Comparison of Long-Pulsed Diode and Long-Pulsed Alexandrite Lasers for Hair Removal: A Long-Term Clinical and Histologic Study

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BACKGROUND. Unwanted facial and body hair is a common problem, generating a high level of interest for treatment innovations. Advances in laser technology over the past several years has led to the development and distribution of numerous red and infrared lasers and light sources to address this issue. Despite the impressive clinical results that have been reported with the use of individual laser hair removal systems, long-term comparative studies have been scarce.

OBJECTIVE. To compare the clinical and histologic efficacy, side effect profile, and long-term hair reduction of long-pulsed diode and long-pulsed alexandrite laser systems.

METHODS. Twenty women with Fitzpatrick skin types I–IV and dark terminal hair underwent three monthly laser-assisted hair removal sessions with a long-pulsed alexandrite laser (755 nm, 2-msec pulse, 10 mm spot) and a long-pulsed diode laser (800 nm, 12.5 msec or 25 msec, 9 mm spot). Axillary areas were randomly assigned to receive treatment using each laser system at either 25 J/cm^2 or 40 J/cm^2. Follow-up manual hair counts and photographs of each area were obtained at each of the three treatment visits and at 1, 3, and 6 months after the final laser session. Histologic specimens were obtained at baseline, immediately after the initial laser treatment, and 1 and 6 months after the third treatment session.

RESULTS. After each laser treatment, hair counts were successively reduced and few patients found it necessary to shave the sparsely regrown hair. Optimal clinical response was achieved 1 month after the second laser treatment, regardless of the laser system or fluence used. Six months after the third and final treatment, prolonged clinical hair reduction was observed with no significant differences between the laser systems and fluences used. Histologic tissue changes supported the clinical responses observed with evidence of initial follicular injury followed by slow follicular regeneration. Side effects, including treatment pain and vesiculation, were rare after treatment with either laser system, but were observed more frequently with the long-pulsed diode system at the higher fluence of 40 J/cm^2.

CONCLUSION. Equivalent clinical and histologic responses were observed using a long-pulsed alexandrite and a long-pulsed diode laser for hair removal with minimal adverse sequelae. While long-term hair reduction can be obtained in most patients after a series of laser treatments, partial hair regrowth is typical within 6 months, suggesting the need for additional treatments to improve the rate of permanent hair removal.

DERMATOLOGISTS ARE frequently consulted by patients regarding treatment possibilities for unwanted hair growth. Whereas only methods and procedures with limited and/or temporary efficacy such as electrolysis, waxing, and depilatory use were available for many years,[1–4] the introduction of laser-assisted hair removal in 1995 marked the beginning of a new era. Using follicular melanin as the target, a plethora of red and infrared laser systems and intense light sources are now being used to reduce hair regrowth and thickness with relatively few side effects.[5–16] Unfortunately these systems have been shown to have little effect on light-colored hairs due to the relative lack of melanin in pale hair shafts.[17,18] The use of higher fluences should conceivably effect greater follicular injury and more prolonged or even permanent hair removal. However, the risk of complications such as vesiculation, dyspigmentation, and scarring also increase with application of greater energy densities to the skin.[19] The newest red and infrared laser systems can effectively deliver such high fluences, but their relative risks and benefits have not been studied. Thus the purpose of this investigation was to compare the clinical and histologic effectiveness and side effect profile of two different long-pulsed laser systems (800 nm diode and 755 nm alexandrite) at various energies for hair removal with prolonged postoperative follow-up.

Materials and Methods

Twenty women (ages 20–60 years, mean age 38.9 years) with Fitzpatrick skin types I–IV and dark (brown or black) terminal hairs voluntarily consented to undergo axillary laser-assisted hair removal with two different laser systems.

C. Handrick, MD and T. S. Alster, MD have indicated no significant interest with commercial supporters.

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Exclusion criteria included any previous laser treatment to the study areas, regional electrolysis within 6 months of study entry, waxing, depilatory or bleach use within 1 month of study entry, shaving or clipping of hair within 1 week of laser treatment, hormonal dysfunction, use of medications or hormones with androgenic effects, history of keloid scarring, active bacterial, viral, or fungal cutaneous infection within the treatment area, isotretinoin use within 6 months of study entry, photosensitivity or seizure disorder triggered by infrared light, and chronic sun exposure or tanning.

