# Hair removal using a combination radio-frequency and intense pulsed light source

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Original Research

# Hair removal using a combination radio-frequency and intense pulsed light source

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*BACKGROUND AND OBJECTIVE*: The long-term removal of unwanted hair is achieved by many laser and intense pulse light sources. One limitation is the treatment of individuals with dark skin. The light energy with the current systems has to penetrate through the epidermis before being absorbed by the hair follicle. In individuals with dark skin the high melanin concentration in the epidermis absorbs high energies that can lead to complications. The objective of our study was to study a new system that combines optical energy, intense pulsed light (IPL), with radio frequency (RF). This allows for the use of less optical energy due to the addition of RF energy. The lower optical fluence allows for safer treatment of darker skin types.
*STUDY DESIGN/MATERIALS AND METHODS*: This was a multicenter study, in which 87 patients were enrolled. A single treatment was performed on a specified body site. Twenty-one of the 69 subjects that completed the study had skin types IV–VI. Each subject was evaluated at 1, 7, 30, and 90 days after the treatment session.
*RESULTS*: Hair counts were significantly reduced from baseline after one treatment by an average of 46%. Individual patient data showed that the percentage in hair count reduction achieved ranged from 0 to 100%, with 43% of the patients having a 50% or greater decrease.
*CONCLUSIONS*: The combination of optical energy and RF when delivered simultaneously achieves effective hair reduction with the use of less optical energy, allowing for the safe treatment of all skin types. *J Cosmet Laser Ther* 2004; **6**: 201–207

## Introduction

Laser and light-based equipment have been one of the most effective means of hair removal over the past 8 years. The main mechanism of action these systems incorporate is the transfer of light energy into heat with melanin as the targeted chromophore.[1] The absorption spectrum of melanin within the hair follicles extends from the ultraviolet to near-infrared wavelengths.[2,3] The high concentration of melanin in the hair follicles during anagen allows for higher energy absorption than the surrounding tissue with subsequent heat production that damages the hair follicle.[4] The technology behind lasers and light-based equipment has been very effective. However, there are concerns related to the wavelength of optical energy and potential side effects. One limitation is the treatment of darker skin types. Advances in technology and the development of longer wavelength lasers such as the

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1064-nm Nd:YAG has greatly enhanced our ability to treat darker skin types; however, the high concentration of endogenous melanin within the epidermis of these individuals greatly increases the risk of crusting, blistering and dyschromia.[5–7] An additional drawback of these technologies is the inability to treat lightly pigmented hairs, which do not contain a high concentration of melanin, namely red, gray, white and blond.[8]

A new device combines optical energy, intense pulsed light (IPL), with radio frequency (RF). The goal behind this approach is to use less optical energy due to the addition of RF energy. The lower optical energy fluence allows for the safer treatment of darker and tanned skin types. RF energy is delivered using bipolar electrodes and is dependent on the electrical properties of the tissue. The energy results in volumetric heating of the tissue and is measured in J/cm$^3$. The current generated follows the lowest impedance route between the two electrodes, independent of target chromophores, thus heating the tissue. Since RF is chromophore-independent, patients with darker skin types can be safely treated. This technology also provides an advantage in treating different hair colors, based on the fact that the RF energy is chromophore-independent, directly heating the hair follicle regardless of the hair color. This multicenter study assessed the efficacy and safety of an IPL-RF device for hair removal on all skin types and various hair colors.[9,10]

# Patients and methods

Three different centers participated in this study. A total of 87 patients were enrolled. Eighteen patients were lost to follow-up. A total of 69 consenting patients were included in the study: 60 female and nine male subjects. The average age of the study group was 35 years with a range from 18 to 64 years; Fitzpatrick skin phototypes ranged from type I through VI. Twenty-one of the 69 subjects had skin types IV, V, or VI (Table I). Thirty-eight subjects had black hair, twenty-four had brown and seven had blond hair (Table II). Six hair-bearing sites were treated as follows: axillae ($n=20$), arms ($n=9$), legs ($n=20$), bikini ($n=5$), trunk ($n=7$), and face/neck ($n=8$) (Table III).

