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Use of Simultaneous Emission of Nd:YAG and Alexandrite Lasers in BLEND Mode for Hair Removal and Permanent Hair Reduction

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Received: 15 May 2025 | **Revised:** 10 January 2026 | **Accepted:** 27 March 2026

Keywords: alexandrite | hair removal | laser | Nd:YAG

ABSTRACT

Objective: To evaluate the safety, efficacy, and patient satisfaction of a novel laser technology that employs simultaneous emission of Alexandrite (755 nm) and Nd:YAG (1064 nm) wavelengths for permanent hair removal, as compared with standard of care treatment using a single wavelength (either Alexandrite or Nd:Yag).

Methods: A prospective, multi-center study with 53 subjects and 230 total treatment sites (multiple sites per subject). The subjects underwent 5 treatment sessions at 6–8 week intervals, with follow-up 12 months after the last treatment session. The percent change in hair count was calculated for each treatment setting, skin type, and treatment area and used to evaluate the efficacy of hair reduction. Pain during treatment and adverse events were recorded.

Results: Fifty-three subjects with skin type I-VI were enrolled in the study (median age 29.0 years, 98.1% female). Legs were the most common treatment area (53.7%) followed by axillae (25.3%) and bikini area (17.9%). Hair counts decreased for all treatment settings. Twelve months after the last treatment session, a mean decrease from baseline of $84.6\% \pm 18.8\%$, $73.4\% \pm 25.3\%$, and $63.9\% \pm 31.2\%$ was observed in areas treated with SET, 755 and 1064 nm, respectively. Reduction in hair count from baseline was also observed for the axillae, legs, and bikini area separately. All treatment settings performed better on the bikini area and legs as compared to the axillae (two-sided p-value < 0.0001). Treatment with SET showed the highest percent reduction in hair count in all treatment areas. Moreover, remaining hair became statistically thinner and lighter between baseline and the 12 month of follow-up for all study groups and treatment sites. Analysis revealed that subjects reported higher satisfaction with the SET treatment compared with the control treatments. Specifically, 69.1% of subjects gave the highest satisfaction score for the SET treatment, compared with 48.9% for the 755 nm treatment and 33.3% for the 1064 nm treatment. Additionally, only 5 out of the 230 treated sites were reported to have treatment-related adverse events, none of them serious.

Conclusion: This study showed the effectiveness, tolerability and high patient satisfaction of treatment with SET when compared to Alexandrite and Nd:YAG lasers treatment, alone. The study results also demonstrated maintained safety with minimal adverse events reported.

1 | Introduction

Unwanted hair growth is a common aesthetic and cosmetic concern for both men and women. Traditional hair removal methods such as shaving, waxing, and plucking have limitations, including temporary results, discomfort, and the potential for skin irritation. In recent decades, laser-based hair removal has emerged as a highly effective and sought-after solution for achieving long-term hair reduction with minimal side effects [1].

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Laser-based hair removal works on the principle of selective photothermolysis [2], wherein the laser energy is preferentially absorbed by the melanin pigment present in hair follicles. The targeted absorption of laser energy heats and damages the hair follicles, ultimately inhibiting their ability to regrow hair [3, 4].

The fundamental challenge of laser-based hair removal lies in achieving optimal outcomes while minimizing adverse effects on the surrounding skin. Various laser wavelengths, pulse durations, and fluence have been explored to optimize the selectivity of hair follicle targeting [5–8], while advanced cooling mechanisms have been introduced to protect the epidermis from excessive thermal damage [9]. Good response to laser hair removal occurs when the targeted hair has a high concentration of chromophores [10].

Early research paved the way for the development of laser systems, such as the Alexandrite (755 nm), Ruby (694 nm), Diode (800–1000 nm), Q-switched and long-pulsed Neodymium-Doped Yttrium Aluminum Garnet (Nd:YAG) (1064 nm), and intense pulsed light (IPL) devices (550–1200 nm) [8, 11–13]. These studies showed a significant reduction in hair growth after multiple treatment sessions while exhibiting a favorable safety profile. As a result, laser hair removal has evolved into a reliable, minimally invasive, and well-tolerated procedure suitable for a wide range of skin types and hair colors [12].

Further refinements in laser technology led to the introduction of advanced hair removal platforms, incorporating various wavelengths and pulse durations, tailored to target specific melanin levels in hair follicles. Notably, the longer wavelength Nd:YAG lasers have shown efficacy in treating darker skin types with reduced risk of epidermal damage [12, 14]. Conversely, the Ruby, Alexandrite, and diode lasers have been favored for their effectiveness on lighter skin types with finer hair [15, 16].

Additionally, researchers have explored the use of multiple laser modalities in combination, aiming to capitalize on the synergistic effects of different wavelengths. Studies have investigated sequential or simultaneous applications of lasers to enhance hair removal outcomes and to address challenging cases involving resistant hair [17].

In this study, we evaluated the safety and efficacy of a dual-wavelength laser system (Splendor X; Lumenis BE, Israel) capable of delivering Alexandrite (755 nm) and Nd:YAG (1064 nm) wavelengths simultaneously within each pulse. The relative contribution of each wavelength can be customized, enabling adjustment of the Alexandrite-to-Nd:YAG ratio according to the patient's skin phototype. For example, higher Alexandrite proportions may be selected for lighter skin types, whereas higher Nd:YAG proportions are typically preferred for darker skin types to optimize treatment efficacy and minimize adverse effects.

2 | Materials and Methods

2.1 | Setting and Participants

We conducted a multi-center, prospective study using within-subject parallel treatment, with before and after analysis.

Study participants were healthy men and women aged 18–50 years with skin type I-VI with black/brown hair in at least one large area (either legs, thighs, chest or abdomen) and one small area: axillae (left and right), bikini area (left and right), front of the neck, back of the neck who wanted to remove hair in these body areas. Individuals were excluded from participation in the study if they had any of the following conditions in the treatment areas: active infections, dysplastic nevi, tattoos, a history of skin cancer or current cancer or pre-cancerous lesions, keloid scars, cold sores, herpes infection, open lacerations, abrasions, inflammatory skin conditions, or skin lesions. Pregnant women, individuals with bleeding coagulopathies, immunosuppressive diseases, autoimmune disorders, livedo retcularis, hormonal disorders that may affect hair growth, uncontrolled systemic diseases, photosensitivity, poor wound healing or intense, deep or recent suntan or sunburn were also excluded. Additionally, individuals taking medications or supplements or cosmetics that may affect sensitivity to light or change in skin metabolism, individuals taking anticoagulants or isotretinoin within 6 months of the study, and those who had previous skin procedures on the area to be treated area or mechanical or chemical hair removal in the area to be treated within 6 weeks before the laser treatment were not included in the study.

