Laser Hair Removal

A Review and Report on the Use of the Long-Pulsed Alexandrite Laser for Hair Reduction of the Upper Lip, Leg, Back, and Bikini Region

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BACKGROUND. The mechanism and permanence of laser-assisted hair removal remains a formidable task in the medical community.

OBJECTIVE. The purpose of this study was to determine the safety and long-term efficacy of the long-pulsed or normal mode alexandrite infrared laser for hair depilation.

METHODS. Beginning in October 1996, a total of 31 anatomic sites on 22 patients ranging in age from 25 to 59 years (mean 42 years) were evaluated to assess hair removal. Treatment sites included 17 upper lips, 9 legs, 2 backs, and 3 bikini regions. Eligible patients were of Fitzpatrick skin types I–III. Patients were treated using the long-pulsed alexandrite infrared laser at 755 nm, single-pulse technique, 10 mm spot size, 10% overlap, pulse durations of 5, 10, and 20 msec, and a fluence of 20 J/cm^2. Subjective patient improvement and objective, blinded graded improvement was assessed at 1, 2, 3, and 6 months.

RESULTS. Objective blinded grading at 6 months revealed that hair reduction varied both with the pulse duration and anatomic location. Maximum reductions observed were 40%, 56%, 50%, and 15% for the lip, leg, back, and bikini areas, respectively. Upper lip hair reduction increased from 40% to 54% at 6 months when a second treatment was performed 8 weeks after the initial treatment.

CONCLUSION. The long-pulsed alexandrite laser is safe and effective in reducing hair growth. Treatment efficacy varies with the anatomic location, pulse duration, and number of treatments. A single-pulse technique utilizing a 10 msec pulse duration at 20 J/cm^2 produced the greatest hair reduction. No permanent adverse effects occurred on skin types I–III at the parameters tested.

Unwanted hair presents a significant problem for many. Numerous methods of hair reduction are described in the literature, but few with any permanancy.[1–12] Recently, induction of permanent, nonscarring alopecia has been reported after high-energy, long-pulse normal mode ruby treatment.[13] The present study reviews the clinical results of a study of another long-pulse alexandrite (LPA) laser.

The general anatomy of an individual hair is shown in (Figure 1). Each hair has three distinct regions: the bulb (which resides near the insertion of the arrector pili), the isthmus, and the infundibulum. Hair cycles through three phases termed anagen, catagen, and telogen (Figure 2).[14–17]

Selective injury confined to the desired target tissue (in this case hair) while sparing surrounding structures or tissue comprises the process of selective photothermolysis.[18] However, for dark hairs there are greater numbers of melanocytes within the follicle than there are within the epidermis. In this situation, an extension of the principle of selective photothermolysis—thermokinetic selectivity (TS)—may be applied. TS theory states that for the same chromophore, larger pulse durations allow intrapulse cooling of smaller targets of the same chromophore.[19–22] To minimize undesired damage to epidermal melanin the principle of TS is applied to select the optimum pulse duration.

The recent introduction of various devices that produce epidermal cooling during laser treatment add additional variables that have not yet been fully investigated. The ideal laser pulse duration probably lies between the epidermal TR of 3 msec, and the follicular TR of 40–100 msec. Grossman et al. proposed that a pulse duration of approximately 10–50 msec might be optimal for directed epidermal damage while minimizing undesired epidermal injury.[4] Thus far the optimal combination of wavelength, pulse duration, fluence, or laser/light source to impart permanent hair removal has not been established.[23,24]

Various laser devices and wavelengths have been utilized in the pursuit of this objective and are well described.[25–45] The LPA used in this study was chosen not only to evaluate the 5, 10, and 20 msec durations, but also because its longer wavelength (755 nm versus