The study protocol was IRB approved and informed consent was obtained from each subject. Patients were excluded for the following reasons: pregnancy, suntan, history of photosensitivity and diabetes, or scarring and infection over the treatment site. All subjects were above 18 years of age. Subjects taking medication known to induce photosensitivity, anticoagulation medication, or Accutane use within the past 6 months prior to the start of the study were also excluded. All female subjects were on acceptable forms of contraception.

| Skin type | Number of patients |
|---|---|
| I | 1 |
| II | 18 |
| III | 29 |
| IV | 14 |
| V | 6 |
| VI | 1 |

***Table I***
*Number of patients with skin types I–VI treated in the study.*

| Hair color | Number of patients |
|---|---|
| Blond | 7 |
| Brown | 24 |
| Black | 38 |

***Table II***
*Number of patients in the study with various hair colors.*

| Anatomical area | Number of patients |
|---|---|
| Axilla | 20 |
| Arm | 9 |
| Leg | 20 |
| Bikini | 5 |
| Trunk | 7 |
| Face/neck | 8 |

***Table III***
*Number of patients based on anatomical sites treated in the study.*

A single treatment was performed on a specified body site. Measurements from identifiable and fixed anatomical sites were used to triangulate the location of the site that was treated. The treatment sites were shaved immediately before treatment, leaving a stubble no longer than 1 mm. The optimal energy fluences for placement of test areas were based on unpublished data dependent on a subject's skin type, hair color, hair density and texture – with the darker skin types receiving less energy. After placement of test areas, the investigators waited 5 minutes in order to rule out any immediate blistering or adverse effects. The treatments were delivered following pre-application of either water or a thin layer of water-based transparent gel onto the skin.

The IPL-RF system used was the Aurora DS (Syneron Medical Ltd, Israel). The optical energy component emitted light at wavelengths of 680–980 nm, with RF of 1 MHz. The optical energy was delivered with a pulse duration of 25 ms and energy fluences ranging from 14 to 30 J/cm$^2$ (mean 24 J/cm$^2$). The RF energy was delivered with a pulse duration of 200 ms with energy density ranging from 10 to 20 J/cm$^3$ (mean 15 J/cm$^3$). The system provides simultaneous application of optical and RF energy. The handpiece used for delivery of the energy had contact cooling set at 5°C for all treatments, and provided a treatment area of $12 \times 25$ mm.

Subjects were evaluated after the treatment for immediate adverse effects such as erythema, edema, blister formation and epidermal changes. Each subject was subsequently evaluated at 1, 7, 30, and 90 days after the treatment session. Evaluation of each site was performed using standardized photography, as well as manual hair counts of the treatment sites before the treatment and at the 90-day follow-up session. Hair clearance was defined as the percentage of hair cleared over the treated area.

## Results

The treatments were well tolerated with little to no pain reported by the subjects. Perifollicular edema and erythema occurred immediately after the procedure. Two of the 69 patients were noted to have transient mild scaliness and crusting after treatment. One subject developed transient hyperpigmentation that persisted for 19 days after the treatment. There were no adverse events seen at 30 and 90 days post treatment, with the exception of two patients with hyperpigmentation at the 1-month follow-up visit; one of these two patients subsequently developed hypopigmentation at the site that persisted until the 3-month visit. Both patients were skin type III, one with dark brown hair on the abdomen and the other with blond hair on the leg. There were no reported cases of scarring or skin textural changes noted in any of the subjects.