The study was approved by the institutional ethics committee and all participants provided signed informed consent prior to enrolling in the study.

2.2 | Treatment and Follow-Up

Prior to the treatment, up to 5 test spots were performed in the selected treatment area to determine the optimal parameters/setting combinations. The investigator started the test spot at a low fluence and adjusted it upwards according to the skin response and the subject's feedback.

Each large area (legs, thighs, chest, abdomen) was divided into 2 or 3 sub-areas according to the area size and the subject's skin type. Each sub-area was treated per investigator's discretion based on the treatment plan (Table 1).

TABLE 1 | Treatment plan with the Splendor-X laser.

Skin type	Area 1	Area 2	Area 3
I-II	SET with preference to 755 nm	755 nm	—
III-IV	SET—equal ratio	755 nm	1064 nm
V	SET with preference to 1064 nm	1064 nm	—
VI	1064 nm	—	—

Abbreviation: SET = simultaneous emission treatment.

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Within each treatment group, parameters varied slightly between subjects based on patient tolerance and skin reaction. However, all treatment parameters remain within preset ranges per study group as defined in the study guidelines. Initially, small areas (left and tight axillae, left and right bikini area, front/back of the neck) were treated with the optimal setting selected by the investigator gradually adjusted upwards in subsequent treatments per investigator's discretion and based upon the skin response and the subject's feedback.

Each subject received two different treatment types: single wavelength and SET (determined according to skin type), allowing for a direct comparison between study groups without subject to subject variability.

Subjects were instructed not to tweeze, pluck, wax, use depilatory creams, or any other hair removal methods in the treated areas throughout the evaluation period. The subjects were instructed not to shave the treatment areas in the 7 days prior to each treatment and follow-up visits, to obtain accurate hair counts.

Due to the mild nature of treatment, no anesthesia was required. Subjects were positioned during treatment in a manner that enabled optimal access to the treated anatomical site. Final treatment parameters per subject were determined according to test spots results. There was no need for overlapping.

Eye protection and all other laser safety means were used by the subjects and all personnel in the treatment room during the use of the device.

Each subject received a total of five treatment sessions at 6–8-week intervals upon re-growth of hair. The treatment duration in each treatment area was recorded.

Subjects returned for follow-up 12 months after the last treatment session.

2.3 | Outcome Assessments

2.3.1 | *Efficacy*

The treatment areas were photographed under controlled conditions by a standard high-resolution digital camera (Canon PowerShot SX130 IS, New York, USA) at baseline (prior to the treatment session) and at the 12-month follow-up visit. The hairs in each treatment area were counted by three blinded evaluators using customized hair count sticker templates consisting of a rectangular sticker with a rectangular window, and mean values were calculated for each area.

Treatment efficacy was assessed as the percent change in hair count from baseline to 12 months after completion of five treatment sessions. The change in hair characteristics (coarseness and color) compared to baseline were also evaluated. Hair coarseness was evaluated on a scale of 1 (very fine) to 10 (very coarse) and hair color was evaluated on a scale of 1 (very light) to 10 (very dark).

Subject attitudes towards their experience were evaluated at the fourth treatment session and at the follow-up visits. Perceived success of treatment was graded on a 5-point scale of; none, slight, moderate, good, very good. Overall satisfaction with treatment was recorded by a 5-point scale of; very dissatisfied, dissatisfied, somewhat satisfied, satisfied, very satisfied. In addition, the subject's likelihood of recommending the treatment or seeking additional treatments were assessed using a 6-point scale of; extremely unlikely, very unlikely, somewhat unlikely, somewhat likely, very likely, extremely likely.

2.3.2 | *Safety*

Following each treatment, immediate and short-term response (erythema, edema, purpura, etc.) were assessed within 30 min post treatment on a 5-point Likert scale (0 = None; 1 = mild; 2 = moderate; 3 = marked; 4 = severe).

To evaluate pain and discomfort associated with the laser treatments, the participants were asked to rate their general pain and comfort level immediately after each treatment using a visual analogue scale (VAS) ranging from 0 (no pain) to 10 (intolerable pain).

Adverse events during treatment and follow-up were recorded.

Downtime was defined as the period (measured in hours or days) following the procedure during which the subject felt unable/unwilling to go out in public due to edema and/or erythema.

2.4 | Statistical Analysis

The data were analyzed using SAS version 9.4 (SAS Institute, Cary NC, USA). Categorical variables were summarized using count, proportion and frequency, and continuous variables were summarized using mean, standard deviation (SD), median, range and confidence intervals. Statistical tests performed are two-sided, except for the primary endpoint which is one-sided. Findings were considered statistically significant if they were equal to or lower than 5%.

The percent change from baseline in hair count was modeled with an analysis of covariance (ANCOVA) model, with baseline hair count, visit, site (as a random effect), treated area, skin type, and treatment setting as covariates. The adjusted means of the change from baseline were calculated together with 95% confidence interval (CI). Full results are demonstrated in Table 2.

3 | Results

A total of 53 subjects were enrolled in the study. The median age of the subjects was 29.0 years (range 19–49) and most (98.1%) were female. About half of the subjects were white (54.7%) and a fifth (20.8%) were Hispanic or Latino. The rest were black (7.5%) and Asian/Pacific islander (7.5%). About two-thirds of subjects (64.2%) had black hair and the rest (36%) had brown hair. Fitzpatrick skin type ranged from I to VI (Table 2). Prior to the study, the most common method for hair removal used by the subjects was shaving (90.6%).

Sixteen subjects (30.2%) were terminated early due to withdrawal of consent ($n = 7$), loss to follow-up ($n = 7$), and investigator decision ($n = 2$).