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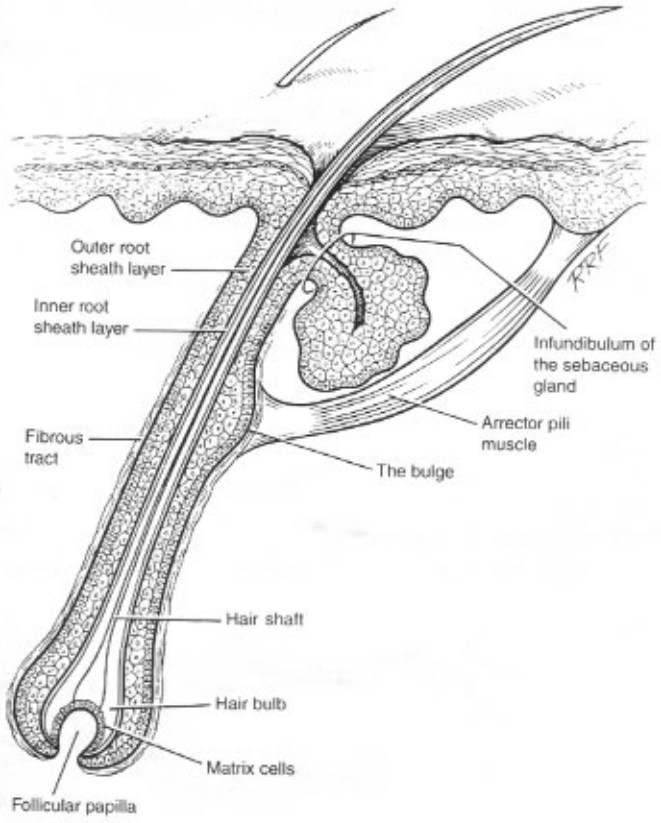

Figure 1. Hair follicle anatomy.

694 nm for ruby) produces a greater depth of penetration. Melanin absorption is less in the 755 nm LPA than the 694 nm ruby. This feature should theoretically minimize side effects related to epidermal pigment change, however, it could also reduce treatment efficacy at the hair follicle.

Materials and Methods

Twenty-two volunteers were selected to evaluate the safety and long-term efficacy of the normal mode long pulsed alexandrite laser (20 J/cm^2; 5, 10, and 20 msec pulse durations) for hair reduction. The average age of the patients was 42 years (range 25–59 years). Fitzpatrick skin types included type II (16 patients) and type III (6 patients). In a prior pilot study it was discovered that patients of skin types V and VI had epidermolysis and transient pigmentary problems, therefore those darker skin types were excluded from this study. White hair is inherently less responsive and was similarly excluded. All patients had brown or black hair. The anatomic sites that were treated included the upper lip (17 patients), legs (9 patients), back (2 patients), and bikini region (3 patients). Prior to treatment all patients provided informed consent as stipulated in the IRB.

Patients shaved 1–3 days prior to treatment. Patients were instructed to avoid sun exposure and tanning beds 2

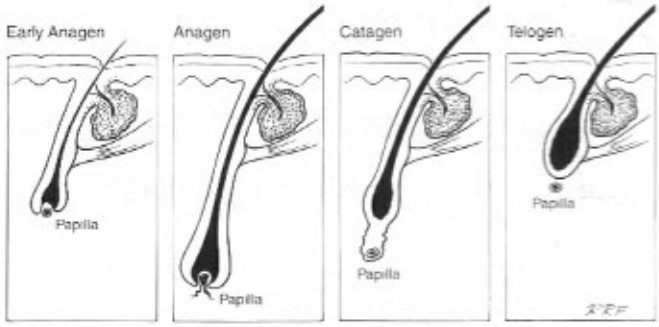

Figure 2. The hair growth cycle.

weeks prior to treatment. Tanning and hydroquinone were prohibited during the study period. Those patients with a history of herpes simplex were prescribed prophylactic acyclovir, 400 mg three times a day, 5 days prior to and 5 days after treatment of the perioral region. All treatment areas utilized a fixed fluence of 20 J/cm^2. The treatment parameters for the upper lip were as follows: 10 mm circular spot size with only a 10-msec pulse duration. The treatment parameters for the leg, back, and bikini regions were divided into four sections composed of a control (no treatment) panel and three additional treatment panels with pulse durations of 5, 10, and 20 msec. The treatment areas utilizing pulse durations of 5 and 10 msec were performed with a 10 mm circular spot size. The 20-msec pulse duration treatment sites were performed utilizing a 7 mm circular spot size to obtain 20 J/cm^2. Laser pulses where delivered through a thin (approximately 0.5 mm) layer of K-Y Jelly chilled to 4°C in an ice water bath. Patients reported erythema, bruising, crusting or scaling, blistering, and skin sensitivity reactions.

