A Prospective Study of Axillary Hair Reduction in Patients Treated With Microwave Technology

Jeremy A. Brauer, MD,*† Julia P. Neckman, MD,* Brian Zelickson, MD,‡ David B. Vasily, MD,§ and Roy G. Geronemus, MD*†

BACKGROUND Removing unwanted body hair is a growing trend in society today, and there are many laser-based devices for hair reduction. There are some limitations to those methods, including the lack of efficacy for lighter color hair.

OBJECTIVE The objective was to quantify hair reduction in the axillae after treatment with a noninvasive microwave energy device.

MATERIALS AND METHODS A prospective, multicenter study was performed at 3 private dermatology clinics. Fifty-six adult subjects seeking axillary hair reduction were enrolled and treated with the device in 1 or 2 treatment sessions 3 months apart at various energy levels, and followed for 12 months. The primary analysis was monitoring reduction of hair counts from baseline to follow-up visits. A subject assessment of overall satisfaction, odor ratings, and sweat reduction ratings was provided at follow-up visits.

RESULTS Fifty-six subjects received treatment, with an average total underarm hair reduction of approximately 70% for both light and dark hair. Percentage of patients with hair reduction of 30% or more was significantly higher than 50% at all follow-up visits. Half of treated subjects reported expected mild transient post-treatment effects such as localized edema, discomfort, and bruising. Other reported events were mild.

CONCLUSION This clinical study provides evidence for safe and permanent axillary hair reduction, showing stable average reduction that lasted through the year of follow-up. Most notably, the study has shown the treatment's efficacy for reduction of light-colored axillary hair.

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Unwanted hair is a common cosmetic problem that spans many cultures and populations. Hair removal through shaving, waxing, tweezing, chemical depilatories, and electrolysis has been shown to improve quality of life,[1,2] but many of the mentioned techniques provide temporary solutions to unwanted hair. Although electrolysis may permanently remove hair, it is a slow and operator-dependent procedure with variable efficacy. Removing unwanted body hair remains an increasingly growing trend in society today, and photoepilation by lasers and related technologies is currently a leading procedure in cosmetic dermatology demonstrating permanent reduction.[3] This is defined by the United States Food and Drug Administration (FDA) as "the long-term, stable reduction in the number of hairs regrowing after a treatment regime, which may include several sessions. The number of hairs regrowing must be stable over time greater than the duration of the complete growth cycle of hair follicles, which varies from 4 to 12 months according to body location. Permanent hair reduction does not necessarily imply the elimination of all hairs in the treatment area."[4]

Microwave devices, although accepted in other medical fields, are not commonly used in dermatology. This energy can be optimized to focus heat at the interface

Laser & Skin Surgery Center of New York, New York, New York; †Ronald O. Perelman Department of Dermatology, NYU Langone Medical Center, New York, New York; ‡Zel Skin and Laser Specialists, Edina, Minnesota; §Lehigh Valley Dermatology Associates, Ltd., Bethlehem, Pennsylvania

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TABLE 1. Hyperhidrosis Disease Severity Scale (HDSS) Definition

HDSS Value	*Definition*
1	My underarm sweating is never noticeable and never interferes with my daily activities
2	My underarm sweating is tolerable but sometimes interferes with my daily activities
3	My underarm sweating is barely tolerable and frequently interferes with my daily activities
4	My underarm sweating is intolerable and always interferes with my daily activities

The question asked is as follows: How would you rate the severity of your hyperhidrosis?

between the skin and subcutaneous tissue and cause irreversible thermolysis of adnexae that reside at that interface. In this study, a new early-generation noninvasive microwave energy device currently available for the safe and effective treatment of primary axillary hyperhidrosis[5] was tested for long-term safety and efficacy for removal of unwanted axillary hair.

The primary objective of this study was to quantify hair reduction in the axillae after treatment with the device, which was used in the same manner as the commercially available technique cleared by the FDA for the treatment of primary axillary hyperhidrosis.
A potentially novel aspect of a microwave device for hair reduction, as opposed to laser-based hair reduction treatments, is that the microwave energy device can possibly reduce underarm hair of lighter color, such as blond, light brown, or light red, and may remove a significant amount of hair after only 1 or 2 sessions.

