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Ruby Laser Hair Removal: Evaluation of Long-Term Efficacy and Side Effects

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Background and Objective: **Although several studies on laser-assisted hair removal have been published, data on long-term follow-up are few. The present study investigated the long-term efficacy and safety of normal-mode ruby laser pulses on hair removal.**
Study Design/Materials and Methods: **The normal-mode ruby laser (Epilaser; 694 nm, 3 msec) was used to treat a wide range of body sites in 51 volunteers. The mean follow-up after the last treatment was 8.37 months.**
Results: **Sixty-three percent of the patients had sparse regrowth. The mean fluence used was 46.5 J/cm² in patients who had sparse hair regrowth and 39.3 J/cm² in patients who had moderate hair regrowth (*P* = 0.0127). Transient pigmentary changes occurred most frequently in patients with skin type 4.**
Conclusion: **The normal-mode ruby laser is an efficient and safe method for long-term hair reduction, especially in fair-skinned individuals with dark hair. Higher fluences produce greater long-term efficacy. Adverse effects are minimal and transient. Lasers Surg. Med. 26:177–185, 2000.**

Key words: fluence; hirsutism; hypertrichosis; treatment

INTRODUCTION

Unwanted hair is a major cosmetic problem. Methods of hair removal such as shaving, waxing, and tweezing frequently cause ingrown hairs, folliculitis, and temporary hair removal. Electrolysis, although tedious and painful, may be permanent in 15–50% of cases [1].

Laser-assisted hair removal has recently received attention because of its noninvasive nature, fast results, and potential for permanence. The Q-switched ND:YAG laser (1,064 nm) can be used in conjunction with a topical carbon–mineral oil suspension, with the carbon acting as a chromophore. This system has shown minimal effectiveness for long-term hair removal [2,3]. Long-term results have been described with ruby (694 nm) [4,5] and Alexandrite (755 nm) [6] lasers, diode lasers [7,8] and noncoherent, filtered, pulsed flashlamps [9,10], which use melanin as a chromophore for selective photothermolysis. Selective thermal damage of pigmented target structures occurs when sufficient fluence at a wavelength, preferentially absorbed by the target, is delivered during a time equal to or less than the thermal relaxation time of the target [11]. Dierickx et al. [5] described hair removal 2 years after a single treatment with normal ruby laser pulses (694 nm, 0.3 msec, 6-mm beam diameter).

The purpose of this study was to describe our clinical experience in a consecutive series of 51 patients treated with a long pulsed ruby laser for hair removal in different anatomic areas at different fluences and numbers of treatments.

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MATERIALS AND METHODS

Subjects

Fifty-one adults (35 women, 16 men; age range = 18–49 years, mean = 33.7 years) were treated. Thirty (59%) patients had Fitzpatrick's skin type 2, 15 (29%) had skin type 3, and six (12%) had skin type 4. All treated areas had brown or black terminal hair. Patients with photosensitivity, recent sun exposure, pregnancy, and history of keloid formation or immunosuppression were excluded. Informed consent was obtained from all patients.

Laser Apparatus

A normal-mode, flashlamp-pumped, 694-nm ruby laser, emitting a 3-msec pulse duration and 7- and 10-mm spot sizes was used, with fluences of 20–70 J/cm^2 when using the 7-mm spot size and 10–60 J/cm^2 when using the 10-mm spot size (model RD 1200-H, Palomar Medical Technologies, Beverly, MA). The beam was delivered through an articulated arm into an actively cooled handpiece designed to maximize delivery of light into the reticular dermis. The arm consisted of a planoconvex sapphire lens actively cooled to 10°C, with a 19-mm convex radius and a focal length of 25 mm in air, to provide a convergent beam at the skin surface.

Laser Treatment

Patients were instructed to refrain from tweezing or waxing for 6 weeks before laser treatment.

The most common areas treated were the face (25.4%) and back (25.4%). Table 1 shows the different treatment sites.