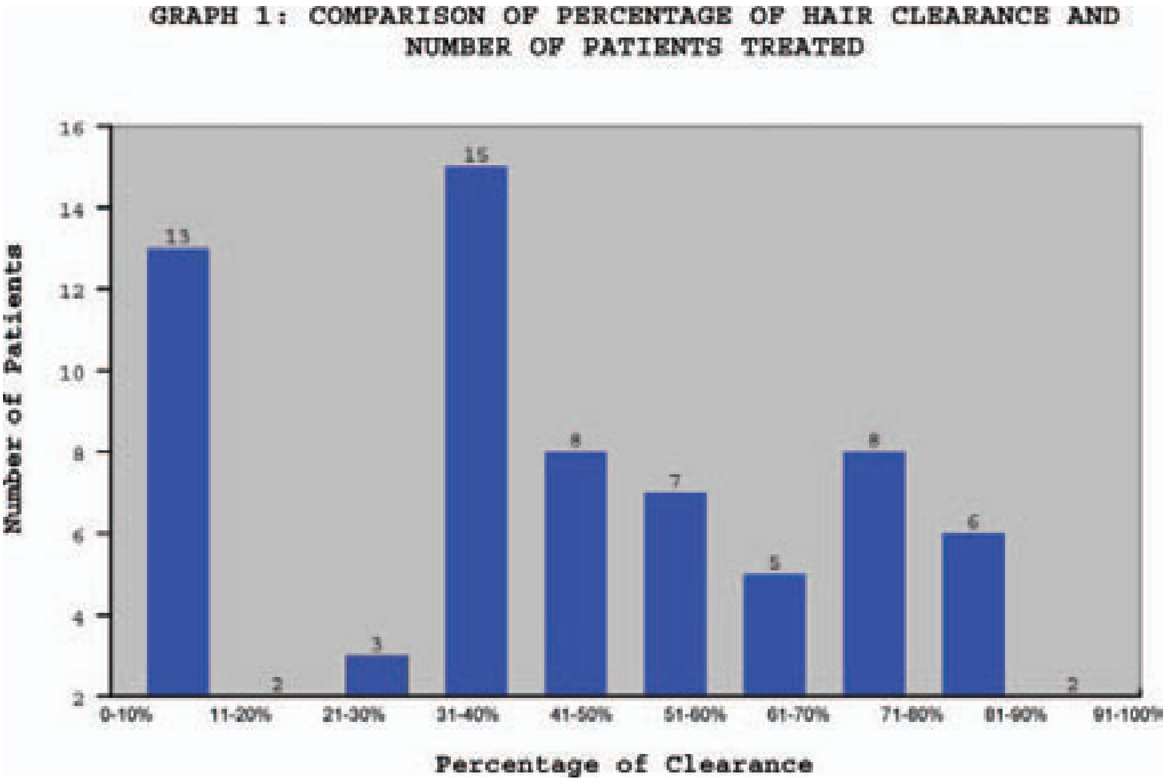
At 90 days after a single treatment the mean hair count was reduced from baseline by an average of 46% (Figures 1–3). Individual subject data showed that the percentage in hair count reduction achieved ranged from 0 to 100%, but 30 (43%) of the 69 patients achieved a 50% or greater decrease (Graph 1). Comparison of the mean percentage hair count reductions by site showed that the best results were achieved when treating the arm (65%), followed in order by axilla (49%), legs (44%), bikini (40%), chest/back (32%), and face/neck (21%) (Graph 2).

The percentage of hair reduction was statistically significant for all three hair colors using the two–tailed Student's *t*-test with $p<0.05$. Mean hair count reductions were 43% for black hair, 49% for brown hair and 35% for blond hair (Graph 3).

