

Clinical Report

Long-Term Fine Caliber Hair Removal With an Electro-Optic Q-Switched Nd:YAG Laser

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Background: In spite of major advances in hair removal therapy, fine caliber hair remains a significant challenge for laser- and light-based devices.

Objective: Evaluate a novel Electro-Optic (EO) Q-switched Nd:YAG laser for pigmented fine caliber hair removal in the Standard Single and a double pulse (DP) mode.

Methods: Eleven patients underwent four laser treatments at monthly intervals. Bilateral anatomical regions received to one side the standard single pulse (SSP) while the other side the DP option. Blinded investigators conducted hair counts at 6 months post-treatment and after 24 months. Patients assessed hair loss and discomfort. Six patients rated their satisfaction at 6 months.

Results: At 6 months, investigators found a reduction of 50% in hair counts with the DP and 46% with standard pulse. Ninety percent in DP and 50% in SSP reported none to mild discomfort. Transient erythema and edema was observed with a lower severity rating with the DP. There were no other untoward effects. 83.3% of patients who completed the study at 6 months expressed satisfaction with the results. At 24 months hair loss was maintained at the same rate.

Conclusion: The EO Q-switched Nd:YAG laser is an effective option for the permanent treatment of unwanted fine hair and has a high-patient satisfaction rate. There is less therapeutic discomfort in the DP mode. *Lasers Surg. Med.* 42:706–711, 2010. © 2010 Wiley-Liss, Inc.

Key words: fine caliber hair; laser hair therapy; permanent hair removal; photoacoustic; photothermal

Traditional methods for the temporary removal of hair include waxing, plucking, shaving, and the use of chemical depilatories. Electrolysis may permanently destroy the terminal follicle, but it is limited being generally relatively slow with a variable efficacy rate. Light therapy has become a major therapeutic approach for hair removal with many laser and intense light sources being utilized. Although it is also associated with a variable therapeutic outcome, it can be rapidly administered to larger areas with each pulse. Laser systems for photoepilation include ruby lasers [1,2],

infrared-light systems (alexandrite [3,4], diode [5,6], and Nd:YAG [7–10]), and intense pulsed light (IPL) alone [11,12] or in combination with radiofrequency energy [13].

An approach to laser-assisted hair removal has been the attempt to treat the hair in a time frame that remains equal to or less than the thermal relaxation times of the hair follicles limiting transference of heat energy from the hair follicle to the perifollicular areas [1,14,15]. Human terminal hair follicles have an estimated thermal relaxation time of 10–100 milliseconds, depending on size. Q-switched laser systems have their pulse durations well below these times. With pulse durations in the nanosecond range, these lasers mainly photomechanically disrupt the hair follicle by extreme and rapid heating of the absorbing chromophore (melanin). The resulting photoacoustic “shock waves” cause disruption of the hair shafts and subsequent follicular damage. This is in addition to any photothermal events.

Besides the pulse duration, Q-switched Nd:YAG lasers have received renewed attention because of their 1,064 nm wavelength which is particularly safe in treating darker skin types [16,17]. The 1,064 nm wavelength penetrates deeply enough to damage the hair follicle with a reduced risk of epidermal damage due to a relative decrease in melanin absorption, even in patients with highly pigmented skin.

The larger the caliber of the hair shaft the greater the target and effectiveness of laser therapy. Fine caliber hairs have traditionally been dramatically less responsive to laser therapy. The purpose of this study was to examine the hair removal capabilities of a novel Electro-Optic (EO) Q-switched Nd:YAG laser having both the standard single

Conflict of interest: Laser made available by manufacturer for the study.

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pulse (SSP) and a double pulse (DP) mode in patients with fine caliber pigmented hair over an extended period.

METHODS

Subjects

Eleven patients were enrolled in this IRB-approved study. Ten patients completed the laser treatment sessions. Ages ranged from 25 to 58 years with a median age of 49. All patients had fine caliber pigmented hairs. Of the 10 patients who completed treatment, five patients were assessed as Fitzpatrick Skin Type II and five patients were judged to have Fitzpatrick Skin Type III. Exclusion criteria included those patients who had undergone laser/IPL treatments, electrolysis or waxing in the designated treatment area within 6 weeks. All patients gave informed consent for treatment and photographs.