Randomization of laser type to each axilla and subsequent randomization of energy densities to upper and lower axillary halves were made by blinded card draw by the patient. Digital photographs of treatment sites at each patient visit were obtained using identical lighting, patient positioning, and camera settings. An average of three manual hair counts of the entire axillary region by a single investigator using 10× illuminated magnification was calculated. Immediately prior to laser irradiation, the skin was cleansed with mild soap, rinsed with water, and any hairs longer than 1 mm were shaved with a safety razor. The long-pulsed 755 nm alexandrite laser was used to treat the hair-bearing skin through a thin layer (1–2 mm) of refrigerator-cooled, water-soluble gel at 25 J/cm^2 (10 mm spot size, 2-msec pulse duration). The long-pulsed 800 nm diode laser was used to deliver 25 J/cm^2 (12.5-msec pulse width) or 40 J/cm^2 (20-msec pulse width) through a 9 mm^2 sapphire chill tip. [Note: These parameters were chosen to maximize the capabilities of each laser system under study. The alexandrite laser system was limited to a fluence of 25 J/cm^2 and pulse duration of 2 msec and therefore identical parameters between the two laser systems could not be compared.] Adjacent, nonoverlapping laser spots using both systems at the parameters outlined were placed over the treatment area by the same operator in every study patient.

Each patient received a total of three laser treatments at monthly intervals using the same laser parameters for each area at every visit. Follow-up clinical evaluations, photographs, and hair counts were also made 1, 3, and 6 months after the third and final laser treatment. Clinical improvement scores were determined by two masked independent medical (noninvestigator) evaluators using the following quartile rating scale: 0, no improvement; 1, <25% improvement; 2, 25–50% improvement; 3, 51–75% improvement; 4, >75% improvement. Patients were also asked to rate their individual pain responses (none, mild, moderate, or severe) to laser treatment at each visit. Skin punch biopsies were obtained from three patients in each treatment area at baseline, immediately after the initial laser treatment, and 1 and 6 months after the third laser session. Histologic evaluations and hair counts within both horizontal and vertical tissue sections were interpreted by a board-certified dermatopathologist blinded to the treatment regimen.

As the decisive criterion for determining the effectiveness of each laser system at each visit, the average degree of hair regrowth was calculated (current hair count/baseline hair count). To determine whether significant differences existed between each treatment approach, repeated measures of analysis of variance (ANOVA) and paired *t*-tests were performed.

Results

Hair Regrowth Rates

The lowest overall hair counts were seen 4 weeks after the second laser treatment, regardless of laser system or fluence used (Table 1). Significant differences in hair regrowth were observed between the use of the alexandrite and diode lasers at 25 J/cm^2, but not at 40 J/cm^2.

Clinical Improvement

Significant and equivalent clinical improvement was seen after each treatment using either the diode or alexandrite laser at 25 or 40 J/cm^2 (Figures 1 and 2) Clinical improvement scores with the alexandrite laser averaged 2.9 after one treatment, 3.2 after two treatments, and 3.5 after three treatments. After long-pulsed diode laser treatment at 25 J/cm^2 clinical improvement scores averaged 3.0, 3.5, and 3.5 after one, two, and three sessions, respectively. Similar clinical improvement after diode laser treatment at 40 J/cm^2 was observed, with scores of 2.8, 3.0, and 3.4 after one, two, and three sessions, respectively.

Side Effects

Mild transient erythema and perifollicular edema were seen immediately after laser irradiation with each laser system, regardless of fluence. The intensity and duration of erythema and edema decreased with each successive laser treatment. The most severe side effects were seen in two individuals with skin type IV, who both responded with transient hyperpigmentation following each diode laser treatment with an energy density of 25 J/cm^2 in one case and 40 J/cm^2 in the other. One of these same patients also exhibited minor vesiculation without hyperpigmentation after the initial alexandrite laser treatment. On the other hand, another patient with skin type I experienced blistering after the second diode laser treatment at 40 J/cm^2. Regardless of skin type, patients rated intra- and postoperative pain with alexandrite laser treatment as mild to moderate, compared to moderate to severe with diode laser irradiation, particularly with application of the higher (40 J/cm^2) fluence. Slightly more discomfort was experienced with each of the lasers during the second and third laser session compared to the first session, but the differences were insignificant. There was no evidence of scarring or atrophy in any patient treated (Figure 1).

Histologic Results

Immediately following laser irradiation using either laser system at 25 or 40 J/cm^2, coagulated hairs were