3.1 | Treatment Characteristics

Most subjects (43/53, 81.1%) received five to six treatments. Seven subjects received only one treatment, two subjects were

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TABLE 2 | Percent change form baseline in hair count by area and device setting.

			Change from baseline in hair count (%)		
			SET	Alex (755 nm)	YAG (1064 nm)
Axillae	Pre- Tx. 5	*N*	14	16	18
		Mean (SD)	− 55.05% (37.22%)	− 44.74% (29.44%)	− 23.69% (49.47%)
		Median [Range]	− 62.81% [− 84.25%; 53.66%]	− 40.34% [− 81.53%; 14.47%]	− 39.56% [− 76.82%; 99.37%]
	3 Months FU	*N*	13	14	18
		Mean (SD)	− 32.52% (58.91%)	− 41.80% (24.73%)	− 21.44% (41.34%)
		Median [Range]	− 47.73% [− 76.77%; 117.5%]	− 43.96% [− 74.10%; 15.51%]	− 23.25% [− 89.46%; 56.89%]
	6 Months FU	*N*	14	12	16
		Mean (SD)	− 63.43% (36.32%)	− 54.91% (29.67%)	− 26.58% (48.12%)
		Median [Range]	− 69.37% [− 99.36%; 32.52%]	− 60.92% [− 82.20%; 30.41%]	− 37.97% [− 80.44%; 122.3%]
	9 Months FU	*N*	8	12	14
		Mean (SD)	− 75.97% (21.93%)	− 49.42% (23.42%)	− 38.44% (24.40%)
		Median [Range]	− 83.66% [− 95.81%; − 36.99%	− 52.39% [− 81.22%; 0.85%]	− 40.83% [− 83.66%; 3.77%]
	12 Months FU	*N*	12	12	16
		Mean (SD)	− 73.31% (16.56%)	− 51.28% (25.49%)	− 40.60% (34.66%)
		Median [Range]	− 75.14% [− 93.97%; − 42.96%	− 56.28% [− 79.44%; 13.92%]	− 51.28% [− 85.13%; 13.90%]
Bikini	Pre- Tx. 5	*N*	16	12	6
		Mean (SD)	− 78.19% (14.11%)	− 49.57% (39.94%)	− 80.41% (19.70%)
		Median [Range]	− 81.37% [− 94.74%; − 46.88%	− 65.04% [− 91.67%; 43.55%]	− 85.67% [− 99.56%; − 44.94%
	3 Months FU	*N*	16	10	6
		Mean (SD)	− 70.26% (21.68%)	− 32.42% (59.05%)	− 57.69% (30.54%)
		Median [Range]	− 72.25% [− 97.37%; − 17.71%	− 48.21% [− 94.26%; 108.3%]	− 60.25% [− 94.34%; − 3.93%]
	6 Months FU	*N*	16	10	6
		Mean (SD)	− 84.06% (16.46%)	− 68.18% (22.74%)	− 52.01% (49.84%)
		Median [Range]	− 90.55% [− 100.0%; − 46.06%	− 72.40% [− 95.77%; − 22.63%	− 61.95% [− 97.38%; 17.50%]
	9 Months FU	*N*	14	10	6
		Mean (SD)	− 90.02% (9.07%)	− 61.14% (10.90%)	− 76.17% (23.66%)
		Median [Range]	− 92.58% [− 100.0%; − 73.09%	− 61.51% [− 78.61%; − 44.74%	− 83.59% [− 97.56%; − 35.00%
	12 Months FU	*N*	16	10	6
		Mean (SD)	− 89.40% (14.57%)	− 72.77% (29.48%)	− 79.72% (15.26%)
		Median [Range]	− 95.92% [− 100.0%; − 45.79%	− 85.36% [− 100.0%; − 16.96%	− 83.26% [− 94.15%; − 50.00%
Leg	Pre- Tx. 5	*N*	39	34	26

(Continues)

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TABLE 2 | (Continued)

		Change from baseline in hair count (%)		
		SET	**Alex (755 nm)**	**YAG (1064 nm)**
3 Months FU	Mean (SD)	− 75.41% (23.96%)	− 61.68% (36.79%)	− 51.17% (39.91%)
	Median [Range]	− 82.58% [− 100.0%; 21.43%]	− 73.89% [− 96.55%; 70.21%]	− 58.94% [− 95.21%; 48.10%]
	N	37	32	27
6 Months FU	Mean (SD)	− 77.55% (18.40%)	− 69.13% (22.02%)	− 52.81% (40.66%)
	Median [Range]	− 83.52% [− 96.05%; − 4.76%]	− 71.03% [− 96.99%; 6.10%]	− 64.52% [− 95.49%; 82.93%]
	N	34	30	26
9 Months FU	Mean (SD)	− 80.43% (17.48%)	− 82.90% (17.09%)	− 67.50% (35.22%)
	Median [Range]	− 86.41% [− 100.0%; − 24.20%	− 86.86% [− 100.0%; − 19.15%	− 79.94% [− 100.0%; 57.14%]
	N	30	25	25
12 Months FU	Mean (SD)	− 88.08% (9.80%)	− 78.47% (25.91%)	− 64.60% (33.24%)
	Median [Range]	− 88.25% [− 100.0%; − 56.45%	− 85.07% [− 99.26%; 6.38%]	− 72.90% [− 100.0%; 12.70%]
	N	33	29	26
	Mean (SD)	− 86.35% (20.20%)	− 84.41% (14.49%)	− 74.50% (23.31%)
	Median [Range]	− 92.65% [− 100.0%; 1.77%]	− 89.92% [− 100.0%; − 56.10%	− 81.00% [− 100.0%; − 1.89%]

treated twice, one was treated three times, one was treated four times, and 43 subjects were treated five or six times.

In total, 230 areas were treated. The median number of treated areas per subject was 4 (range 1–5). The most common treatment setting was SET with an equal ratio of 755 and 1064 nm (88/230, 38.3%), followed by 755 nm (76/230, 33.0%) and 1064 nm (66/230, 28.7%). As shown in Table 3, legs were the most common treatment area (124/230, 53.9%) followed by axillae (64/230, 27.8%) and bikini area (36/230, 15.7%).