Before treatment, the area to be treated was shaved; a topical anesthetic cream (EMLA, Astra USA, Inc., Westborough, MA) was applied and kept under occlusion for 1 hour before laser treatment. The tolerated fluence used at each treatment depended on the patient's skin color. Starting fluences when using the 7-mm spot size were 40 J/cm^2 for skin type 2, 30 J/cm^2 for skin type 3, and 20 J/cm^2 for skin type 4. If any sign of epidermal injury, such as immediate whitening, vesiculation, or forced epidermal separation (Nikosky's sign), was observed during the procedure, the fluence was decreased by 20–30%. Fluence was increased or decreased in subsequent treatments depending on the patient's tolerance and presence of side effects. The average fluence used was 44 J/cm^2 (range = 10–70 J/cm^2). Retreatment was performed when hair started growing back. The average number of treatments was 2.7 (range = 1–6).

TABLE 1. Distribution of Treatments Sites

Anatomic area	Number of patients (%)
Abdomen	1 (1.96)
Arm	1 (1.96)
Feet	1 (1.96)
Shoulder	1 (1.96)
Axillae	3 (5.89)
Chest	3 (5.89)
Thigh	4 (7.84)
Bikini	9 (17.64)
Back	13 (25.49)
Face	15 (29.41)
Total	51 (100)

The handpiece was held firmly against the skin surface before, during, and after each laser pulse; no gel was applied. Occasionally an ice pack was applied immediately after laser treatment. Patients were instructed to apply a topical antibiotic ointment if scaling or crusting developed and to avoid sun exposure for a few weeks after treatment. Clinical evaluation was done and photographs were obtained during each follow-up visit.

Response Evaluation

The removal of hair was assessed in a blinded fashion by three dermatologists not involved in the study by comparing pretreatment photographs with photographs taken during the last follow-up visit. The camera settings, lighting, and position of patients using anatomic landmarks were replicated at each follow-up to optimize the quality of the photographs. Efficacy of treatment was graded according to hair regrowth as none (no hair regrowth), sparse (<25% of hair regrowth), moderate (25–75% of hair regrowth), or full (>75% of hair regrowth).

Side effects such as persistent erythema, hyperpigmentation, hypopigmentation, textural change, and scarring were graded visually by the investigators.

Statistical Analysis

The effects of fluence, time of follow-up on hair regrowth, and pigmentary changes in different areas were analyzed with Fisher's exact test. Student's t-test was performed to compare the differences on mean fluence across groups. $P < 0.05$ was considered statistically significant.

