairs...
compared with laser alone, waxing and laser, or waxing alone at the 1 month evaluation (Nanni and Alster, 1997) (Figure 5). Short term hair reduction in the range of 20–60% has been obtained with the long-pulsed nd:YAG lasers (Bencini et al., 1999; Goldberg and Samady, 2000). However, in the controlled study of Nanni and colleagues using a single treatment episode, a 100% hair regrowth was observed at 6 months (Nanni and Alster, 1997). Longer-term results are not available.

Overall, clinical studies have demonstrated less hair reduction with the nd:YAG laser compared with those results published with the ruby or alexandrite lasers (Goldberg et al., 1997; Bencini et al., 1999; Goldberg and Samady, 2000). One study comparing treatments with the Q-switched nd:YAG laser and a long-pulsed alexandrite laser suggested that the former was more effective for the treatment of axillary hair growth (Rogers et al., 1999). However, inexplicably the investigators seriously biased their study by treating patients with only one session of the alexandrite laser, and for only one pass; in contrast, they used three passes over the skin with the nd:YAG laser in two separate treatment sessions 4 weeks apart. Even then, the differences in hair reduction at 3 months were minimal (19 versus 27% for the alexandrite versus nd:YAG laser respectively). As with other laser systems, repeated treatments seem to have better efficacy compared with single treatments (Bencini et al., 1999). However, the optimum treatment interval has not yet been established.

Theoretical considerations to improve the performance of the nd:YAG laser have been proposed, including an improvement in the exogenous chromophores used; however, these issues remain to be proved. Although the nd:YAG laser usually achieves less dramatic results than other laser systems available for hair reduction, due to its decreased absorption by melanin, it may cause less incidence of epidermal side-effects, including blistering and abnormal pigmentation (Nanni and Alster, 1999). In addition, the nd:YAG laser may be useful in the treatment of lighter hairs, when used with the topically applied carbon suspension.

**Long-pulsed alexandrite laser**

There are a number of potential advantages to using the long-pulsed alexandrite laser for hair removal. The long-pulsed alexandrite laser systems are compact and can be used in small rooms if adequate ventilation is available. Their flexible fiberoptic arm is easy to manipulate and provides access to hard-to-reach body areas. The spot size (5–7mm) and frequency (1–5 Hz) improves the possibility of rapidly treating large body areas. Melanin absorption is somewhat less at the wavelength of the alexandrite (755 nm) compared with the ruby (694 nm) laser, suggesting that epidermal damage may be less in patients with darker skin. Consistent with this theoretical advantage, one report of 150 subjects with Fitzpatrick skin types IV–VI treated with repeated sessions using the alexandrite laser (18 J/cm², 40 ms) reported only a 2% complication rate (Garcia et al., 2000). However, pigmentedary changes and blistering have also been reported in up to 14 and 15% of treated patients respectively, and especially in women with darker skin types (Nanni and Alster, 1998; Lloyd and Mirkov, 2000). Treatment sessions can be painful when higher fluences and faster repetition rates are used, or when treating sensitive body areas like the upper lip or bikini areas, and anesthetizing solutions (e.g. lidocaine/prilocaine cream) are often used pretreatment.

The reported success rate of hair removal using the alexandrite laser has ranged from 40–80% at 6 months after several treatments (Boss et al., 1999; McDaniel et al., 1999; Garcia et al., 2000; Gorgu et al., 2000; Lloyd and Mirkov, 2000). In a
controlled randomized study using a single treatment session on various skin areas, using a single pulse (5, 10 or 20 ms) alexandrite laser (20 J/cm²), investigators reported ~40% reduction in hair growth 6 months after treatment (McDaniel et al., 1999). This increased to >50% (on the upper lip) if a second treatment was performed after 8 weeks. An uncontrolled study, using a uniform protocol, demonstrated a mean of 74% hair reduction 1 year after five treatment sessions at the bikini area (Lloyd and Mirkov, 2000). A prospective study compared four sessions of electrolysis at 3 week intervals to three sessions of alexandrite laser treatment at 4 week intervals for axillary hair removal (Gorgu et al., 2000). Six months after the first treatment, a 35.28% hair reduction was demonstrated in the electrolysis group compared with 74.06% in the alexandrite laser group. In this study, patients preferred laser epilation to electrolysis, even though they understood that it was not permanent.