Fifty-seven subjects with Fitzpatrick skin type II were treated with SET (30/57, 52.6%) and/or with 755 nm alone (27/57, 47.4%). Seventy-four subjects with Fitzpatrick skin type III were treated with 755 nm alone (30/74 subjects, 40.5%) followed by SET with an equal ratio (27/74, 36.5%) and 1064 nm (17/74, 23.0%). Areas of subjects with Fitzpatrick skin type IV were treated in similar proportions with 1064 nm (21/55, 38.2%) and SET with an equal ratio (19/55, 34.6%) and to a lesser extent with 755 nm (15/55, 27.3%). Subjects with Fitzpatrick skin type V and VI were mostly treated with 1064 nm (Table 3).

The median treatment time per area was 2 min (range 1–21 min).[1] The areas with the shortest median treatment time were the axillae (median 1 min, range 1–5 min) and the bikini area (median 1 min, range 1–8 min). The chest had the longest treatment time (median 11 min, range 4–15 mins) (Table 4).

The most common spot size used among all settings was 20 × 20 nm (174/230, 75.7%). This spot size was used exclusively for the 755 and 1064 nm. In the SET settings 27 × 27 mm and 24 × 24 mm spots were also used (Figure 1).

3.2 | Effectiveness of Treatment

Hair count was performed on 43 subjects who received 5–6 treatment sessions and attended the 12-month follow-up visit. As no assessments were available for the neck, abdomen and chest, hair count analyses were performed for the axillae, bikini and leg areas only.

Hair counts decreased for all treatment settings. At the last treatment visit, a mean decrease of 69.2% ± 29.2%, 54.3% ± 36.1%, and 44.8% ± 45.2% was observed in areas treated with SET, 755 and 1064 nm, respectively. Twelve months after the last treatment session, a mean decrease from baseline of 84.6% ± 18.8%, 73.4% ± 25.3%, and 63.9% ± 31.2% was observed in areas treated with SET, 755 and 1064 nm, respectively (Figure 2).

The percent change from baseline in hair count by setting was modeled with an analysis of covariance (ANCOVA) with baseline hair count, visit, site (as a random effect), treated area, skin type, and treatment setting as covariates showed that the percent reduction in hair count from baseline to both timepoints was statistically significant. Reductions in hair count from baseline were also observed for the axillae, legs and bikini areas separately (Figure 3A–C).

All treatment settings performed better on the bikini areas and legs than on the axillae (two sided *p*-value: < 0.0001). Treatment with SET showed the highest percent reduction in hair count in all treatment areas.

ANCOVA with baseline hair count, visit, site (as a random effect), treated area, skin type, and treatment setting as covariates showed a statistically significant reduction in hair count

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TABLE 3 | Demographic and baseline characteristics of the study population.

Variable	Study population $N = 53$
Age, years, median (range)	29.0 (19–49)
Sex, *n* (%)	
Female	52 (98.1%)
Male	1 (1.9%)
Race, *n* (%)	
Caucasian (White)	29 (54.7%)
Hispanic/Latino	11 (20.8%)
Black	4 (7.5%)
Asian/Pacific	4 (7.5%)
Other	5 (9.4%)
Hair Color, *n* (%)	
Black	34 (64.2%)
Brown	19 (35.8%)
Skin type, *n* (%)	
I	3 (5.7%)
II	14 (26.4%)
III	15 (28.3%)
IV	11 (20.8%)
V	5 (9.4%)
VI	5 (9.4%)
Hair removal method, *n* (%)	
Shaving	48 (90.6%)
Waxing	2 (3.8%)
None	2 (3.8%)
Depilatory	1 (1.9%)

from baseline to 12 months after the last treatment session ($p < 0.0001$).

The treated hair in all areas became thinner (adjusted mean ± standard error -2.98 ± 0.32, $p < 0.0001$) and lighter (-2.38 ± 0.63, $p < 0.0001$) between baseline and 12 months after the last treatment session.

Figure 4 shows representative images of treatment areas before and after treatment.

At the 12-month follow-up, 81.8% of subjects treated with SET, 80.0% of subjects treated with 755 nm and 58.82% of subjects treated with 1064 nm reported good to very good improvements in hair reduction. The highest perceived success of treatment was reported by subjects treated with the SET mode (Figure 5). Most subjects were also satisfied to very satisfied with the treatment (75.41%, 79.59%, and 60.78% of subjects treated with SET, 755 and 1064 nm respectively) (Figure 6).

3.3 | Treatment Tolerance and Safety

Mean pain score during the treatment was 2.63 ± 2.24 (median 2.10, range 0–8.40). On average, the most painful treatment areas were the chest and the abdomen, and the least painful treatment areas were the neck and the axillae (Figure 7).

Most subjects did not experience purpura or edema following the treatment (Figure 6). Trace to mild erythema and trace to mild edema were reported in 51.1% and 36.5% of treatment areas, respectively. Trace to moderate purpura was recorded in 2.96% of treatment areas. Marked erythema and edema were recorded only in 3 (0.28%) and 5 (0.46%) treatment areas, respectively. These responses were expected and resolved within 24 h (Figure 8).

On average, redness, swelling, and purpura subsided after 4.03, 0.51, and 0.78 h, respectively. As the treatment progressed, the

TABLE 4 | Treatment settings according to treatment area and skin type.

	SET	755 nm	1064 nm	Total
Area, *n* (%)				
Abdomen	1 (50.0%)	1 (50.0%)	—	2 (100%)
Axillae	22 (34.4%)	20 (31.3%)	22 (34.4%)	64 (100%)
Bikini area	16 (44.4%)	12 (33.3%)	8 (22.2%)	36 (100%)
Chest	1 (50.0%)	1 (50.0%)	—	2 (100%)
Leg	47 (37.9%)	41 (33.1%)	36 (29.0%)	124 (100%)
Neck	1 (50.0%)	1 (50.0%)	—	2 (100%)
Skin type, *n* (%)				
I	5 (55.6%)[b]	4 (44.4%)	—	9 (100%)
II	30 (52.6%)[b]	27 (47.4%)	—	57 (100%)
III	27 (36.5%)[a]	30 (40.5%)	17 (23.0%)	74 (100%)
IV	19 (34.6%)[a]	15 (27.3%)	21 (38.2%)	55 (100%)
V	7 (35.0%)[c]	—	13 (65.0%)	20 (100%)
VI	.	.	15 (100%)	15 (100%)

Abbreviation: SET = simultaneous emission treatment.
[a]SET with equal ratio of 755 and 1064 nm.
[b]SET with preference to 755 nm.
[c]SET with preference to 1064 nm.

