Long-term Photoepilation Using a Broad-spectrum Intense Pulsed Light Source

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Background: The goal of laser or flashlamp photoepilation is to produce long-term, cosmetically significant hair removal. We document the long-term efficacy achieved with an intense pulsed light source for photoepilation.

Design: Prospective study comparing long-term results of single vs multiple treatments, and effects of anatomic site and skin type on efficacy of photoepilation with a device emitting broad-spectrum, noncoherent (nonlaser) radiation from 550- to 1200-nm wavelengths, in macropulses divided into 2 to 5 minipulses.

Setting: Private dermatology practice.

Patients: Thirty-four patients (8 men, 26 women) with hirsutism.

Interventions: Parameters for the study were wavelength of 615 to 695 nm, pulse duration of 2.6 to 3.3 milliseconds, fluence of 34 to 42 J/cm², 10 × 45-mm exposure field, and application of 1°C cooling gel.

Main Outcome Measures: Hair removal efficiency, calculated as percentage ratio of the number of hairs present compared with baseline counts, and patient satisfaction questionnaire completed at last follow-up.

Results: The mean hair removal efficiency achieved was 76% after a mean of 3.7 treatments. More than 94% of the sites reached mean hair removal efficiency values greater than 50%. Hair removal efficiency was not significantly related to skin type, hair color, anatomic site, or number of treatments. Side effects were mild and reversible and occurred in a minority of patients (hyperpigmentation in 3 and superficial crusting in 2).

Conclusions: Our data document the long-term clinical efficacy of intense pulsed light source–induced hair removal in light and dark skin phenotypes. Maximal photodepilation was achieved from the initial 1 to 3 treatments; only a small added benefit was seen after more treatments.

Arch Dermatol. 2000;136:1336-1340

The goal of laser or flashlamp photoepilation is to produce long-term, or permanent, cosmetically significant hair removal. The major proposed mechanism of action is “selective photothermolysis,” with follicular melanin as the major target chromophore. Wavelengths in the red and infrared range (600-1100 nm) of the electromagnetic spectrum are optimal for this goal. Melanization of the hair follicle has been shown to be maximal during the anagen phase. It has been proposed that efficiency of photoepilation may be optimal during this phase; since the length of the hair cycle varies among different anatomic regions, equipment settings may need to be modified accordingly to take advantage of phase-dependent melanization. However, recent studies have questioned the primary role of anagen melanization in efficacy of photoepilation. Multiple treatments may increase melanocyte synthetic activity, which may produce more beneficial results. Hair color, pilosebaceous depth, and hair follicle thickness also may influence photoepilation efficiency; specifically, white to blond hairs, deeper pilosebaceous depth, and thicker diameter of hair follicles are associated with decreased photoepilation efficiency.

Another mechanism proposed to be important in photoepilation is “thermokinetic selectivity,” whereby target structures of large volume such as hair shafts are unable to transmit absorbed energy to surrounding structures, compared with smaller volume structures containing the same chromophore. By selecting the appropriate pulse length, the thermal damage may be concentrated in the target structures (follicular papilla, germinative cell layer, and...
PATIENTS AND METHODS

STUDY GROUPS

The study group consisted of 8 men and 26 women with excess body hair, aged 16 to 68 years (mean, 38 years), who entered a multiple-treatment protocol and had long-term follow-up of 12 to 30 months since their first treatment. The 34 patients each had 1 anatomic site studied by 1 of 2 investigators (N.S.S. and R.A.W.), and were enrolled between April 1997 and September 1999. Fitzpatrick skin types ranged from II to V. and all patients had black or brown terminal hair in the areas selected for treatment. Previous modalities used on the test sites before flashlamp irradiation included waxing (14 patients), chemical depilatories (20 patients), and shaving (16 patients). Any such treatments were discontinued at least 4 weeks before IPL irradiation. Patients avoided UV-B exposure for 4 weeks before and after each treatment session.

Of the 34 total patients, a subgroup of 14 patients was available for evaluation 12 months or more after their final treatment. This subgroup was enrolled between April 1997 and August 1998, and received multiple treatments to a total of 14 anatomic sites.