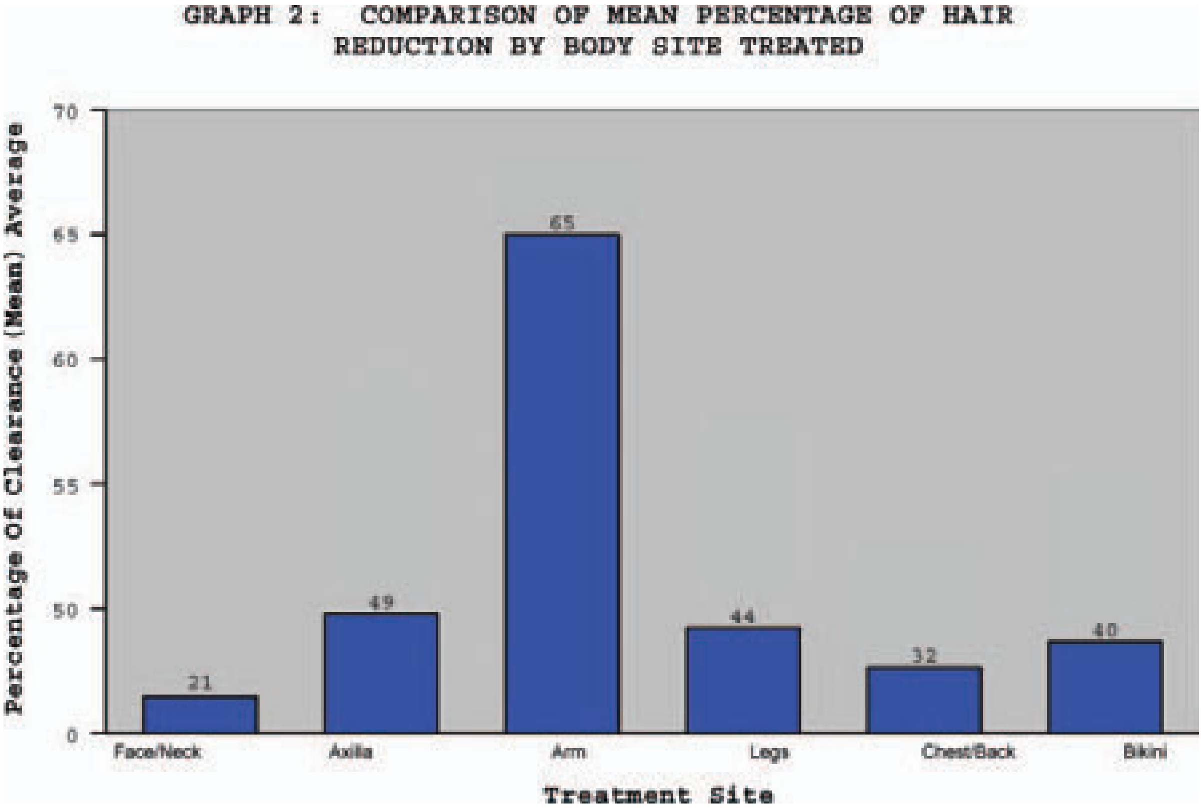
## Discussion

The Aurora DS system incorporated ELOS™ Technology (Electro-Optical Synergy) by combing electrical RF and optical energy (wavelength 680–980 nm). RF current distribution depends on impedance distribution within tissue. RF energy is chromophore-independent; therefore, patients with darker skin types can be safely treated with RF. The addition of RF energy allows for lower optical energy fluences in order to achieve hair loss. The cooled epidermis has higher impedance than the target that was preheated by the light pulse, and with the epidermis conducting a low current and less heat transfer there is a lower risk of adverse effects. The optical energy that is delivered by the system is chromophore-sensitive: by heating the hair structure it increases the temperature of the tissue which in turn decreases the resistance or impedance. The lower impedance in the follicle allows for greater RF energy being deposited.[9,10]

The distribution of RF current is based on the geometry of the electrodes and the distance between them. The depth of penetration is half the distance between the electrodes. Under ideal circumstances in the absence of cooling and preheating, the depth of penetration of RF current is 4 mm (distance between the electrodes is 8 mm). This depth allows for heat generation around the hair follicles. The keratin within the hair shaft is not conductive and has high impedance. RF current flows around the hair shaft, path of