Serial photographs were taken with a 35 mm Nikon macro system, a digital imaging system, and a stereotactic cage with lighting standardized and film from a single emulsion batch processed at the same laboratory. Objective, blinded photo grading was performed by a team of cosmetic surgeons and research assistants blinded to controls, actual treatment sites, and patient identity. Objective grading was performed on actual hair counts and subjective "combined assessment" grading was performed which was based on three parameters: hair count, hair shaft diameter, and hair color. Treatment results were comparatively analyzed using paired-difference t-tests where $P < 0.05$ reflected statistical significance. In addition, 95% confidence intervals were obtained on all data points.

Results

Most patients complained of minimal discomfort during treatment. All experienced transient mild erythema. Postoperatively no pain was reported, although a mild "sunburn-like" sensation persisted for up to 72 hours posttreatment. The patient diary data revealed that 10 sites (32%) had postoperative erythema lasting a

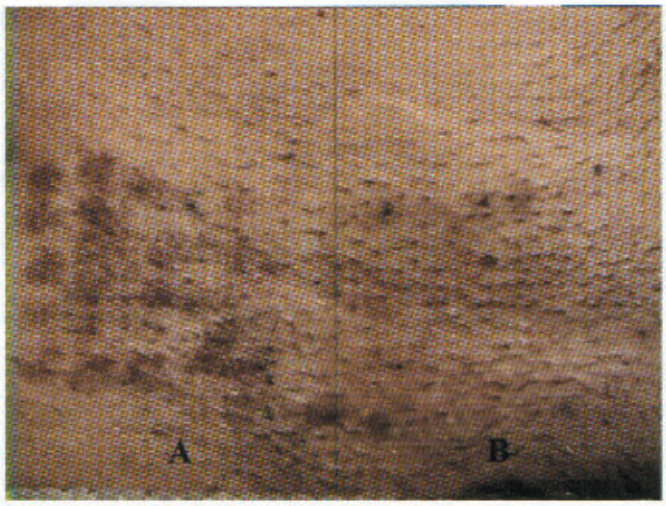

Figure 3. Transient hyperpigmentation 1 week after treatment: A) 20 msec treatment site, B) 10 msec treatment site.

mean of 1.8 days. Four sites (13%) had mild crusting lasting a mean of 4.5 days. Seven sites (23%) had skin sensitivity lasting a mean of 1.5 days. Four sites (13%) reported fine vesiculation lasting a mean of 2 days. Two patients (9%) with skin type III developed transient hyperpigmentation lasting from 4 to 14 days (mean 9 days) (Figure 3). All hyperpigmentation had resolved by the 1 month follow-up visit. No bruising, purpura, scarring, hypopigmentation, or infections were observed.

Patients subjectively graded their own hair reduction at 3 months via questionnaire. This revealed hair reduction rates of 55%, 71%, 60%, and 67% for the lip, leg, back, and bikini regions, respectively (95% confidence intervals were 41–69, 58–84, 120–240, and 5–129, respectively) (Figure 4). In comparison, blinded objective grading using the "combined assessment" protocol at 3 months yielded similar results (Figure 5). A 52% reduction in hair regrowth was noted on the right lip when treated for 10 msec. The percentages obtained at 5, 10, and 20 msec, respectively, were legs, 64%, 61%, and 55%; back, 53%, 35%, and 53%; and bikini, 35%, 43%, and 37%. Patients consistently recorded a greater percentage improvement than that objectively determined by the blinded review panel.

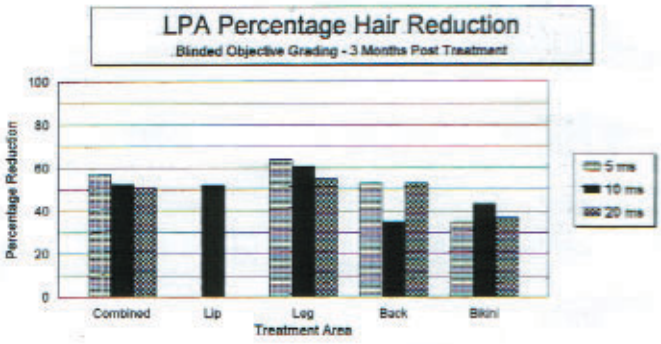

Figure 5. Blinded, objective grading, 3 months.