PHOTOEPILATION PROTOCOL

Immediately before IPL treatment, hairs were trimmed to 1 mm and a 1°C cooling gel transparent to the irradiation wavelengths was applied to the surface. The IPL treatment was administered with surface exposure parameters related to Fitzpatrick skin type (Table 1), to a 10 × 45-mm exposure field. All patients received 3 monthly treatments, and 13 had subsequent treatments as necessitated for further clinical improvement and/or because of partial regrowth of hair. Further treatments were administered at intervals of 1 month or more.

The present report documents the long-term efficacy and permanent results achieved with an IPL source for photoepilation (Epilight; ESC Medical Systems, Norwood, Mass/Yokheam, Israel). This device emits broadband, noncoherent (nonlaser) radiation from 530- to 1200-nm wavelengths. Unique to this technology is modulation of a pulse into a series of 2 to 5 minipulses, the duration and delay of which are customizable within the millisecond range. A footprint spot size of 10 × 45 mm or 8 × 35 mm is available. Theoretically, these options should allow deep penetration of radiation with a uniform beam, targeting deeper follicles as well as coarse or thin hair, while achieving “epidermal bypass” to minimize dyschromia. According to the specifications provided by the manufacturer, almost all skin types can be treated using these parameters.

In a previous study, on 58 subjects, we reported mean hair loss at follow-up ranges of less than 3 months, 3 to 6 months, and 6 months or longer of 49%, 57%, and 54%, respectively, with a single treatment, and 74%, 56%, and 64%, respectively, with multiple treatments (wavelength, 590–695 nm; pulse duration, 2.9–3.0 milliseconds; fluence, 40–42 J/cm²). Herein we report on a series of 34 patients with long-term follow-up, of whom 8 were previously described with a shorter follow-up interval.

RESULTS

CLINICAL ASSESSMENT

A 1-cm² grid was used to count hairs at baseline and at various subsequent times (including 1, 2, 3, 4, 6, 8, 9, 12, 14, 16, 18, 20, 24, and 30 months after IPL treatment for different patients) as previously described. The data summarize the final clearance results observed at the last follow-up visit, accounting for different follow-up intervals after initial treatment (range, 12-30 months; mean ± SD, 21 ± 5.1 months). The treatment sites were localized with respect to defined anatomic landmarks (umbilicus, iliac crest, nipple, mandibular ramus, chin, or acromion), confirmed by reference to standardized photographs (Yashica Medical Eye II [Tokyo, Japan] with macrolens, shooting area of 24 × 360 mm, shooting distance of 15.5 cm, and consistent lighting and patient positioning). The hairs were counted with the aid of a hand lens by either of 2 investigators (N.S.S. and R.A.W.) in a nonblinded manner. The hair removal efficiency (HRE) was calculated as a percentage of the number of hairs present compared with baseline counts. Results were tabulated semiquantitatively as “excellent” (HRE of 76%-100%), “good” (51%-75%), “fair” (26%-50%), or “poor” (0%-25%). Side effects, if any, were recorded at each visit.

For analysis, data were stratified according to the following subsets: (1) light vs dark skin phenotypes (Fitzpatrick skin types I-III vs IV-V), (2) hair color (light-to-medium brown vs dark brown vs black), (3) anatomic location (torso vs extremities vs face), and (4) number of treatments (1-3 vs 4-7). At the end of treatment, a questionnaire was administered to determine the level of patient satisfaction: not satisfied, slightly satisfied, moderately satisfied, and greatly satisfied.

STATISTICAL ANALYSIS

The χ² and the paired t tests were used to compare groups. P < .05 was considered significant.

Table 1. Photoepilation Protocol for Long-term Study

<table>
<thead>
<tr>
<th>Fitzpatrick</th>
<th>Filter, nm (Long-Pass)</th>
<th>Fluence, J/cm²</th>
<th>Pulse Duration, ms</th>
<th>No. of Pulses</th>
<th>Pulse Delay, ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>615</td>
<td>39-42</td>
<td>3.3</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>III</td>
<td>645</td>
<td>34-36</td>
<td>3.0</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>IV</td>
<td>645</td>
<td>34-40</td>
<td>3.0</td>
<td>3</td>
<td>40</td>
</tr>
<tr>
<td>V</td>
<td>695</td>
<td>38-40</td>
<td>2.6</td>
<td>3</td>
<td>30</td>
</tr>
</tbody>
</table>

In a previous study on 58 subjects, we reported mean hair loss at follow-up ranges of less than 3 months, 3 to 6 months, and 6 months or longer of 49%, 57%, and 54%, respectively, with a single treatment, and 74%, 56%, and 64%, respectively, with multiple treatments (wavelength, 590–695 nm; pulse duration, 2.9–3.0 milliseconds; fluence, 40–42 J/cm²). Herein we report on a series of 34 patients with long-term follow-up, of whom 8 were previously described with a shorter follow-up interval.
(pretreatment vs at final follow-up) were highly significant \((P<10^{-10})\) (Figure 1).