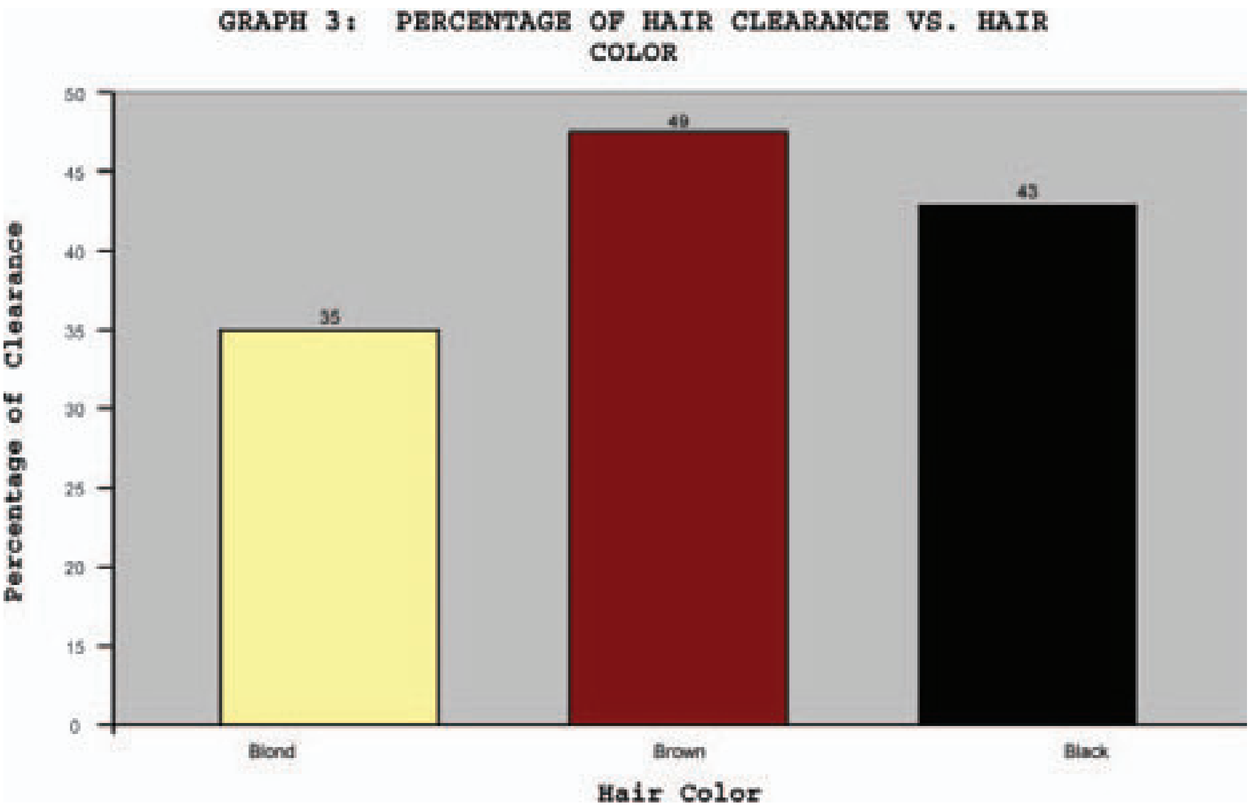



*Graph 1*




*Graph 2*

low impedance, and deposits the heat around the shaft, thus heating the hair follicle. The combined effect of optical and RF energy allows for effective heat generation and destruction of the hair follicle, as previously stated. The basic mechanism in RF energy delivery is conductive media resulting in low reflection and scattering of energy compared with light energy.[9] This feature further increases the efficient penetration to the hair bulge and follicle. Easy