Subjective patient evaluation was not performed at 6 months. The same blinded objective grading showed 40% hair reduction for the left lip. The right lip region, which received a second treatment at 2 months, showed 54% hair reduction. Treatments of 5, 10, and 20 msec produced reductions in hair growth of the legs, 32%, 56%, and 41%; and back, 25%, 50%, and 45%, respectively. Only three patients were treated in the bikini region with 8%, 15%, and 8% hair reduction for 5, 10, and 20 msec confidence intervals, respectively. The 95% confidence intervals were leg, 24–40, 46–66, 32–50; back, 11–39, 34–66, 18–72; and bikini, 0–16, 0–30, 0–16, respectively (Figure 6). Comparing combined hair reduction data for 1, 3, and 6 months, a gradual decline in hair reduction rates was observed, with the greatest decline for patients treated with the shortest (5 msec) pulse duration (Figure 7).

In a few cases identical hairs could be identified in pre- and postimages. Some hairs showed marked lightening in color, while the diameters of hair shafts decreased in others. However, these observations were unable to be quantified objectively (Figure 8).

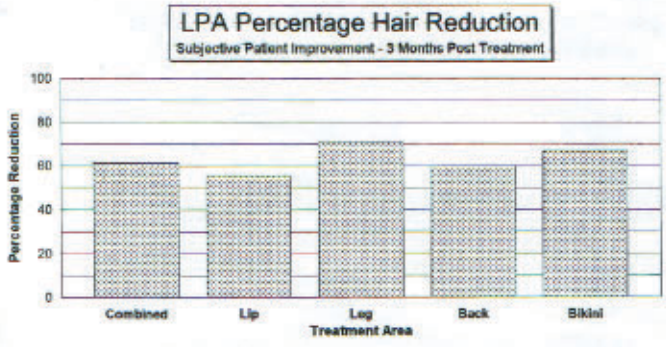

Figure 4. Subjective patient evaluation, 3 months.

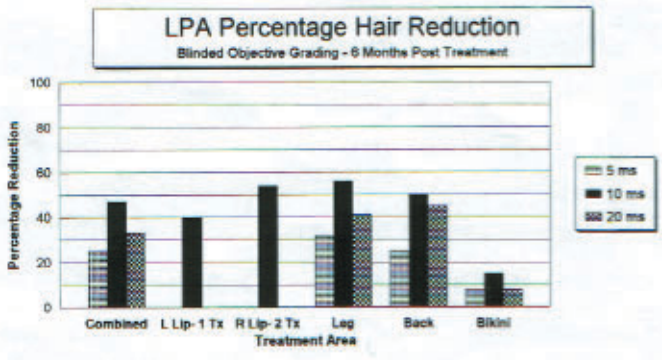

Figure 6. Blinded, objective grading, 6 months.

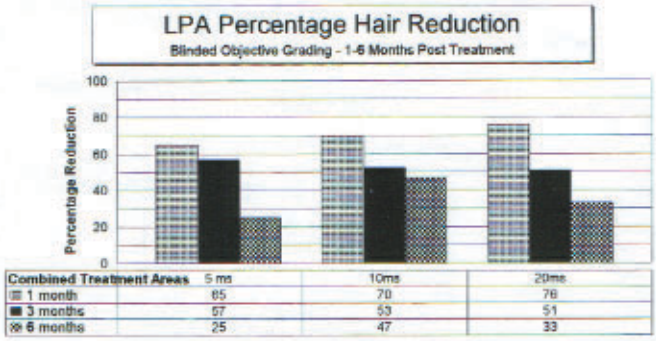

Figure 7. Combined comparison of blinded, objective grading of hair reduction by pulse duration.

Discussion

This study demonstrated a substantial reduction in hair regrowth without significant epidermal injury. Other than the minor transient side effects noted earlier, there were no serious adverse events, permanent pigment changes, or scarring. Comparison of blinded objective grading at 6 months showed the 10-msec pulse duration treatment sites had significantly better hair reduction rates than for 5 msec sites ($P = .0002$) and somewhat better rates than 20 msec sites ($P = .04$).

Hair reduction varied by anatomic site, with the legs showing the greatest reduction at 6 months. When a second treatment was performed on the lip, synchronized with the hair cycle (8 weeks), a significant incremental improvement in hair reduction was observed ($P = .02$).