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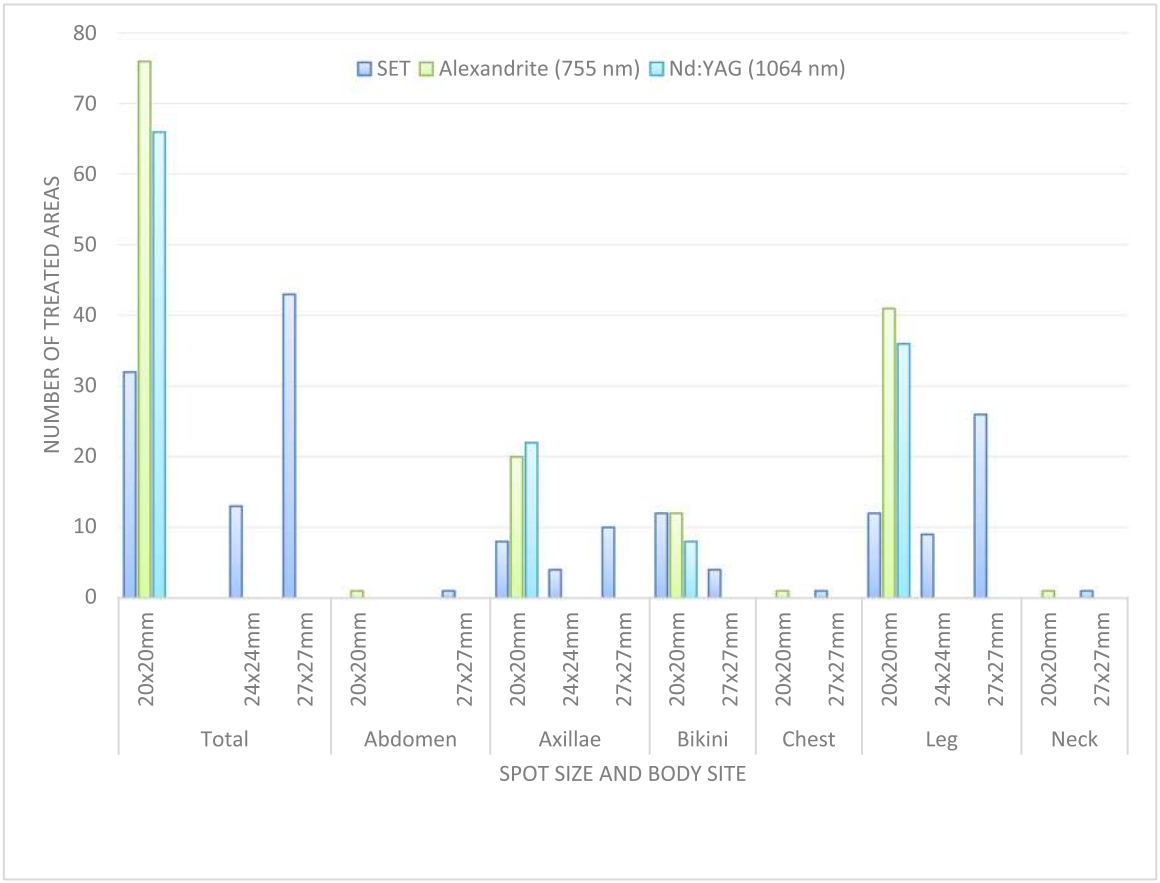

FIGURE 1 | Spot sizes used by treatment setting.

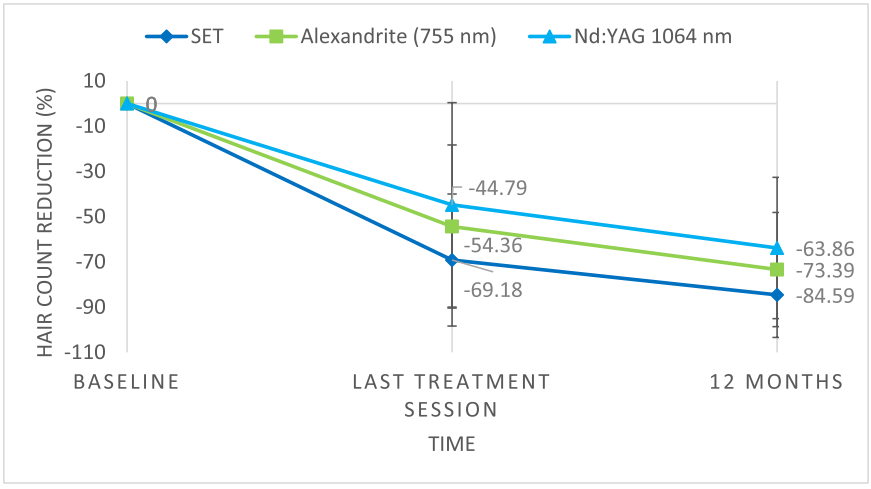

FIGURE 2 | Percent change from baseline in hair count by device setting.

duration of downtime became less significant. Subjects felt comfortable going out, on average, within 5 min after the procedure.

Six adverse events were reported in 6 patients (11.3%). Five events—all of them mild or moderate in intensity—were considered related to the treatment. None of the adverse events were serious. Two subjects developed hives on the legs. In one subject these hives resolved after 15 min. The second subject also had inflammation and was given loratadine. Another subject reported pruritic erythematous papules over her entire right leg. One subject reported mild hyperpigmentation on the lower right anterior side of the leg. One subject had a tattoo that was inadvertently lasered. All adverse events resolved.

Overall, 1082 treatment sessions of 230 areas were performed during the study period with only 4 cases of AE related to the treatment procedure representing 0.0037 rate of mild to moderate AEs.