*Graph 3*

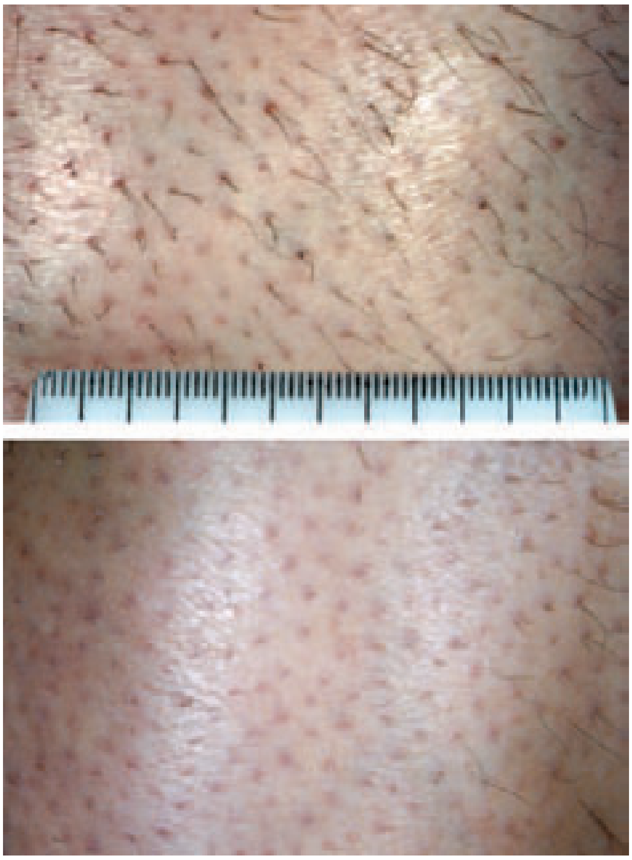


***Figure 1***
*Patient 1:before treatment and 60 days after one treatment.*

***Figure 2***
*Patient 2: before treatment and 90 days after one treatment.*

***Figure 3***
*Patient 3: before treatment and 90 days after one treatment.*

measurement of the impedance of the skin is another important property of RF current that allows monitoring of skin conditions during treatments. In our study, this combination of RF energy, when delivered simultaneously with pulsed light, achieved effective hair removal with the use of less optical energy than stand-alone IPL systems, allowing for the safe treatment of all skin types. Intense pulsed light-based systems[12] and such lasers as the long-pulsed Nd:YAG, long-pulsed diode, alexandrite, and the Q-switched Nd:YAG, have been shown to be beneficial in hair reduction.[11,13–15] Lasers and IPLs are associated with infrequent complications; the greatest risk being associated with the treatment of darker skin types.[16,17] These adverse effects, which include hyperpigmentation, hypopigmentation, blistering, and crusting, are often associated with the treatment of skin types IV and above.[18] The high concentration of melanin in the epidermis of individuals with dark skin results in considerable energy absorption in the epidermis, increasing the risk of adverse effects. Since RF is not selectively absorbed by melanin, and functions by heating the area surrounding the hair shaft, safer treatment of darker skin types and various hair colors may be achieved when a lower optical energy fluence is used. Another advantage with the use of RF is the longer pulse durations used with both the IPL and RF. Recent studies have demonstrated that longer pulse durations cause thermal injury through the entire follicular unit that result in more permanent hair removal, while producing less thermal damage in the epidermis.[19–21]

A total of 43% of the patients in this multicenter study demonstrated a 50% or greater reduction in their hair counts. In a study using the IPL for hair reduction, Gold et al. showed a 50–60% reduction in hair counts 12 weeks after one session. The energy fluence levels ranged from 34 to 55 J/cm$^2$, pulse sequences of two to five pulses of 1.5–3.5 ms separated by delays of 20–50 ms. The cut-off filters were in the wavelength range of 590–690 nm.[22] A follow-up study one year after one treatment session demonstrated a 75% reduction in hair count. However, only 77% (24/31) of the patients were seen in follow-up, and of these 24 patients 16 had skin type II, and there was only one patient each with skin type V and VI included in the study.[22] Bencini et al. demonstrated a 20–40% hair loss after one treatment session using a long-pulsed Nd:YAG laser. These results were maintained over 24 weeks. Treated blond hairs decreased by 30–40% after one session.[23] Lou et al. achieved a 79–69% hair reduction 1 month after one treatment session with an 800 nm diode laser. At the 3-month follow-up there was a 25–35% reduction in hair count.[24]

Our results also indicate that, as with all laser and light-assisted hair removal approaches, patients should anticipate a need for several treatments to achieve the optimal outcome. Sadick et al. demonstrated a 76% hair reduction after a mean of 3.7 treatments using a broad-spectrum IPL source. The treatment parameters used in Sadick's study were significantly higher optical fluences compared with those used in our study. The optical fluence was in the range of 34–42 J/cm$^2$, with pulse durations of 2.6–3.3 ms.[3] compared with 14–30 J/cm$^2$ (mean 24 J/cm$^2$) and a 25 ms pulse duration in our study. It is also possible that a further increase in the RF energy may achieve a further decrease in hair counts, especially of light hair. As such, it appears that the addition of RF energy has allowed for a reduction in IPL. However, the true role of RF energy should be further evaluated by comparative study with IPL.

The combination of optical and RF energy appears to be a safe and effective method for the treatment of hair removal, even in individuals with darker pigmentation. This system has also demonstrated benefit in the treatment of blond hair. However, that benefit requires further investigation with more long-term studies and comparison trials. Our results also indicate that, as with all laser and light-assisted hair removal approaches, multiple treatment sessions will be required to obtain optimal results.

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