Treatment Protocol

All treatments were performed with an EO Q-switched Nd:YAG laser (RevLite™, HOYA ConBio, Fremont, CA). Patients in this prospective, randomized, split-treatment study received a total of four laser treatments at monthly intervals, with follow-up visits at 3, 6, and 12 months after the final treatment. Bilateral treatment areas were designated. One side would receive the SSP mode, and the other side received treatment with the DP option. Patients were randomized as to the side to be treated with either the SSP or DP, as well as to the order of treatment.

The parameters used for therapy were for the SSP mode 3.2 J/cm², with a 6 mm spot size and for the DP mode 3.8 J/cm² with an 8 mm spot size. In the DP mode, the energy is delivered in a divided dose. Patients were provided with verbal and written post-treatment skin care instructions. Patients were also instructed not to attempt any method of hair removal within the treatment area for the duration of the study. Digitalized, high-resolution photographs were taken of the treatment area at baseline and at the 3, 6, and 12 months follow-up visits. Blinded reviewers who were not involved in the laser treatments performed hair counts using magnified photographs. Hair counts at 3, 6, and 12 months post-final treatment were compared to baseline hair counts and used to calculate the percentage of improvement (reduction/lessening of hair in the treatment area). In addition, the following improvement scale was also used by the patients: Grade 1 = no improvement, Grade 2 = mild improvement, Grade 3 = moderate improvement, Grade 4 = excellent improvement.

Patients were asked to assess the tolerability of the SSP and DP modes of treatment. Stinging/burning sensations were recorded on a 4 point scale: 0 = none, 1 = mild, 2 = moderate, 3 = severe. Also, after each treatment was performed, treating investigators were asked to record the treatment response with regard to any erythema, edema, or blistering. Treatment responses were judged on a 5 point scale: 0 = none, 1 = minor, 2 = mild, 3 = moderate, 4 = severe. At the 6 month follow-up visit, patients assessed their satisfaction with the results of treatment on a 4 point

TABLE 1. Hair Count Percentage of Reduction at 3 Months

Patient	Location	Percent reduction	
		DP side (%)	SSP side (%)
1	Legs	46	55
2	Legs	17	41
3	Axillae	10	22
4	Arms	61	55
5	Thighs	63	73
6	Thighs	71	91
7	Arms	79	28
Average reduction		49.6%	52.1
Median		61.0%	55.0

scale: 1 = unsatisfied, 2 = slightly satisfied, 3 = satisfied, 4 = very satisfied.

RESULTS

Hair Counts

Percentages of reduction in hair counts for seven patients at 3 months after the final laser treatment are shown in Table 1. The other three patients were lost to follow-up and did not return for evaluation. On the side treated with the SSP, the average percent reduction in hair counts at 3 months after treatment was 52.1%, with a median value of 55.0%. On the side treated with the DP option, the average reduction in hair counts at 3 months was 49.6%, with a median reduction value of 61.0%.

Six patients returned for an evaluation at 6 months post-treatment. As shown in Table 2, all six continued to show a reduction in hair counts from the baseline values. Percentage of reduction values on the SSP side averaged 45.7%, with a median reduction of 44.0% (Fig. 1). Average reduction on the DP side was 50.0%, with a median value of 53.5% (Fig. 2).

Table 3 summarizes the hair count percentage of reduction results at the 3 and 6 months follow-up visits. Reduction was considered excellent if the percentage of change was greater than 70%. At 6 months, 50% of patients

TABLE 2. Hair Count Percentage of Reduction at 6 Months

Patient	Percent reduction	
	DP side (%)	SSP side (%)
1	36	60
2	75	63
3	13	7
4	29	25
6	71	91
7	76	28
Average reduction		50.0
Median		53.5



Fig. 1. Six months post-laser therapy over lower leg having four procedures at 4-week intervals using the single pulse mode at $3.2\text{J}/\text{cm}^2$ and a 6-mm spot size. [Right before and Left after].



Fig. 2. Six months post-laser therapy over thigh having four procedures at 4-week intervals using the double pulse mode at $3.8\text{J}/\text{cm}^2$ and an 8 mm spot size. [Right before and Left after].

($n = 3$) showed excellent reduction on the side treated with the DP option. One patient (17%) showed good reduction (31–70%) on the DP side of the treatment area and two patients (33%) showed fair reduction (<31%) in hair counts on the DP side. On the SSP side of the treatment area, 50% of patients ($n = 3$) received fair reduction of <31% at 6 months, while two subjects (33%) reached a good reduction level of 31–70% and one patient (17%) had excellent reduction at >70% change.