Transient hyperpigmentation was observed in two patients with type III skin. This darkening lasted 3–4 weeks and then resolved without lasting sequelae.

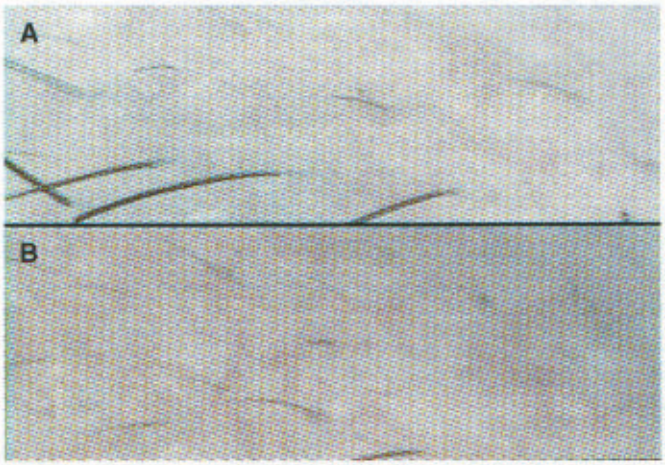

Figure 8. Digital videomicroscopic photos of the identical site of the right upper lip (magnification 30×). A) pretreatment and B) 6 months after first treatment (4 months after second treatment). Note the decreased hair shaft diameter and pigmentation changes of the same hairs.

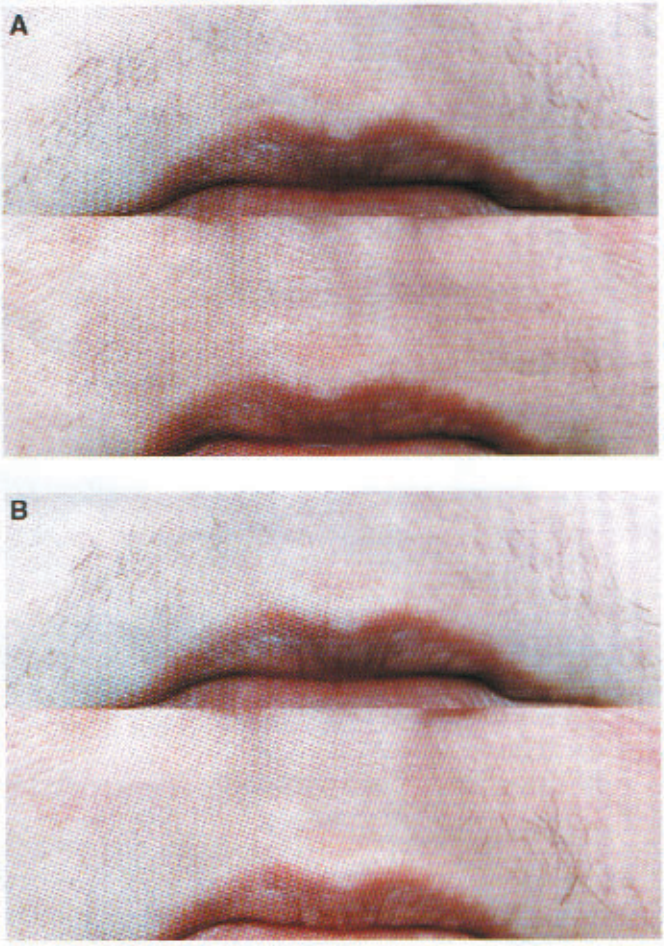

Figure 9. A) (Top) Pretreatment and (Bottom) 2 months post initial treatment and 1 month using LPA with 100 mm spot diameter at 20 J/cm², single pulse technique (10% overlap) at 10 msec with chilled K-Y jelly. B) (Top) Pretreatment and (Bottom) left lip 6 months after single treatment; right lip 6 months after first treatment and 4 months after second treatment at same parameters as 9A.

This phenomenon has also been observed in some patients with type III and IV skin, most noticeably in suntanned patients, patients with severe lentiginous photoaging, and a few patients with acute sun exposure who had not yet developed a visible tan. How these phenomena correlate with the TS theory and pulse duration, as well as effects of epidermal cooling, are important clinical issues that warrant further investigation.