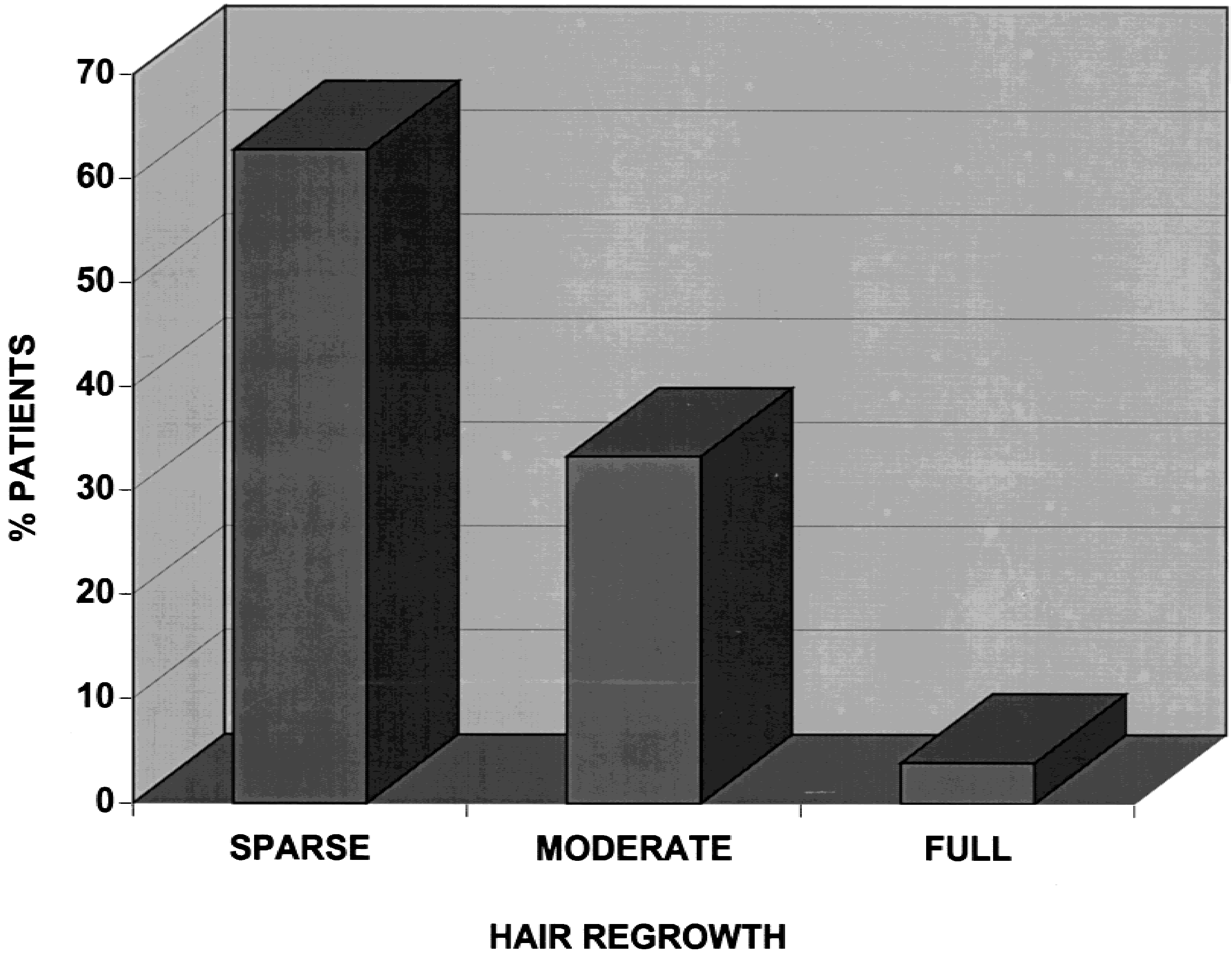

Fig. 1. Hair regrowth rates at the final follow-up visit.

RESULTS

The median follow-up after the last treatment was 8 months (mean = 8.37 months). There was no significant difference in hair regrowth in patients followed for more than 6 months after the last follow-up when compared with patients followed for 3–6 months ($P = 0.781$). At the final follow-up, the majority of the patients (63%) had sparse regrowth, whereas only 3.9% had full regrowth (Figs. 1, 2A,B).

Fluences of 40 J/cm^2 or more were more effective in producing hair loss compared with fluences less than 40 J/cm^2 ($P = 0.0125$; Fig. 3). The mean fluence used in patients who had sparse hair regrowth was 46.5 J/cm^2, and the mean fluence in patients who had moderate hair regrowth was 39.3 J/cm^2 ($P = 0.0127$). Multiple treatments had an additive effect (Fig. 4); all patients who received five or six treatments had sparse regrowth. Table 2 shows hair regrowth at final follow-up, mean fluence, and number of treatments.

In this study, the face and axillae had less hair regrowth than did the back and bikini in the final follow-up. However, because of the limited sample size, this difference was not statistically significant.