Temporary hyperpigmentation ("footprinting") occurred in 3 patients (9%) and resolved within 12 weeks in all treated individuals. Superficial crusting occurred in 2 patients (6%) and resolved without scarring in 2 weeks or less. The incidence of side effects did not vary significantly as a function of skin type.

A majority of treated sites (21 of 34 sites, 62%) exhibited excellent HRE and 11 sites had good results; thus, 94% of the sites reached mean HRE values above 50%. Only 2 patients had fair results and none had poor outcome (Figure 2). Anatomic site was not a significant variable determining HRE (torso mean HRE, 78%; facial mean HRE, 72%).

![Image](http://example.com/image1.png)

**Figure 1.** Final clearance as a function of time in 34 patients receiving multiple treatments. HRE indicates hair removal efficiency.

![Image](http://example.com/image2.png)

**Figure 2.** Distribution of clearance values obtained at final follow-up visit (number of sites). HRE indicates hair removal efficiency.

Although patients with skin types I to III experienced a slightly higher HRE than types IV to V (76% vs 73%), this difference was not statistically significant. Moreover, hair color was not a significant variable affecting HRE (dark brown hair, 82%; black hair, 68%; light-to-medium brown hair, 70%). Finally, HRE was not significantly related to number of treatments (1-3 treatment mean HRE, 75%; 4-7 treatment mean HRE, 77%).

In the subgroup of 14 patients followed up for more than 12 months (mean, 20 months) after the last treatment (Table 2), a final HRE of 83% was achieved after a mean of 3.9 treatments, slightly better than the overall group results (Figure 3).

To determine any possible difference regarding short-term or long-term follow-up HRE, percentages were combined into 6 separate groups with cutoff times at 5, 10, 15, 20, 25, and 30 months of follow-up. Mean HRE values continued to improve after the last treatment, with a final HRE of 92%±12% at 30 months’ follow-up. Figure 4 demonstrates a representative patient with excellent results at long-term follow-up.

Of the 29 individuals who completed the satisfaction questionnaire at the last follow-up, only 3 (10%) were not satisfied at all. Twenty-four (83%) were moderately to greatly satisfied; of these, 15 (52%) were greatly satisfied.

**COMMENT**

Four clinical responses may ensue after the light exposure (Table 3). First, heat-induced destruction of the hair shaft without germinative area damage may lead to hair “drop-out,” ie, the hair shaft falls out and then regrows at the next scheduled anagen cycle as a nonaffected, terminal hair. Second, besides the hair shaft, there may be partial injury to the germinative (amplification) zone of the hair follicle, resulting in trichoregulatory dysfunction, telogen-shock response, prolonged telogen dropout, and eventual regrowth of normal hair once the anagen phase has been reinstated. Third, partial germinative zone injury may lead to the development of dystrophic hairs (thinner and finer in texture, with variable hypopigmentation). Finally, long-term photoepilation may ensue, defined as a reduction in the number of hairs over an interval longer than the nor-