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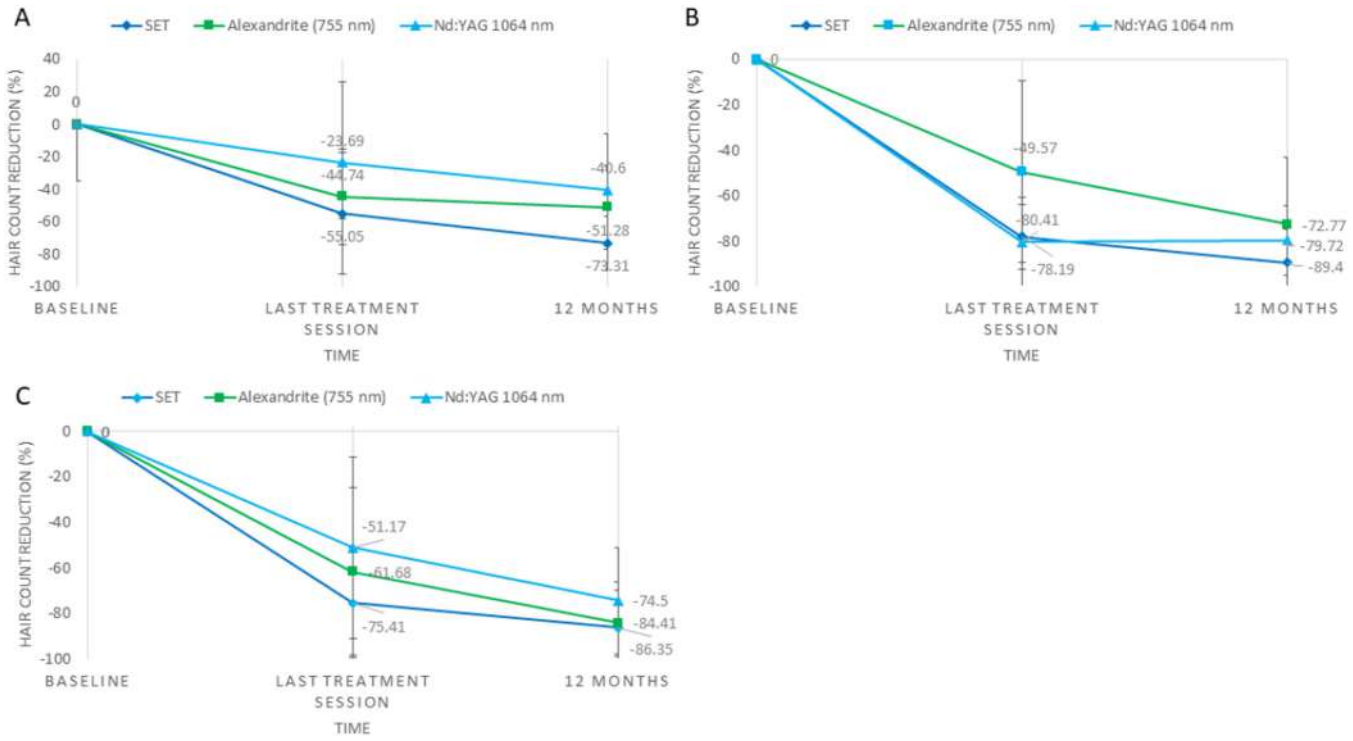

FIGURE 3 | Percent change from baseline in hair count by anatomical area. (A) Percent change from baseline in hair count in the axillae. (B) Percent change from baseline in hair count in the bikini area. (C) Percent change from baseline in hair count in the legs.

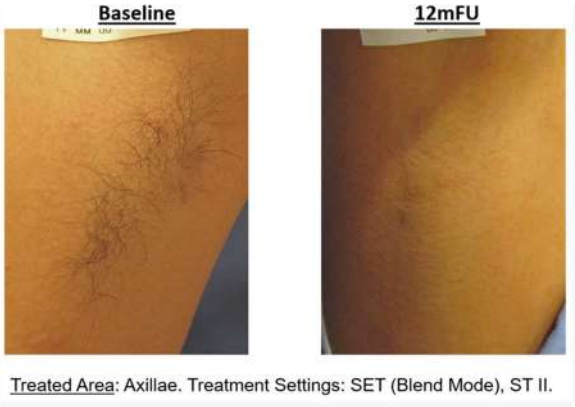

FIGURE 4 | Representative images of treatment areas before and after treatment.

4 | Discussion

Combining Alexandrite and Nd:YAG lasers for hair removal aims to improve the efficacy and safety of hair removal treatments for individuals with various skin types and hair colors, and thickness. The idea behind this combination is to target hair follicles at different depths and with different melanin concentrations, as the two lasers have distinct wavelengths [18]. Effective hair reduction is possible if the melanin within the hair shaft, hair follicle epithelium, and the heavily pigmented matrix, and also the stem cells in the area of the bulge, are targeted [12, 15]. Only lasers with wavelengths ranging from 630 to 1100 nm can irradiate the entire length of anagen hair extending 2–5 mm into the dermis [1].

Our results showed that hair removal using each laser alone and in combination significantly reduced hair counts after 5 treatment sessions. Hair count continued to decrease for up to 12 months after the last treatment session. The reduction in hair count was observed for skin types I to V. A statistically significant reduction in hair color and coarseness were also observed across all study groups. Hair removal was less effective in the axillae and for subjects with skin type VI.

Zerbinati et al. [19] reported similar results of hair removal in men and women with skin type I–V using a device delivering blended simultaneous emission of Alexandrite and Nd:YAG lasers. The subjects in that study also received 4–5 treatment sessions at 6-8-week intervals. Mean hair reduction after 4 treatment sessions and a year of follow-up was 76.1% for axillae, 77.3% for the bikini line, 78.5% for legs, 74.1% for the thorax, and 74.5% for the back. After 5 sessions hair reduction levels were: 83.0% for axillae, 82.1% for the bikini line, 82.2% for legs, 79.6% for the thorax, and 81.6% for the back [19].