Table 1. Hair Regrowth (Data Analysis)

			t-test		
Treatment session	*Mean hair regrowth (%)*	*ANOVA (repeated measures analysis of variance)*	*Alexandrite 25 versus diode 25*	*Alexandrite 25 versus diode 40*	*Diode 25 versus diode 40*
4 weeks S/P × 1					
Alexandrite 25	54.0	Not quite significant	Not significant	Not significant	Significant (P = .0180)
Diode 25	46.2				
Diode 40	59.8				
4 weeks S/P × 2					
Alexandrite 25	35.5	Significant (P = .0003)	Significant (P = .0006)	Not significant	Significant (P = .0009)
Diode 25	25.6				
Diode 40	40.4				
4 weeks S/P × 3					
Alexandrite 25	48.2	Not significant	Significant (P = .014)	Not significant	Not significant
Diode 25	40.4				
Diode 40	45.4				
3 months S/P × 3					
Alexandrite 25	83.2	Not quite significant	Significant (P = .0162)	Not significant	Not significant
Diode 25	69.2				
Diode 40	77.8				
6 months S/P × 3					
Alexandrite 25	60.4	Not quite significant	Significant (P = .0359)	Not significant	Significant (P = .04)
Diode 25	54.2				
Diode 40	62.5				

observed within hair follicles as well as a variable amount of inflammation and pigmentary incontinence (Figure 3). Histopathologic evaluation 1 and 6 months after the final treatment revealed follicular miniaturization and fewer numbers of terminal hairs in all biopsy specimens, irrespective of the laser or fluence used (Figure 4).

Discussion

Significant and equivalent hair reduction was observed after either long-pulsed alexandrite or long-pulsed diode laser treatment. Given the continued improvement in clinical scores after each successive laser treatment, it was surprising that the lowest hair counts were seen after the second laser session, with significantly less hair regrowth after the use of the diode laser at 25 J/cm^2 (compared to the alexandrite at 25 J/cm^2 or diode at 40 J/cm^2). This particular finding is counterintuitive, as more hair destruction would be expected with the use of the higher fluence (40 J/cm^2). A possible explanation for the differences seen may relate to the different pulse durations used (2 msec for alexandrite, 12.5 msec for diode at 25 J/cm^2, and 20 msec for diode at 40 J/cm^2). Although no significant differences have been reported with the use of the alexandrite laser at pulse durations of 5, 10, and 20 msec,[20] the use of a 2-msec versus 12.5-msec or 20-msec system represents a greater and perhaps more significant discrepancy.

Another unanticipated finding was the increase in hair count after the third laser treatment (compared to after the second, but still lower than baseline). The increase in hair regrowth may be explained by the fact that the duration of telogen for axillary hairs is 3 months, thus requiring that long for laser-irradiated hair shafts to cycle back into anagen.[18] It had previously been suspected that hairs in early anagen were most susceptible to laser irradiation (presumably due to the presence of increased amount and distribution of follicular melanin and more superficial dermal positioning of hair growth centers);[21] however, this theory has subsequently been disproved.[18] At present it remains unknown exactly which portion of the hair follicle is best targeted to effect its destruction.

Hair counts performed 6 months after the final laser treatment in this study demonstrated continued hair reduction, with lower hair counts than at postoperative month 3, underlining the capability of both systems to effect long-standing hair removal. This long-term dropout effect may be related to critical ischemic damage to a percentage of hairs after laser irradiation. In addition, most patients reported slower hair regrowth 6 months after treatment, necessitating less frequent shaving. The shaving rate prior to laser

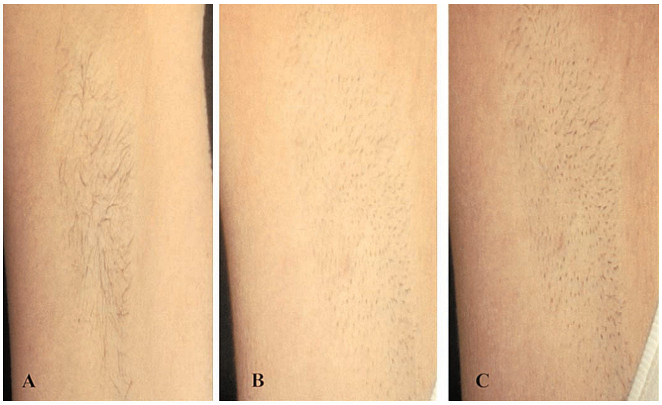

Figure 1. Axillary hair: A) prior to the first long-pulsed alexandrite laser treatment at 25 J/cm^2, B) 1 month after the second alexandrite laser treatment, and C) 6 months after the third treatment session. (Note: No shaving or clipping of hair was performed within 1 week of each photograph.)

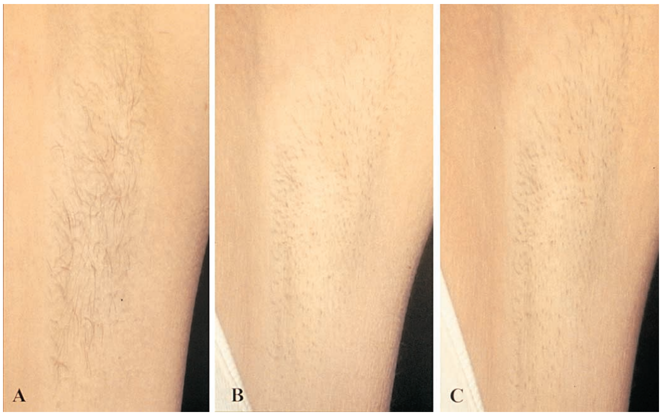

Figure 2. Axillary hair: A) prior to long-pulsed diode laser treatment, B) 1 month after two laser sessions, and C) 6 months after three consecutive treatments at 25 J/cm^2 (upper half) and 40 J/cm^2 (lower half). (Note: No shaving or clipping of hair was performed within 1 week of any photograph.)

treatment ranged from every 1 to 4 days, compared to every 4 weeks following the treatment course.