Fifteen subjects (29.4%) had transient pigmentary changes: 3.9% had hypopigmentation, 15.7% had hyperpigmentation, and 9.8% had both. The incidence of hyperpigmentation and hypopigmentation differed according to the anatomic area (Table 3). Mean fluence used in patients with pigmentary changes was not statistically different from the mean fluence used in patients with no side effects ($P = 0.61$). Patients with skin type 4 had the highest incidence of pigmentary changes ($P = 0.012$; Table 4, Fig. 5A,B). All pigmentary changes were transient, with a

Fig. 2. **A:** An axilla before treatment. **B:** The same axilla 20 months after the second treatment.

mean clearance time of 5.6 months (range = 1–12 months). No permanent pigmentary changes, textural change, or scarring occurred in any subject. Table 5 shows hair regrowth at final follow-up, treatment site, mean fluence, and incidence of side effects for each treatment site.

DISCUSSION

Long-pulsed ruby laser is an effective and safe method of hair removal. The 694-nm wavelength deeply penetrates into the dermis, where follicular melanin is by far the dominant chromophore [12]. Absorption of laser light by melanin in the hair shaft, epithelium, and matrix cells causes thermal damage of the hair follicles.

Two important target sites are thought to be the germinative cells of the hair, matrix, and papilla or bulb and/or the follicular stem cells located near insertion of the arrector pili muscle or bulge [13,14].

Thermal conduction during the laser pulse heats a region around each microscopic site of optical energy absorption [11]. Therefore, the spatial scale of thermal confinement is related to laser pulse duration. For best epidermal cooling, pulse duration would occur between the relaxation time for the epidermis (3–10 msec) and that for most hair follicles (~10–100 msec for hair follicles 100–300 μm in diameter) [4,15,16]. In this study, the pulse duration was 3 msec, which allowed thermal confinement even in fine-hair follicles, and is at or near the thermal relaxation time of epidermis, allowing sparing of the epidermis during conductive contact cooling.