Methods and Materials

Patients

This was a prospective, multicenter, single-group study of individuals with unwanted axillary hair. The study enrolled subjects who met eligibility criteria, including at least 18 years of age or older at the time of written informed consent, had at least 16 visible hairs per axilla in 2 × 2 cm area at baseline and, in the opinion of the physician, treatment with the microwave energy device was technically feasible and clinically indicated. Subjects were followed out to 1 year after their final treatment session. There was no control group used in this study. Although not required for study inclusion, subjects self-reported baseline scores were collected for underarm sweat using the Hyperhidrosis Disease Severity Scale (HDSS, Table 1) and underarm odor using a 10-point scale. The study was conducted in accordance with the Declaration of Helsinki, and all subjects signed an institutional review board–approved informed consent before any study procedures.

Hair Assessments

The primary measure of the study was to calculate the reduction in underarm hair in a defined area in the center of each axilla. At baseline and each follow-up visit, a photograph was taken of both axillae from each subject. Subjects were required to shave their underarms at least 7 days before the visit, and then refrain from shaving until after the visit. For this analysis, a template that defined a 2 × 2 cm "box" in the center of the axilla was used to identify the limits of the area to be counted (Figures 1 and 2).

The study also analyzed a subgroup of patients with light-colored axillary hair that is not easily treated by other commonly available treatments. A second hair reduction evaluation analysis consisted of an independent, blinded side-by-side analysis of randomly ordered baseline and post-treatment follow-up photographs, and a qualitative assessment of hair reduction.

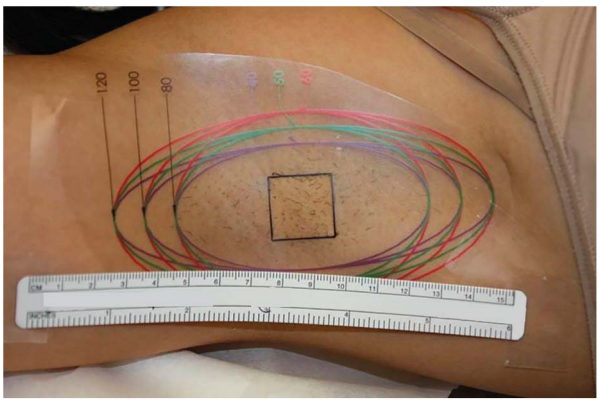

Figure 1. Example of overlay to identify 2 × 2 cm hair box for hair counting.