TABLE 3. Hair Count Reduction Summary

	3 Months (N = 7)				6 Months (N = 6)			
	SSP		DP		SSP		DP	
	n	%	n	%	n	%	n	%
Excellent reduction (> 70% change)	2	29	2	29	1	17	3	50
Good reduction (31–70% change)	3	43	3	43	2	33	1	17
Fair reduction (<31% change)	2	29	2	29	3	50	2	33

At the 24 months follow-up, five patients had returned for evaluation. The hair count reduction persisted at similar levels to the 6 months follow-up visit (Table 4). For the SSP side, there was a 52.6% average percentage reduction from baseline while the DP side was at 53.8%. Five patients achieved a good or an excellent reduction (> 30% change) at the DP side and four patients on the SSP side (Figs. 3 and 4).

Subject-Rated Percentage of Improvement

Patients rated the extent of their improvement for each side of the treatment as Grade 1 (no improvement), Grade 2 (mild improvement), Grade 3 (moderate improvement), or Grade 4 (excellent improvement). At 6 months after the final laser treatment, six subjects assessed the extent of improvement in hair reduction (Table 5). Again, all subjects reported at least a Grade 2. For the standard pulse side treated, three subjects (50%) rated their improvement as excellent, two subjects (33%) rated their improvement as moderate, and one subject (17%) rated the improvement as mild. On the DP side, one subject (17%) rated the improvement as excellent, four subjects (66%) rated their improvement as moderate, and the remaining one subject (17%) judged the improvement as mild.

Treatment Tolerability

Patients were asked to rate any stinging/burning sensations during treatment and immediately post-treatment on each side, using a scale of 0 (none), 1 (mild), 2 (moderate), or 3 (severe). Ten patients recorded their perceptions of the tolerability of the treatment. In addition, an average rating was calculated for each patient's experience during treatment and immediately post-treatment for the SSP and DP modes.

Table 6 shows an average rating for each patient, both during treatment and post-treatment. During the laser session, the average stinging/burning rating for 90% of patients ($n = 9$) remained at a score of 1 (mild) or less on the DP side. In contrast, only 50% ($n = 5$) were at this same average rating for the SSP side. Average ratings immediately post-treatment revealed less discomfort for all subjects. When analyzed individually, it becomes apparent that most subjects experienced less stinging/burning at the fourth treatment than they had at the first treatment for both modalities.

Treatment Reactions

Investigators assessed each treatment area for treatment reactions. Treatment reactions were judged on a

TABLE 4. Hair Count Percentage of Reduction at 24 Months

Patient	Location	Percent reduction DP side (%)	Percent reduction SSP side (%)
1	Legs	71	63
2	Legs	67	65
3	Axillae	31	22
4	Arms	40	38
6	Thighs	60	75
Average reduction	53.8%	52.6	
Median	60.0%	63.0	

5 point scale: 0 = none, 1 = minor, 2 = mild, 3 = moderate, 4 = severe. A total of 44 treatments were delivered. Ten patients received four treatments, and two patients did not complete the study and received only two treatments. The most frequently observed treatment reaction was transient erythema ($n = 35$; 79%). The large majority of instances were judged to be minor, with only five (11%) instances rated as mild. Temporary edema was observed in 61% ($n = 27$) of cases. The severity of this symptom was rated as minor. Investigators did not observe any scaling post-treatment. Transient erythema and edema were observed more frequently on the side treated in SSP mode. These ratings tended to have a slightly higher severity rating (mild as opposed to minor). There were no other untoward effects exhibited by the patients. No patients reported any downtime as a result of their treatments.

Patient Satisfaction

Six patients completed an overall satisfaction survey at 6 months. Three of the patients noted that they were “very satisfied” with the results of treatment. Two patients reported that they were “satisfied.” One patient reported that she was “unsatisfied” with the results. The majority of



Fig. 3. Twenty-four months post-laser therapy over lower leg having four procedures at 4-week intervals using the single pulse mode at 3.2 J/cm^2 and a 6-mm spot size. [Right before and Left after].



Fig. 4. Twenty-four months post-laser therapy over thigh having four procedures at 4-week intervals using the double pulse mode at 3.8 J/cm^2 and an 8-mm spot size. [Right before and Left after].

patients (83.3%) who completed the study expressed satisfaction with the results of treatment.