In a small study of ruby laser hair removal,

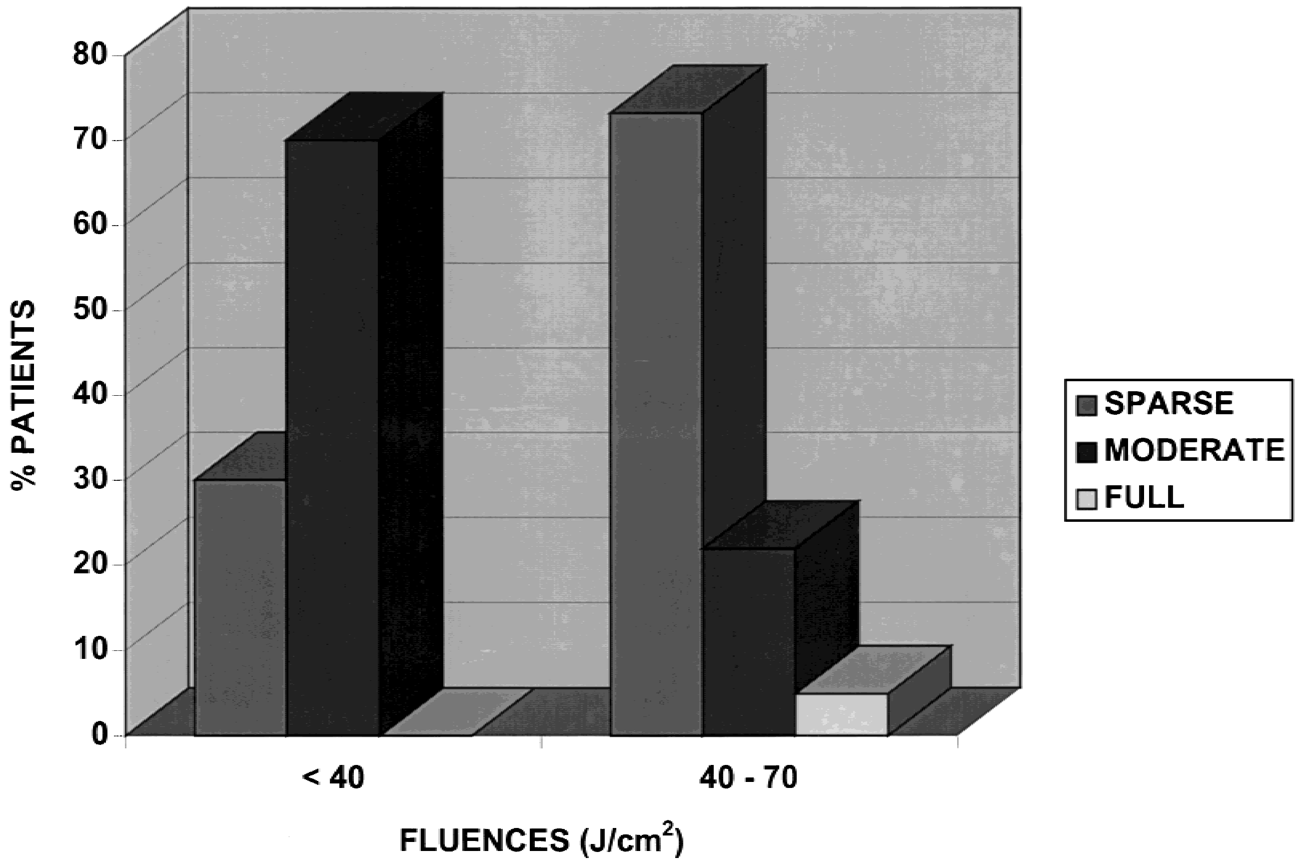

Fig. 3. Influence of the fluence on efficacy.

Grossman et al. [4] showed that a single treatment produces a hair-growth delay, followed by partial regrowth at 6 months' follow-up. Dierickx et al. [5] later reported permanent hair reduction 2 years after a single treatment with high-fluence ruby laser pulses (at least 30 J/cm^2). The same study reported that "steady-state" loss was achieved at 6 months' follow-up. The mean follow-up time in our study was 8 months after the last treatment. Whether this follow-up time is long enough to claim permanency for different body sites remains to be confirmed.

Treatment fluences, pulse duration, spot size, and numbers of treatment are important factors for achieving long-term hair reduction. In this study, the majority of patients (63%) had sparse hair regrowth at a mean follow-up of 8 months after the last treatment, at a mean fluence of 46.5 J/cm^2 and a mean of 2.7 treatments. This has also been shown in other studies using different ruby lasers [17,18].

Complete hair removal (100% of all hair removed in the treated area) was not achieved in any patient. However, the regrowing hair after ruby laser treatment was thinner and lighter and therefore less visible, which contributed to the overall and cosmetic improvement. Dierickx et al. [5] suggested that miniaturization of coarse terminal hair follicles to vellus like hair follicles is the main mechanism by which ruby laser pulses cause permanent hair reduction, which is consistent with our observations.

Walther et al. [19] reported that hair removal with ruby laser could not be achieved with 20 J/cm^2, a spot size of 2 mm, and a pulse duration of 0.5 msec. Dierickx et al. [5] obtained long-term hair removal with a 0.3-msec pulse duration, a much larger spot size (6 mm), and fluences up to 60 J/cm^2.

Almost one-third of our patients presented with temporary pigmentary changes, occurring mainly in the darker skin types. It is also important to note that pigmentary side effects occurred mainly in the bikini area and back (55.6% and 46.2% of the patients treated in these areas, respectively). Only 6.7% of the patients treated on the face had pigmentary changes.