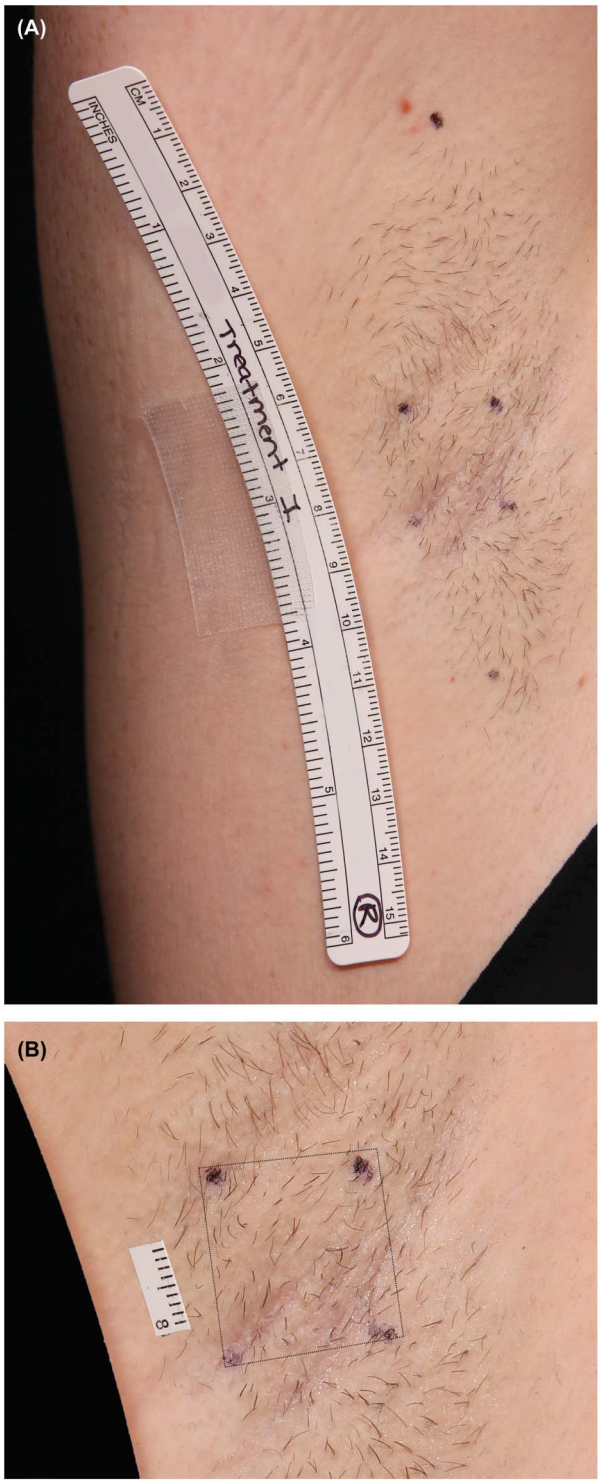

Figure 2. (A) Original photograph as taken by the clinic staff, showing the 4 corners of the box and identification ruler. (B) Cropped and deidentified photograph with the electronic box edges added. This photograph was used by the independent assessors for hair counts.

Treatments and Study Visits

The treatments were provided by a noninvasive device with integrated surface cooling of the skin that delivers focused microwave energy to the lower part of the dermis (miraDry MD4000 System; Miramar Labs, Santa Clara, CA). The study protocol consisted of 2 treatment sessions, scheduled approximately 3 months apart. After the first treatment session, the investigators used the patient input to determine an appropriate energy level setting for the second treatment session. Photographs were taken at the follow-up visits 3, 6, 9, and 12 months relative to the final treatment session.

Study Efficacy Measures

A panel of 3 independent, trained assessors reviewed each deidentified photograph independently. The assessors were health care professionals, experienced in dermatologic procedures and clinical studies, and were from clinics that were not involved in the study. Using standard computer viewing tools (Imagej, NIH, downloaded June 24, 2013), they counted the hairs in the box. The hair count from each photograph was calculated from the average of the 3 independent readings. Hair counts were used to calculate the hair reduction for each patient.

The percent reduction for a given patient was determined by calculating the reduction for each axilla separately and then averaging. If images from one axilla were missing then the result was calculated from the other axilla by itself. A "responder" analysis was defined by calculating the percentage of subjects who had at least a 30% reduction compared with baseline. In addition, the average reduction was calculated for each follow-up visit. The statistical 95% confidence limits and SDs were calculated using standard programs such as the SAS program (SAS version 9.3 or later; SAS Institute, Inc, Cary, NC) and StatXact (Cytel Corporation, Cambridge, MA).

A second assessment of blinded side-by-side evaluation of pairs of randomly ordered photographs (Figure 3) was performed to determine whether there was perceivable hair reduction by picking which photograph had the most hair; and estimating the amount of hair reduction. Unlike the previous

TABLE 2. Global Assessment of Hair Reduction Categories Used in the Blinded Review

Category Score	*Category Description*
1	1%–25% reduction
2	26%–50% reduction
3	51%–75% reduction
4	76%–100% reduction

hair-counting analysis, which looked at a fixed box at the center of the axilla, this analysis was an overall assessment of the full axilla. Deidentified pairs of photographs from the same subject, one from before treatment, one from after, were randomly ordered and presented side-by-side. The single assessor, a board-certified dermatologist qualified by experience in hair reduction procedures (JAB), first reviewed the paired photographs and recorded which photograph had the most hair. If the photographs both seemed to have the same amount of hair, that was noted. In addition, for those pairs where a difference was determined, a global assessment of the amount of hair reduction was provided, according to the scale in Table 2. The same assessor reviewed all pairs in the study. Figure 3 shows an example pair of images that were presented to the blinded assessor. The ruler that identifies the patient and time points has been blacked out, but the full hair-bearing area of the axilla can be seen for assessment.

Safety Assessments

At each study visit, subjects were asked a general question about their health. Reported procedure effects were categorized as Grade 0 if they were minor expected sequelae from the procedure (such as local swelling or bruising). Other events were categorized as Grade 1 (minor) to Grade 3 (severe). The duration of all events was tracked, and the investigators assigned the degree that the event was related to the procedure or device (none, remote, possible, probable, and unknown).