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**Table 2. Long-term Follow-up Subgroup (Follow-up >12 Months After Last Treatment)**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Location</th>
<th>No. of Treatments</th>
<th>Last Follow-up Date</th>
<th>Months Since Initial Treatment</th>
<th>Months Since Last Treatment</th>
<th>Final Hair Count</th>
<th>Hair Removal Efficiency, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chest</td>
<td>5</td>
<td>12/14/98</td>
<td>19</td>
<td>15</td>
<td>1</td>
<td>89</td>
</tr>
<tr>
<td>2</td>
<td>Abdomen</td>
<td>3</td>
<td>12/98</td>
<td>15</td>
<td>13</td>
<td>3</td>
<td>79</td>
</tr>
<tr>
<td>3</td>
<td>Chest</td>
<td>4</td>
<td>6/99</td>
<td>24</td>
<td>15</td>
<td>1</td>
<td>91</td>
</tr>
<tr>
<td>4</td>
<td>Lip</td>
<td>3</td>
<td>2/99</td>
<td>20</td>
<td>18</td>
<td>4</td>
<td>56</td>
</tr>
<tr>
<td>5</td>
<td>Mandible</td>
<td>3</td>
<td>11/98</td>
<td>15</td>
<td>13</td>
<td>8</td>
<td>69</td>
</tr>
<tr>
<td>6</td>
<td>Back</td>
<td>3</td>
<td>4/28/99</td>
<td>20</td>
<td>18</td>
<td>2</td>
<td>78</td>
</tr>
<tr>
<td>7</td>
<td>Bikini</td>
<td>3</td>
<td>6/99</td>
<td>14</td>
<td>12</td>
<td>1.5</td>
<td>75</td>
</tr>
<tr>
<td>8</td>
<td>Bikini</td>
<td>3</td>
<td>10/99</td>
<td>24</td>
<td>22</td>
<td>1.5</td>
<td>70</td>
</tr>
<tr>
<td>9</td>
<td>Bikini</td>
<td>6</td>
<td>9/16/99</td>
<td>20</td>
<td>14</td>
<td>0.5</td>
<td>98</td>
</tr>
<tr>
<td>10</td>
<td>Abdomen</td>
<td>5</td>
<td>4/25/99</td>
<td>21</td>
<td>15</td>
<td>1</td>
<td>96</td>
</tr>
<tr>
<td>11</td>
<td>Chin</td>
<td>6</td>
<td>6/23/99</td>
<td>26</td>
<td>16</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>12</td>
<td>Lip</td>
<td>3</td>
<td>9/99</td>
<td>29</td>
<td>26</td>
<td>2.5</td>
<td>83</td>
</tr>
<tr>
<td>13</td>
<td>Face</td>
<td>2</td>
<td>9/99</td>
<td>13</td>
<td>12</td>
<td>1</td>
<td>94</td>
</tr>
<tr>
<td>14</td>
<td>Face</td>
<td>5</td>
<td>9/99</td>
<td>21</td>
<td>15</td>
<td>2.5</td>
<td>86</td>
</tr>
</tbody>
</table>
mal hair cycle (usually 1-3 months depending on the particular given anatomic region). Long-term (or potentially permanent) photoepilation most likely is a consequence of light-induced interactions with the primary “bulge” and secondary matrix germinative regions of the pilosebaceous unit. To induce permanent hair removal, “pantricho” destruction of the entire germinative areas of the hair follicle (bulge/trichoepithelium/matrix) must occur. Permanent, nonscarring hair loss has been described following a single treatment with high-fluence ruby laser pulses, similar to that seen with flashlamp devices. Miniaturization of the terminal hair follicles seems to account for this response.

Results of this study using an IPL source for photoepilation confirm that partial, long-term hair removal may be achieved. Successful hair removal with the Epilight has previously been reported at shorter follow-up periods. A preliminary study by Weir and Woo demonstrated 42% and 37% reduction of hair density using a single treatment with high-fluence ruby laser pulses, similar to that seen with flashlamp devices. Miniaturization of the terminal hair follicles seems to account for this response.

Figure 3. Percent clearance as a function of time in 14 patients receiving multiple treatments and long-term follow-up (> 12 months since the last treatment).

Figure 4. Patient 3. Pretreatment (A) and posttreatment (B) results. Hair removal efficiency at 24 months’ follow-up was 91% (skin type II, chest, 4 treatments, 615-nm filter, fluence of 40 J/cm², pulse duration of 3.3 milliseconds, 2 pulses, pulse delay of 30 milliseconds).