While not observed in this study, potentially more severe or even permanent pigment dyschromias may occur at injury thresholds using energies higher than those that produce hyperpigmentation. It was anticipated that observed hair reduction would increase as pulse duration increased from 5 to 10 to 20 msec. At the 6 month period the sites treated for 10 msec experienced greater hair reduction compared to the sites treated for 5 and 20 msec (Figure 9). Unfortunately

Figure 10. Chin of a 32-year-old woman with type II skin. A) pretreatment and B) 6 months after first treatment to chin and 4 months after second treatment to right chin.

technical problems necessitated substitution of the 7 mm spot size for all of the 20 msec treatment sites. Studies have demonstrated a significant decrease in the depth of penetration using the 7 mm compared to the 10 mm spot size. Thus it is possible that the percentage hair reduction at 20 msec relative to 10 msec is actually higher than was observed in this study.

It is also important to note that while the 5 and 10 msec pulses from this LPA laser were "true" long pulses, the 20 msec pulse was instead composed of a burst of six pulses, each pulse 0.83 msec long with "off" periods of 3 msec. The six shorter pulses have a peak power four times higher than if it were a continuous 20 msec pulse. Thus there are several possible factors that may account for the differences observed in hair reduction between pulse durations. The TS theory suggests that the longer pulse durations should produce fewer adverse pigmenting events (but not necessarily any difference in hair reduction). This study suggests that longer pulse durations may indeed produce greater hair reduction than shorter pulse durations (Figure 7) and that this difference may increase with longer follow-up (Figure 10). Of interest, pilot study patients with more than 2 years of follow-up show persistent hair reduction, with the greatest reduction occurring in areas treated with double pulsing. Further studies are required to clarify the effects of pulse duration, treatment intervals, and double pulsing.

Conclusion

This study demonstrates the feasibility of performing hair reduction safely and rapidly with minimal patient discomfort for dark hair on Fitzpatrick skin types I–III that are not recently sun exposed or suntanned using the long-pulsed alexandrite laser hair reduction technique. The degree and duration of reduction vary by anatomic site and by the treatment parameters selected. Two treatments synchronized to the hair growth cycle appeared to improve results.

Histopathology and further long-term follow-up studies with larger sample sizes are needed to determine what parameters provide truly permanent hair removal versus a simple delay in hair regrowth. Fluence, multiple pulses, pulse duration, epidermal cooling, treatment intervals, and anatomic variability all need more investigation. Safety and efficacy for photoaged or recently tanned skin and for darker skin types also requires more evaluation.

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Commentary

New technology and procedures routinely results in boundless enthusiasm by physicians and patients as they seek the "magic bullet" for difficult clinical problems. As time passes the value of a new technology or procedure is evaluated and enthusiasm wanes. Eventually the technology or procedure may fade into obsolescence or become a standard technique. Laser hair removal was introduced 2 years ago. Without question, we have had a wave of boundless enthusiasm! We are now entering into the second stage where we evaluate the efficacy of this technique. Unfortunately, commercialism has resulted in skewed science. Evaluation of the devices for laser hair removal has been confounded by potential financial gain. The market is lucrative and the public tantalized by laser technology.

This study was performed in a private practice setting that has had extensive experience with lasers. Like many other reports on the use of lasers for hair removal, this article suffers from a lack of quality prospective scientific methodology. However, it is important that we recognize those at the leading edge, such as these authors, are searching for treatment parameters for which no standard exists.

The results of this study are much like many others we have seen in which the clinical results after laser hair removal are not permanent. Maximum reduction of hair loss in this study ranged from 15% to 56%, depending on anatomic site. Only 22 patients were treated in 31 anatomic sites. Some of the evaluation of sites was based on as few as two or three regions. There was no comment made about the male:female ratio, which is as significant as skin type, hair color, and other factors related to hair growth.

The authors succeed in demonstrating efficacy and safety and have expanded our knowledge to help improve this technique. However, as yet we cannot accept laser hair removal as the standard of care until technology has further evolved. Randomized prospective site controlled, sex controlled, pigment and hair type controlled studies must be performed with long-term follow-up using hair counts, hair shaft diameter measurement, and accurately documented photography in a double-blind fashion. These studies are difficult to do and costly, but they are necessary if clinicians are to accept laser hair removal as part of our standard armamentarium for the treatment of hirsutism, or unwanted hair.

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