Results

Demographic information for all subjects enrolled and treated in the study is included in Table 3. Fifty-six adult subjects were enrolled and treated at 3 clinical sites. Forty-seven completed the study, with 9

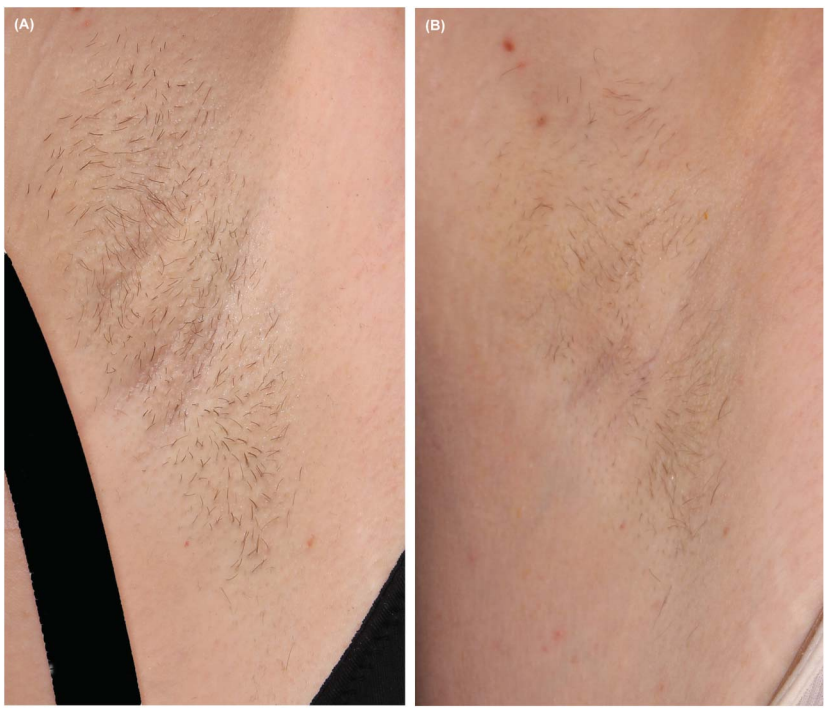

Figure 3. Example pair of images for the side-by-side review. In this case, the assessor (correctly) chose image (A) as the baseline image, and rated this axilla as having a reduction category score of 3, corresponding to 51% to 75% reduction in axillary hair (B).

TABLE 3. Demographics of All Enrolled and Treated Subjects (*n* = 56)

Age, yrs	
Median	32.5
Range	18–61
Sex, *n* (%)	
Male	11 (20)
Female	45 (80)
Race, *n* (%)	
Caucasian	49 (88)
Black	1 (2)
American Indian	2 (4)
Native Hawaiian	1 (2)
Other	3 (5)
Skin Type, *n* (%)	
Fitzpatrick Type I	13 (23)
Fitzpatrick Type II	18 (32)
Fitzpatrick Type III	15 (27)
Fitzpatrick Type IV	8 (14)
Fitzpatrick Type V	2 (4)
Fitzpatrick Type VI	0
Body mass index (average)	25.8

subjects lost to follow-up before the final 12-month visit. There were a total of 13 subjects who had only one treatment, the remainder had 42 images that were able to be used.

Hair Count Reduction After Treatment

From the hair counts, 88.1% of subjects had at least a 30% reduction in axillary hair at the 3-month follow-up visit (Table 4), and the data demonstrate that the hair reduction remained stable 6, 9, and 12 months after treatment. In addition to the responder analysis, the average and SD of the hair count reduction was calculated and is also shown in Table 4.

A subgroup analysis was conducted for hair count reduction seen with dark-colored hair compared with light-colored hair. As shown in Table 4, the average percent reduction of hair at 3 and 12 months was near 70% (66% and 72%, respectively).

The blinded side-by-side analysis also showed that the treatment generated a visible reduction in underarm hair; the results are shown in Table 5. In 99% of the pairs, the blinded reviewer was able to correctly identify the baseline photograph when comparing the baseline to 12-month follow-up photographs. And in 89% of the pairs, it was estimated that there was at least a 25% reduction in the hair.