In a randomized, assessor-blinded trial of legs treated with 18- and 12-mm spot size Alexandrite laser, 12-mm spot size Nd:YAG laser, and combined 12-mm spot size alexandrite and Nd:YAG lasers, that were sequentially administered in the same session, the percent of hair reduction 8 months after 4 treatment sessions was 86.0%, 79.6%, 73.6%, and 79.6%, respectively [20]. Ross and Domankevitz [21] reported similar effectiveness of alexandrite, Nd:YAG and blended alexandrite/Nd:YAG mode for hair removal in the lower extremity (54%, 47% and 58% hair reduction, respectively) 2 months after 2 treatment sessions [21].

Similar to our results, Ross and Domankevitz [21] reported percentage of hair reduction in the axilla 2 months after 2 treatment sessions with either alexandrite, Nd:YAG and blended alexandrite/Nd:YAG mode, was relatively low at 20%, 33% and 28%, respectively [21]. have found that the Nd:YAG laser was better than the alexandrite/Nd:YAG blended mode

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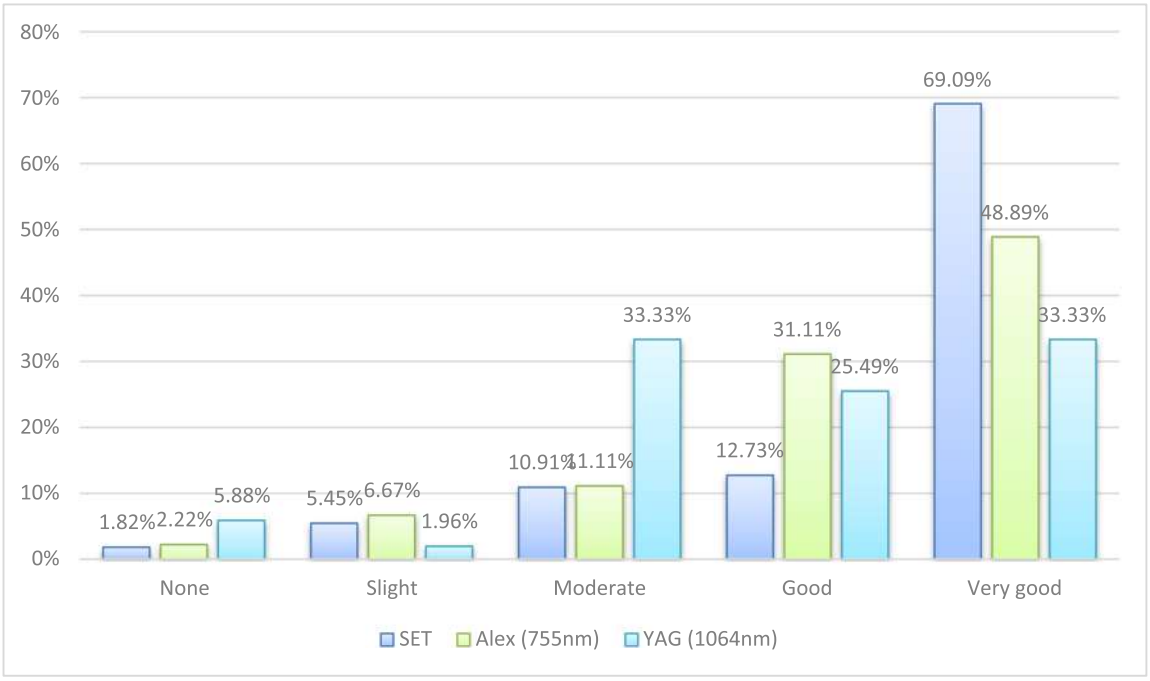

FIGURE 5 | Subject-perceived success of treatment in hair reduction at 12 months after the last treatment session.

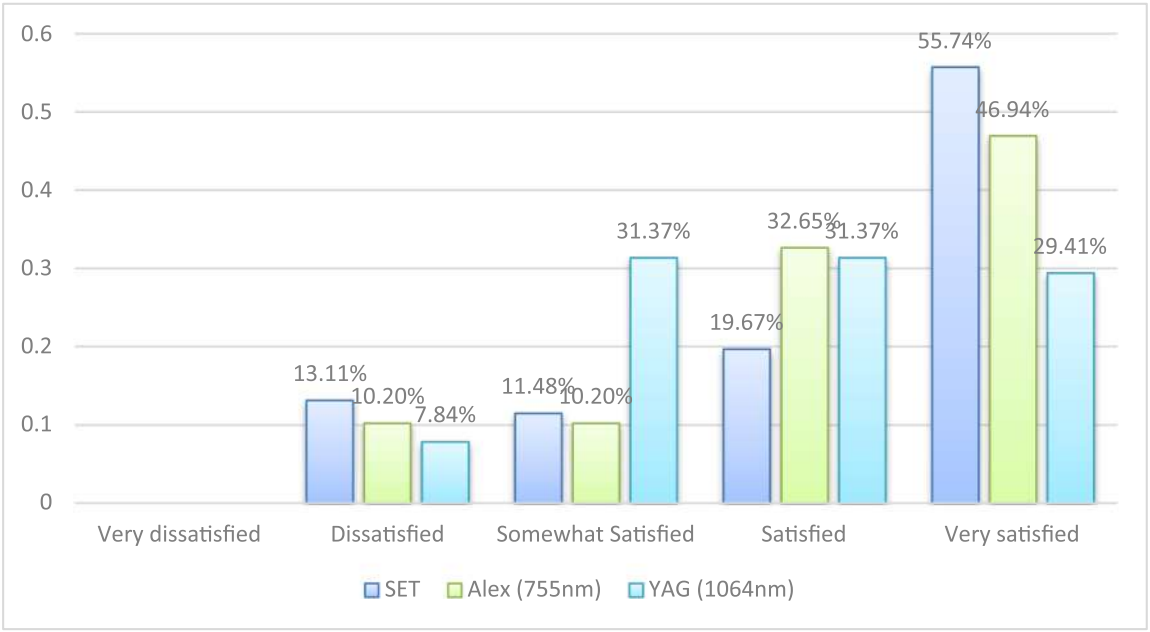

FIGURE 6 | Subject satisfaction with the treatment at 12 months after the last treatment session.