In practice, the ideal patient for laser hair

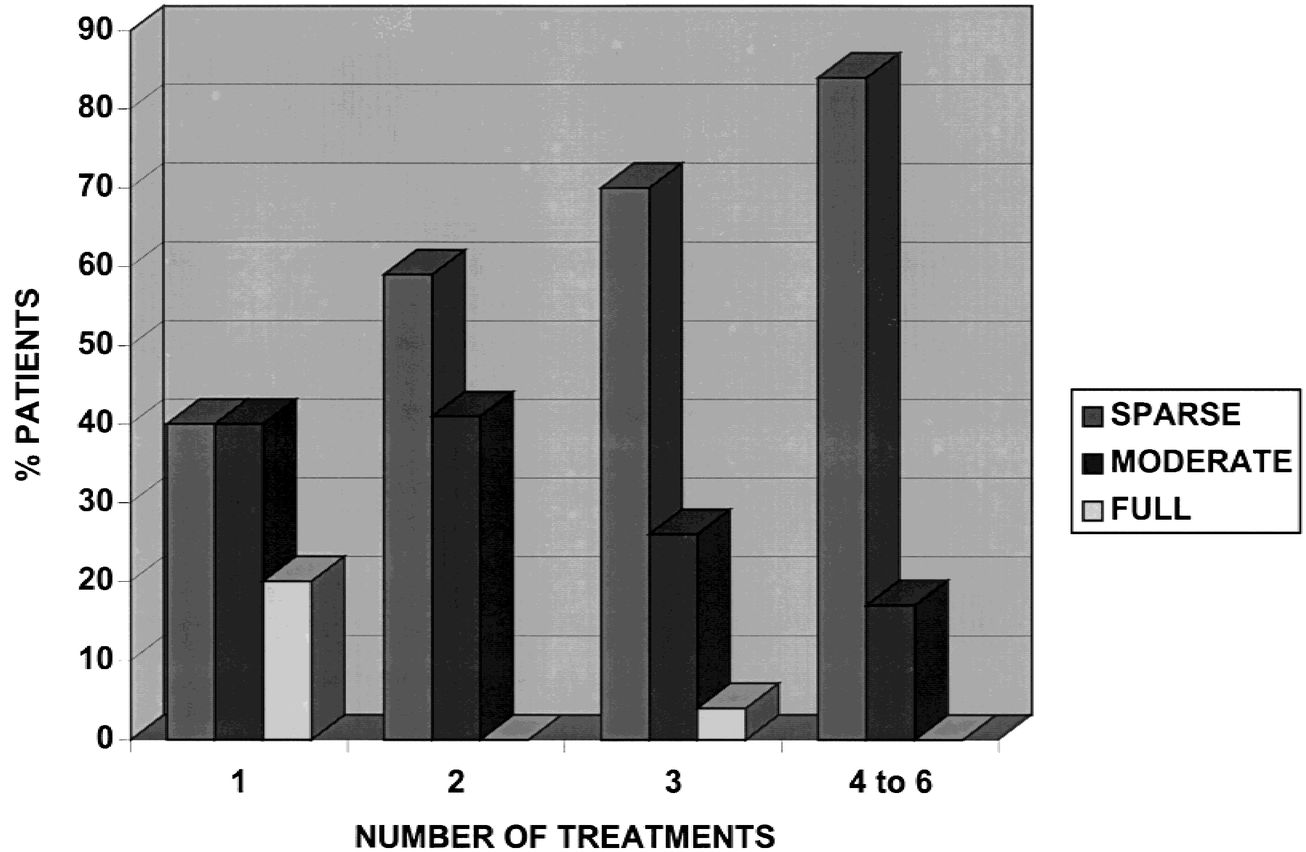

Fig. 4. Influence of the number of treatments on efficacy.