TABLE 4. Summary of Efficacy Results

	Follow-up Visit Time From the Last Treatment Session			
Efficacy Measure	*3 mo*	*6 mo*	*9 mo*	*12 mo*
Hair count	Primary			Secondary
% of subjects with >30% reduction [lower 95% CL]	88.1% (37/42) [76.6%]	97.5% (39/40) [88.7%]	92.1% (35/38) [80.8%]	95.5% (42/44) [86.4%]
Hair count				
Average reduction (SD)	66% (± 30%)	72% (± 29%)	75% (± 28%)	75% (± 27%)
Light hair subgroup (*n*)	66% (*n* = 12)			72% (*n* = 13)
Side-by-side axilla review				
% of pairs having at least 26%–50% reduction	74% (63/85)	78% (65/83)	78% (66/85)	89% (83/93)
Patient satisfaction with hair reduction: % of subjects rating "very satisfied" or "somewhat satisfied"	81% (38/47)	70% (31/44)	68% (30/44)	70% (33/47)
Odor self-assessment, mean reduction on a 10-point scale	2.6 ± 3.0	2.8 ± 2.8	2.5 ± 2.8	2.4 ± 2.7
% of subjects with HDSS reduction to score of 1 or 2	92% (23/25)	96% (25/26)	96% (24/25)	89% (25/28)

CL, confidence limits; HDSS, Hyperhidrosis Disease Severity Scale; SD, standard deviation.

TABLE 5. Results From Side-by-Side Axilla Analysis

	3 Mon (*N* = 85)	*6 Mon* (*N* = 83)	*9 Mon* (*N* = 85)	*12 Mon* (*N* = 93)
Correctly identified the baseline photograph, *n* (%)	77 (91)	72 (87)	76 (89)	92 (99)
Estimated % reduction, *n* (%)				
Category 1: 0%–25%	14 (16)	7 (8)	10 (12)	9 (10)
Category 2: 26%–50%	8 (9)	14 (17)	17 (20)	25 (27)
Category 3: 51%–75%	27 (32)	32 (39)	20 (24)	27 (29)
Category 4: 76%–100%	28 (33)	19 (23)	29 (34)	31 (33)
Success (reduction >25%)	63/85 = 74%	65/83 = 78%	66/85 = 78%	83/93 = 89%

Secondary Results—Hyperhidrosis Reduction and Patient Satisfaction

Additional analyses were completed using the subject-reported assessment of overall satisfaction, odor reduction, and sweat reduction. The results were consistent with published results of initial clinical studies for the novel microwave device[5] and commercial experience. In this study, for those subjects who had baseline Hyperhidrosis Disease Severity Scale scores of 3 or 4 (i.e., more extreme sweating), 89% had scores that dropped to a score of 1 or 2 (showing no or tolerable levels of sweat) a full year after treatment. The mean subject-reported odor score reduction was 2.4 to 2.8 points and was also statistically significant at each follow-up visit ($p < 0.0001$). The level of patient satisfaction ranged from 68% to 81%, very similar to the average hair reduction.

Safety

No procedure-related serious adverse events occurred during the study. During the procedure, the most common Grade 0 procedure events were pain during treatment delivery (reported in 75% of subjects), stinging or pain during anesthesia injections (64%), shaking due to epinephrine from the anesthesia (23%), and numbness or tingling in treatment area lasting less than 24 hours due to anesthesia (14%). Other reported Grade 0 events showed that a large number of subjects experienced mild postprocedure effects that typically lasted a few days to a week; the most common were edema (55% of subjects), altered sensation/tingling (30%), and discomfort in the treatment area (26%).

Other more rare treatment-related adverse events were noted in 10 (18% of subjects); 75% of these events were graded as mild. The most common effect seen was altered sensation in the skin of the treatment limb (6 events in 4 patients, average duration 110 days). The second most common effect was swelling in the arm adjacent to the treated axilla (4 events in 3 patients, average duration 7 days). One subject was diagnosed with unilateral ulnar neuropathy with a concurrent unrelated adverse event that was ongoing 6 months after treatment, after which she was lost to follow-up.

Discussion

Removing unwanted body hair is an increasingly growing trend in society today, and photoepilation by lasers or related technologies is currently the fastest growing procedure in cosmetic dermatology.[3,6] Other methods for removing unwanted hair include plucking, bleaching, shaving, waxing, and chemical depilatories. Threading is also a common practice in some cultures. None of these other methods provide a permanent solution to unwanted hair, and can be inconvenient and tedious.[7] Electrolysis is a method for hair removal allowing for permanent hair removal of both terminal and nonterminal hair, as well as of both pigmented and nonpigmented hair. However, this time-consuming and painful technique is extremely operator dependent, and efficacy in achieving permanent hair removal is variable among patients.[8,9] Thus, it is often impractical in terms of treating a large area.