The need for less frequent shaving (and associated high patient satisfaction) may be explained by the miniaturization of follicles seen histologically in the posttreatment biopsy specimens. Upon laser-induced follicular damage, the follicle is propelled into telogen, thereby effecting decreased hair density as well as an alteration in hair cycling characteristics.

The frequency and severity of side effects seems to depend on both patient-related and laser-associated factors. Three of four patients with significant side effects (hyperpigmentation and vesiculation) had darker skin tones (Fitzpatrick phototype IV). The increased epidermal melanin seen in patients with darker skin tones serves as a competing chromophore and facilitates absorption of energy in the skin. In terms of laser-associated factors, the use of higher fluences produced more treatment-related pain. Regardless of the fluence used, the diode system was nearly always rated as being more painful, despite the concomitant use of contact cooling, which typically reduces treatment discomfort. It is probable that increasing the time of contact of the chill tip with the skin would have resulted in less pain, but slower treatment sessions. Since laser-assisted hair removal is considered an elective procedure, pain is an important factor for patients in determining whether to undergo laser treatment. In addition, the faster treatment times attainable with the use of the scanner (available on the alexandrite laser used

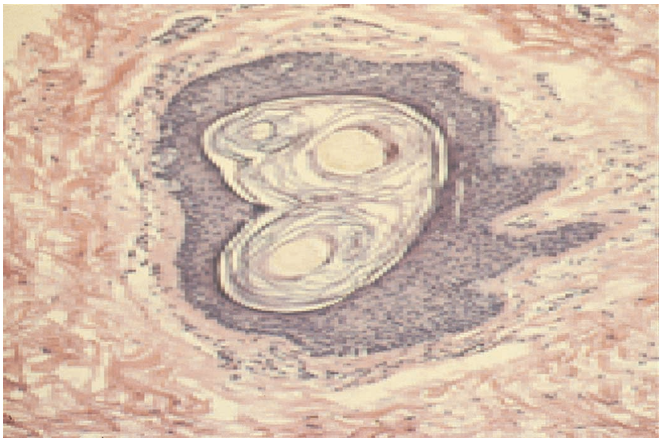

Figure 3. Coagulated hairs in follicles with inflammation and pigmentary incontinence seen immediately after long-pulsed alexandrite or diode laser irradiation. (Horizontal orientation; magnification 25×.)

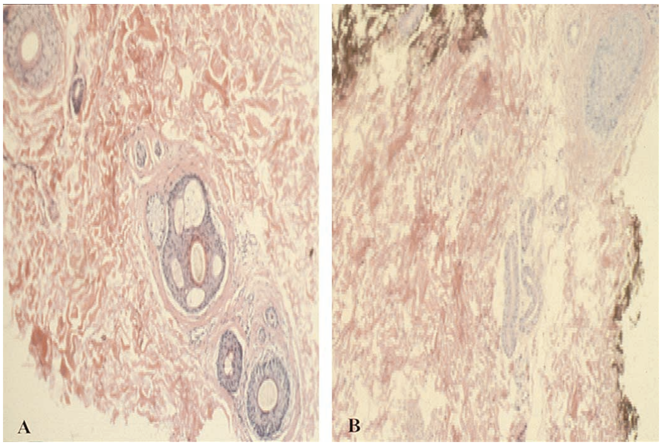

Figure 4. Compared to the presence of large pigmented terminal hairs, A) pretreatment, follicular miniaturization and paucity of terminal hairs were the norm after B) three successive (monthly) long-pulsed alexandrite or diode laser sessions. These histologic changes continued to be evident 6 months after the final treatment. (Oblique orientation; magnification 10×.)

in this study) make it more practical for extensive treatment areas.

Conclusion

Either a long-pulsed alexandrite or a long-pulsed diode laser system can be safely used to effect long-term laser hair removal. While the diode laser system at 25 J/cm^2 (12.5-msec pulse) provided slightly greater hair reduction compared to the diode at 40 J/cm^2 (20-msec pulse) or alexandrite at 25 J/cm^2 (2-msec pulse), its slightly higher rate of side effects (vesiculation and hyperpigmentation) and associated pain may make its use less desirable in patients with darker skin tones.

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