TABLE 2. Distribution of Subjects According to Hair Regrowth at the Final Follow-up, Mean Fluence, and Number of Treatments

		Hair regrowth at final follow-up		
Mean fluence	Number of treatments	Sparse (%)	Moderate (%)	Full (%)
<40 J/cm^2	1	0	0	0
	2	0	4 (7.8)	0
	3	3 (5.9)	3 (5.9)	0
	4	0	1 (2)	0
	5–6	0	0	0
Subtotal		3 (5.9)	8 (15.7)	0 (0)
≥40 J/cm^2	1	2 (4)	2 (4)	1 (2)
	2	10 (19.6)	3 (5.9)	0
	3	12 (23.5)	4 (7.8)	1 (2)
	4	1 (2)	0	0
	5–6	4 (7.8)	0	0
Subtotal		29 (56.9)	9 (17.6)	2 (3.9)
Total		31 (62.8)	17 (33.3)	2 (3.9)

removal has dark hair and fair, untanned skin. Such patients are usually best treated with high fluences (>39 J/cm^2) at the 7- or 10-mm spot size and almost always achieve reduction of hair to a sparse amount in 3–6 treatments, with minimal or no side effects. Darker skin types with dark

TABLE 3. Incidence of Pigmentary Changes for Different Areas

Anatomical area	Incidence of pigmentary changes (%)
Abdomen	1/1 (100)
Axillae	1/3 (33.3)
Back	6/13 (46.2)*
Bikini	5/9 (55.6)*
Face	1/15 (6.7)*
Thigh	1/4 (25)
Total	15/51 (29.4)

*The face had significantly less pigmentary change than did the bikini and back ($P < 0.05$).

TABLE 4. Incidence of Pigmentary Changes According to Skin Type

Skin type	Incidence of pigmentary change (%)
2	6/30 (20)
3	4/15 (26.7)
4	5/6 (83.4)*
Total	15/51 (29.4)

*Incidence was statistically significantly different from types 2 and 3, $P = 0.012$.

Fig. 5. **A:** Hypopigmentation and hyperpigmentation in a patient with skin type 4 1 month after treatment. Spontaneous repigmentation and clearance occurred after 6 months. **B:** Hyperpigmentation in a patient with skin type 4 1 month after treatment. Spontaneous clearance occurred after 5 months.

TABLE 5. Distribution of Subjects According to Hair Regrowth, Treatment Sites, Average Fluence, and Side Effects (Pigmentary Changes)

		Sparse (%)		Moderate (%)		Full (%)	
Mean fluence	Anatomic area	No side effects	Side effects present	No side effects	Side effects present	No side effects	Side effects present
<40 J/cm^2	Axillae	0	0	0	0	0	0
	Back	0	2 (4)	2 (4)	1 (2)	0	0
	Bikini	0	0	1 (2)	0	0	0
	Chest	0	0	1 (2)	0	0	0
	Face	1 (2)	0	2 (4)	0	0	0
	Thigh	0	0	0	0	0	0
	Other[a]	0	0	0	0	0	0
Subtotal		1 (2)	2 (4)	6 (11.8)	1 (2)	0 (0)	0 (0)
≥40 J/cm^2	Axillae	2 (4)	1 (2)	0	0	0	0
	Back	3 (5.9)	1 (2)	2 (4)	1 (2)	0	1 (2)
	Bikini	3 (5.9)	4 (7.8)	0	0	0	1 (2)
	Chest	1 (2)	0	1 (2)	0	0	0
	Face	8 (15.7)	0	1 (2)	1 (2)	0	0
	Thigh	3 (5.9)	1 (2)	2 (4)	0	0	0
	Other[a]	0	1 (2)	3 (5.9)	0	0	0
Subtotal		20 (39.2)	8 (15.7)	9 (17.6)	2 (4)	0 (0)	2 (4)
Total all fluences		21 (41.1)	10 (19.6)	15 (29.4)	3 (5.9)	0 (0)	2 (4)

[a]Other includes abdomen, arm, feet, and shoulders (in four subjects).

hair also respond well, but with a higher incidence of side effects. To limit epidermal damage in dark skin types, the treatment fluence below 40 J/cm^2 was often necessary, which also reduces efficacy and requires a higher number of treatments. We strongly recommend avoidance of sun exposure before and after the ruby laser hair removal treatment. Patients with light-colored hair and dark skin are generally poor candidates for laser hair removal and should consider other conventional methods such as electrolysis.

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