DISCUSSION

Laser and other light source hair removal have had remarkable successes for hair removal treatment. However, there are still limitations to achieving the desired final outcome. Some of the barriers to complete and permanent hair removal involve hair follicle self-repair and regeneration after incomplete follicular damage[18] and to the revolving anagen, catagen, and telogen cycles, which allow hairs that are in different stages to be simultaneously present in the same region. The sensitivity of human hair follicles to laser light changes within the hair growth cycle, with the anagen phase being the most susceptible.[19] Therefore, patient response to laser irradiation can vary, even from session to session.

The treated anatomical site, the thickness of skin and hair in that area can also affect the results of laser treatment. Pigmented hairs containing more melanin increase the targeted chromophore and potential of greater follicular damage and eventual therapeutic outcome. As such, the thicker darker hairs have been the most responsive to laser hair removal. In contrast, white or blond hairs or the finer caliber pigmented hairs are fairly resistant to laser therapy.

Long-pulse Nd:YAG laser use for hair removal was reported by Finkelstein and Blastein[7] when they reported their use in 1990 for epilation of hair bearing grafts. Its use for general hair removal was published by Bencini et al.[8] and soon after in 2000 by Goldberg and Samady.[9] Tanzi and Alster[17] conducted a study of a long-pulse 1,064-nm Nd:YAG laser for dark terminal hair removal in 36 subjects with Fitzpatrick Skin Types I–VI. Patients received three treatments at 4- to 6-week intervals. At 6 months investigators noted a mean reduction of 48–53% in body hair counts. All Skin Types responded well to therapy.

TABLE 5. Subject Assessment at 6 Months (N = 6)

	Extent of improvement					
	Excellent		Moderate		Mild	
	n	%	n	%	n	%
SSP side	3	50	2	33	1	17
DP side	1	17	4	66	1	17

TABLE 6. Average Tolerability Rating Over Four Treatments During and Post-Treatment (N = 10)

Stinging/burning average over four treatments	During Treatment				After Treatment			
	Standard single pulse		Double pulse		Standard single pulse		Double pulse	
	n	%	n	%	n	%	n	%
None	2	20	1	10	5	50	6	60
≤0.5	2	20	1	10	2	20	4	40
≤1.0	1	10	7	70	3	30		0
≤1.25	3	30		0		0		0
≤1.5	1	10	1	10		0		0
≥2.0	1	10		0		0		0

Initially, the Q-switched Nd:YAG laser was used in conjunction with a preliminarily applied carbon solution to enhance therapeutic outcome [20]. Using the Q-switched Nd:YAG lasers for hair removal without placing a carbon solution was originally suggested by Nanni and Alster [21]. This was followed by a report by Liew and Gault [22] who treated patients with the Q-switched Nd:YAG laser alone. The report did not indicate hair caliber and did not report on long-term hair removal outcome. But it did confirm the potential of using this laser alone to enhance therapeutic outcome.

The current trial was designed to test the hair removal capabilities of the EO Q-switched Nd:YAG laser in SSP mode and in DP mode for fine caliber pigmented hair. These types of hairs are often present in patients, but due to the small caliber of the hair shaft, even with pigment, these hairs have remained fairly resistant to laser therapy. Remarkably, both modalities achieved at least a 45% reduction in hair counts at 6 months persisting to 24 months at a greater than 50% level. The DP option provided a more comfortable treatment experience, as well as less stinging/burning and erythema post-treatment. These results of hair count reduction are consistent with other studies of lasers and IPL-based devices on patients having the more responsive thicker caliber hairs [3,6,10].

Dierickx et al. [2] provided some indication that 6 months was a valid follow-up period for a study of hair removal. They followed 7 out of 13 patients of a completed 6-month study out to 2 years. In this follow-up study, there was no significant change of terminal hair counts beyond 6 months after ruby laser exposure. This suggests that 6 months may be sufficient to assess final outcome over some anatomical sites. Our study has gone significantly beyond 6 months

now out to 2 years. Although the numbers of patients in this study also are limited, the indications are that this particular laser approach achieves permanent hair loss in patients with pigmented fine hairs. Further study with larger numbers of patients is anticipated to confirm these preliminary results.

CONCLUSION

It appears the rapid production of short-pulsed laser energy within an EO Q-switched Nd:YAG laser system produces sufficient acoustic and thermal forces to achieve acceptable rates of permanent hair reduction and patient satisfaction. This is the first report in which the exclusive treatment of fine caliber hairs using a laser or other light system has reported a positive outcome. In addition, post-treatment perifollicular erythema and discomfort were significantly reduced with a unique DP mode.

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