Table 3. Potential Effects of Light-Pilosebaceous Interactions

<table>
<thead>
<tr>
<th>Target Effect</th>
<th>Result</th>
<th>Growth Delay</th>
<th>Hair Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hair shaft</td>
<td>Hair shedding</td>
<td>-</td>
<td>Normal terminal hair</td>
</tr>
<tr>
<td>Trichoregulation</td>
<td>Telogen shedding</td>
<td>+</td>
<td>Normal, with anagen regrowth</td>
</tr>
<tr>
<td>Partial germinative zonal disruption</td>
<td>Dystrophic hair regrowth</td>
<td>+/-</td>
<td>Tapered/hypopigmented hair</td>
</tr>
<tr>
<td>Total germinative zone ablation</td>
<td>Permanent alopecia</td>
<td>Not applicable</td>
<td>No regrowth</td>
</tr>
</tbody>
</table>

In the present study, a mean HRE of 76% was achieved after a mean of 3.7 treatment sessions, in patients followed up for a mean of 21.1 months. The long wavelengths, ability to partition high-energy fluences, and a single treatment in patients with skin types IV and V, respectively, examined over 15 months; patients with skin types IV and V were treated with a 645- and 695-nm cut-off filter, respectively, with average fluence of 37 J/cm², 3 to 4 minipulses, a pulse duration of 2.8 to 2.9 milliseconds, and 57- to 60-millisecond delay between pulses. Gold et al performed a single-exposure study with an IPL system. After 12 weeks, a 60% HRE was noted. Fluences ranged from 34 to 55 J/cm². Another study reported a 75% HRE 12 months after a single treatment in 24 patients with skin types I to VI and light brown to black hair; no specific treatment parameters were mentioned. In a multicenter study, 40 women with hirsutism of the upper lip and chin achieved a 76.7% HRE after an average of 6 treatments; the average fluence was 38.7 J/cm² and mean wavelength was 585 nm. Schroeter et al reported on 40 women with a median age 38.6 years, having hirsutism of the upper lip and chin. The HRE was 76.7% within 6 treatments, with an average fluence of 38.7 J/cm² and a mean wavelength of 585 nm. Weiss et al treated 23 patients with an IPL source with a double-treatment protocol (cutoff filter of 615-645 nm based on Fitzpatrick skin type, pulse duration of 2.8-3.2 milliseconds, 3 pulses, and fluence of 40-42 J/cm²), and showed an HRE of 42% at 8 weeks and 33% at 6 months. Preliminary data have also been reported with a second-generation, broad-spectrum IPL source. Ten female patients with dark hair at the groin and of skin types II to IV were treated (600 nm) 4 times with a 1-month interval. An HRE of 74.7% at 4 and 8 months after the last treatment were 74.7% and 80.2%, respectively.

In the present study, a mean HRE of 76% was achieved after a mean of 3.7 treatment sessions, in patients followed up for a mean of 21.1 months. The long wavelengths, ability to partition high-energy fluences, and

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long pulse durations available with this technology may explain the similarity of our results to those described with the long-pulsed ruby laser.10

It is somewhat surprising that we demonstrated equal photoepilation efficiency in light-to-medium brown and black hair. A likely explanation is that the amount of energy delivered is sufficient to damage the hair in either subtype long-term. The similar HRE in treatments involving the face and torso is also unexpected, but should be interpreted with caution in view of the relatively small number of patients examined in this long-term study. Anagen turnover is increased in the scalp and face regions, compared with the torso and extremities, and might have been expected to favor a greater photoepilation efficiency on the former sites.34 Further studies are necessary to substantiate body site–dependent clinical photoepilation efficiency, related to relative anagen duration and pilosebaceous depth and average hair shaft diameter.

Patients in this study had the greatest HRE after 1 to 3 treatments. Although further treatments led to some increased hair removal, the added benefit was small. Possibly, the initial flashlamp treatment has sufficient energy to destroy the largest number of anagen follicles during the initial treatment session. Light-induced regression of follicles into the catagen or telogen phase may make these targets less susceptible to subsequent treatments.2,7

All treated sites in this study achieved greater than 50% HRE when evaluated more than 12 months following the last treatment; this finding correlated with the observed high level of patient satisfaction. It is unlikely that any miniaturized or damaged hairs could regrow after such a long period. The observed increasing improvement of HRE following the last treatment may be related to partial pilosebaceous injury with subsequent long-term “dropout” effect.

In conclusion, our data document the long-term clinical efficacy of IPL-induced hair removal in light and dark skin and hair phenotypes. Maximal HRE was achieved from the initial treatments. The documentation of maintenance of diminished hair counts for up to 30 months after last treatment supports the long-term value of IPL technology in the treatment of hirsutism.

Accepted for publication June 30, 2000.

This study was supported in part by ESC Sharplan, Norwood, Mass.

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REFERENCES