The microwave energy device is a novel microwave energy device that is currently commercially available for the treatment of primary axillary hyperhidrosis through nonselective heating of the subcutaneous eccrine and apocrine glands. Patient satisfaction with

the procedure for axillary hyperhidrosis is high, and adverse events are typically transient and well tolerated. The primary objective of this study was to quantify hair reduction in the axillae after treatment with the microwave device, which was used in the same manner as the commercially available technique for the treatment of primary axillary hyperhidrosis. This clinical study has provided evidence for safe and permanent axillary hair reduction showing stable average reduction greater than 70% that lasted through 1 year of follow-up. Notably, this was shown effective and without adverse dyspigmentation in skin Types I to V.

Although black and brown hairs contain sufficient amounts of melanin to serve as the target chromophore for laser hair removal, the lack of melanin or presence of eumelanin in the hair follicle, which clinically correlates to white, gray, or red/blonde hair, is predictive of a very poor response. For patients with little to no melanin in their hair follicles, futile attempts have been made to use an exogenous chromophore that can be topically delivered to the hair follicles, thereby making the removal of white, gray, red, and blonde hair hypothetically possible. This concept was first demonstrated with a topical carbon solution dissolved in mineral oil.[10] However, this has not shown significant efficacy by experienced clinicians.[11] The current failure of these treatments to target lighter hair colors excludes the light-haired population and the ever-growing graying population from the hair removal market. An epidemiological study spanning 5 continents and 23 regions reported that almost all patients older than 60 years of age (91% of the studied population) were found to have graying hair of over 40% density.[12] This comprises a huge and consuming percentage of patients seeking effective hair removal, which can now be safely and effectively targeted by microwave energy in the underarm.

Treatment with the microwave energy device is one of the only modalities found to be significantly and highly effective for removal of light-colored axillary hair, a potentially revolutionary aspect of a microwave device for hair. At 3 months, the mean percentage reduction of light-colored hair was 66.4%, and the mean percentage reduction of dark-colored hair was 65.5%. This continued to improve at 12 months. Again, it is important to note that this was seen in skin Types I to V without any residual pigmentary alterations.

In addition, subject assessment of overall satisfaction, odor reduction, and sweat reduction were consistent with published results of initial clinical studies for the novel microwave device[5] and commercial experience. In this study, 89% had HDSS scores that dropped to 1 or 2 (showing no or tolerable levels of sweat) a full year after treatment. The mean subject-reported odor score reduction was also statistically significant at each follow-up visit. The level of patient satisfaction for amount of hair reduced ranged from 68% to 81%, very similar to the average hair reduction using other methods.

The limitations of this study are as follows: This study was conducted at 3 sites without sham or control groups for comparison. The number of subjects who missed study visits and/or were lost to follow-up was higher than planned, but the sensitivity analyses showed that the results met the primary end point even when the missing patients were assumed to be nonresponders. The authors believe that these limitations do not affect the overall conclusions, given the statistical significance of the results, which were supported by the additional hair analyses. Also, the authors must note that the 3 sites did not start treatment simultaneously, and the initial site started treating at lower energy parameters showing a dose response when increasing the energy that then informed the succeeding 2 sites to use higher treatment parameters with even more efficacy in hair reduction.

Short-term adverse events related to the therapy were generally minor. Post-treatment edema, erythema, and discomfort in the treatment area were common and resolved quickly after therapy. Some patients experienced longer-lasting transient effects, such as altered sensation in or around the treatment area, papule, and nodule formation in the axilla, and the majority reported wetness reduction as a welcomed effect. Some subjects were still experiencing axillary hair loss when they exited the study. One patient experienced treatment-related neuropathy that was resolving at 6 months, after which she was lost to follow-up.

Conclusion

This clinical study has provided evidence for safe and permanent axillary hair reduction of both dark-colored and light-colored hair in Fitzpatrick skin Types I to V, showing stable average reduction in the range of 70% that lasted through the 12 months of follow-up. Most remarkably, these results are independent of skin type or hair color, which makes these findings unique when viewed in the overall landscape of laser- and energy-based device hair removal. Limitations include lack of control group; however, the authors believe that these limitations do not affect the overall conclusions.

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Address correspondence and reprint requests to: Jeremy A. Brauer, MD, Laser & Skin Surgery Center of New York, 317 East 34th Street, New York, NY 10021 or e-mail: jbrauer@laserskinsurgery.com