It does not appear that the use of longer-pulsed alexandrite lasers provides greater therapeutic efficacy than shorter pulses. One study compared the success rate of pulses of 5, 10 and 20 ms (McDaniel et al., 1999). The 5 ms pulse provided the greatest degree of benefit, if objectively assessed, for all sites and assessments periods (1, 3 and 6 months) combined; although a greater degree of hair reduction was observed for the 10 ms if only the 6 month data was analysed. Another study, using only a subjective assessment of hair growth, did not find a difference between treatment with 2 and 20 ms pulses (Boss et al., 1999), although the investigators found that the short pulse alexandrite laser was five times faster to apply than the long pulse instrument.

**Diode laser**

In this system the energy is emitted by multiple arrays of semiconductor diodes. They are compact and portable, run on standard 120 volt current and, do not require a cooling or ventilation system. The diode laser system generates a laser light of ~800 nm wavelength. In a prospective controlled trial this laser demonstrated a significant reduction in hair growth (Lou et al., 2000). Overall, clinical studies with the diode laser system have reported variable success rates range from 65–75% hair reduction at 3 months after one to two treatments with fluences of 10–40 J/cm², to >75% hair reduction in 91% of subjects 8 months after three to four treatments at 40 J/cm² (Williams et al., 1999; Campos et al., 2000b; Lou et al., 2000; Handrick and Alster, 2001). As expected, repeated treatments, generally at 4 weeks intervals, appears to improve results (Lou et al., 2000; Handrick and Alster, 2001), although not all investigators agree (Williams et al., 1999a). Alternatively, conflicting data exists whether the fluence of the laser, at least between 15 and 40 J/cm², affects therapeutic success (Campos et al., 2000b; Lou et al., 2000). Less fluence may be required to achieve the same efficacy in more pigmented skin (Williams et al., 1999). In general, the diode laser system has been found better tolerated by patients with darker skin types (V–VI) than the ruby laser (Adrian and Shay, 2000; Greppi, 2001); possibly because its energy is ~30% less absorbed by melanin than that of the ruby laser, but with better optical penetration (Campos et al., 2000b). Although the incidence of pigmented skin changes has been as high as 29%, most of these changes are transient and well tolerated (Campos et al., 2000b; Lou et al., 2000).

**Intense pulsed light (IPL) source**

This technique is not a real laser system because it delivers broad spectrum, non-coherent radiation with wavelengths of 550–1200 nm. The specific light parameters (wavelength, number of pulses, pulse duration, delay between pulses and energy fluence) are selected by computer according to skin type and hair colour of the individual. A set of four filters is available to select the specific wavelength needed. In general, filters with higher cut-off values are used with darker skin types. Spot sizes of 10×45 and 8×35 mm are available. Refrigerator-cooled gel is recommended when higher energy light pulses are going to be used.

The first published report of the use of IPL for hair removal was for the treatment of terminal beard hairs in two transsexual patients (Raulin et al., 1997). Histological evaluation at the time revealed hair follicle atrophy. After 6 months (13 and 41 sessions), hair was practically absent with no pigmented or textural changes noted. After a single treatment, hair reductions ranging from 33 to 60% are observed at 6 months after treatment (Gold et al., 1997; Weiss et al., 1999). Repeated treatments appear to improve outcome (Schroeter et al., 1999), although more than three treatments do not appear to increase the success rate (Sadick et al., 2000). Treatment with IPL may be useful for light coloured hair (Gold et al., 1999; Schroeter et al., 1999), although more treatment sessions are generally required. A few patients with Fitzpatrick skin types V–VI have been successfully treated with this method (Johnson and Dovale, 1999; Weiss et al., 1999). No prospective randomized studies comparing the use of IPL for hair removal with a control area (i.e. no treatment) are available.

Long-term hair removal has been claimed using IPL. In a non-controlled study of 14 subjects treated with this technology, and followed for >12 months after their last treatment (mean ± SD: 16.0 ± 3.9 months), a mean of 83% hair reduction was obtained after two to six treatments (Sadick et al., 2000). The secondary effects included transient hyperpigmentation in 9% and crusting in 6% of patients. The authors attributed the high success rate obtained to the ability of this technology to provide energy of long wavelengths, selected high-energy fluences on a specific range and long-pulse durations. However, the results from this study should be interpreted with caution due to the absence of controls and the lack of a uniform treatment and follow-up protocol. Other studies using the same technology have reported a similar efficacy, but a higher hyperpigmentation rate of 20% (Schroeter et al., 1999).

**Complications of laser hair reduction**

Most serious complications during laser hair reduction occur as a consequence of inadvertent contact between the laser beam and non-targeted tissues. Laser with visible light is transmitted by the cornea and can inflict retinal hemorrhage, necrosis and scarring, resulting in permanent visual fields defects (Aghassi et al., 1999). After laser-assisted hair removal, most patients experience erythema and oedema lasting no more than 48 h. Blistering or crusting may occur in 10–15% of patients (Figure 6). Temporary hyperpigmentation occurs in 14–25% of patients and hypopigmentation occurs in 10–17%. It is highly recommended that patients avoid sun exposure after laser treatment to prevent solar-
induced post-inflammatory hyperpigmentation (Hasan et al., 1999). Dyspigmentation is less common with the use of longer wavelengths, as in the alexandrite or diode lasers and longer pulse durations (Nanni and Alster, 1998). In general, complications are more common in patients with darker skin (see Figure 3). Prophylactic treatment of patients with a history of oro-labial herpes simplex virus has been recommended before treatment of upper lip or chin areas to avoid a laser-induced flare-up of the disease onto already inflamed skin (Bjerring et al., 1998).

Summary

Overall, laser hair reduction is a promising technique for the treatment of the hirsute patient. Nonetheless, we should note that most studies have been uncontrolled and included <50 patients, none have been blinded, and all have used a variety of treatment protocols, equipment, skin types and hair colours. In general, laser hair removal is most successful in patients with Fitzpatrick skin colours I–IV, who have dark coloured hairs. Repeated therapies are necessary, although complete alopecia is rarely achieved and it is unclear at what point the maximum benefit is achieved from multiple therapies. In general, treatment with the ruby, alexandrite or diode lasers, or the IPL results in similar success rates, although it somewhat lower for the Nd:YAG laser.

Laser hair removal should not be considered as ‘permanent’, at least considering the current data available. To quote the Food and Drugs Administration (FDA), ‘Manufacturers should be aware that receiving an FDA clearance for general permission to market their devices does not permit them to advertise the lasers for either hair removal or wrinkle treatment, even though hair removal or wrinkle treatment may be a by-product of any cleared laser procedure. Further, manufacturers may not claim that laser hair reduction is either painless or permanent unless the FDA determines that there are sufficient data to demonstrate such results. Several manufacturers received FDA permission to claim, ‘permanent reduction,’ NOT ‘permanent removal’ for their lasers... Permanent hair reduction is defined as the long-term, stable reduction in the number of hairs re-growing after a treatment regime, which may include several sessions... [and] does not necessarily imply the elimination of all hairs in the treatment area’ (http://www.fda.gov/cdrh/consumer/laserfacts.html). We should note that, contrary to the Center for Drug Evaluation and Research (CDER), the Center for Devices and Radiological Health (CDRH) of the FDA reviews the manufacturer’s data from investigational studies only to see if the product does what it claims to do effectively and does not present any unreasonable risks to the patient. It does not compare equipment either with regards to safety or efficacy.

Several key questions remained to be answered. Exactly what part of the hair follicle has to be destroyed in order to attain permanent hair removal, and should we strive to destroy the whole follicle, or only a specific part of this structure? Is an exogenous pigment necessary for the best targeting, and if it is, how do we best impregnate the hair follicle with this pigment? How does laser hair removal compare with electrology in permanently reducing hair, if only electrology were performed with a more realistic frequency? Is the therapeutic outcome of patients with hirsutism better or worse than that of women with other types of unwanted hair? Does concomitant hormonal therapy improve or hinder the results of laser hair removal? How do we best minimize damage to surrounding structures and minimize the risk of burns and pigmentation abnormalities? Only larger prospective, controlled, blinded and uniform studies will be able to provide us with these answers.

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DiBernardo, B.E., Perez, J., Usal, H., Thompson, R., Callahan, L. and Fallek, Goldberg, D.J. and Samady, J.A. (2000) Evaluation of a long-pulse Q-
Goldman, L., Blaney, D.J., Kindel, D.J. and Franke, E.K. (1963) Effect of the
References
L.A.Sanchez, M.Perez

Handrick, C. and Alster, T.S. (2001) Comparison of long-pulsed diode and
Hartz, A.J., Barboriak, P.N., Wong, A., Katayama, K.P. and Rimm, A.A.

McKnight, E. (1964) The prevalence of hirsutism in young women.
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