and alexandrite laser alone for hair removal in the axilla, attributing the results to the greater optical density of the axilla hairs due to their greater diameter compared to hair diameter in the legs. Our results showed that treatment was less effective in the axillae. Khoury et al. [22] reported mean hair reduction of 71.3%, 48.2%, and 68.1% for the alexandrite, Nd:YAG, and combination alexandrite and Nd:YAG lasers (administered sequentially in the same session), respectively, 2 months after the last of three treatments sessions to remove hair in the axillae. In that study, the percent reduction in hair count was higher 1 month after treatment compared to 2 months after the last treatment session [22]. Low percent reduction of axillary hair was also observed following 3 treatment sessions at 6-8-week intervals of 20 women with Fitzpatrick skin type II and dark, red, or light-colored hair who were treated with either diode, Nd:YAG, and alexandrite lasers alone or with a sequential combination of the three lasers. This can be due to a unified study design for treatment intervals, which was not aligned with these areas' naturally faster hair cycle. Three months after the last treatment session the percent reduction was 59.3%, 58.7%, 31.9% and 39.8% for the alexandrite, diode, Nd:YAG and the combination treatment, respectively. Individuals with red or light-colored hair and Fitzpatrick phototype II skin were found to have decreased efficacy of laser

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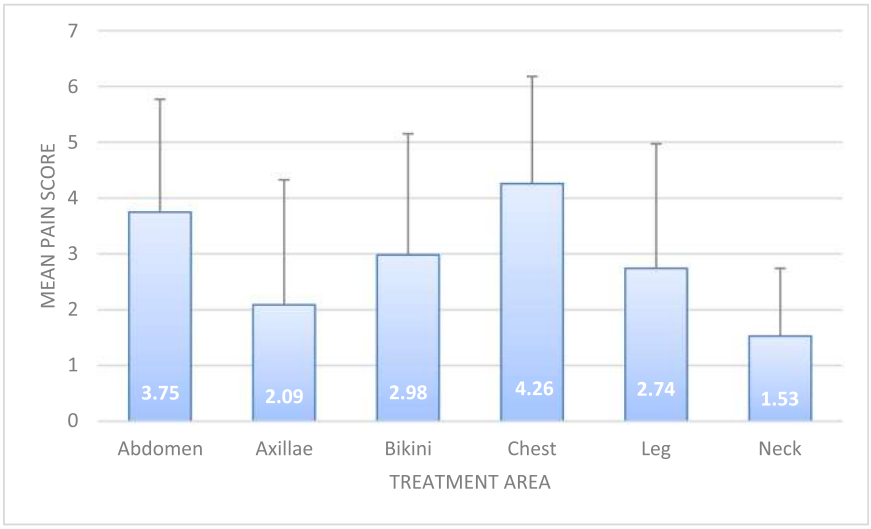

FIGURE 7 | Mean pain score (standard deviation) by anatomical area.

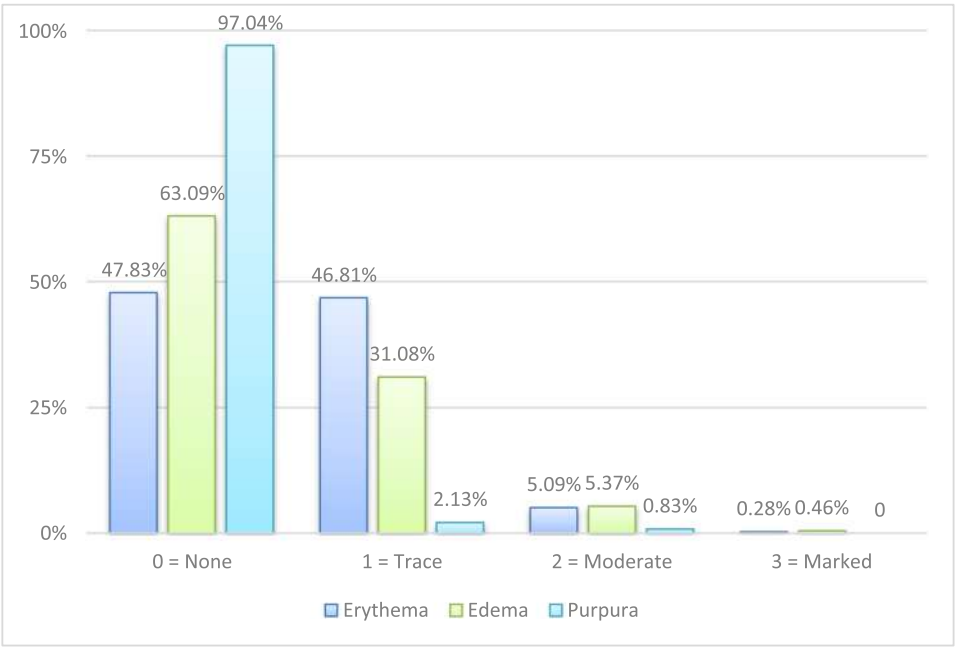

FIGURE 8 | Immediate response events following treatment.

treatment than those with dark-colored hair and the same phototype [23]. Bernstein et al. [24] investigated the percentage of hair reduction in the axilla using a multiplex device with sequential alexandrite and Nd:YAG pulses in which groups were treated with different orders of the wavelengths. After 4 treatment sessions at 4–6-week intervals, the percentage of hair reduction was 83%, 81%, and 86% for the alexandrite, alexandrite/YAG sequence, and YAG/alexandrite sequence, respectively [24]. The higher efficiency might be due to more suitable treatment time intervals compared to other treated areas, as part of the study design limitations. According to Ross and Domankevitz [21] Nd:YAG laser was better than the Alexandrite/Nd:YAG blended mode and alexandrite laser alone for hair removal in the axilla, due to the greater optical density of the axilla hairs due to their greater diameter compared to hair diameter in the legs.

Khoury et al. reported that the alexandrite laser was found to be slightly more effective than the combination of alexandrite and Nd:YAG, and the combination alexandrite, but not statistically significantly so, and Nd:YAG treatment arm was statistically more effective than the Nd:YAG alone but no statistically significant difference was seen between the alexandrite alone and the combination treatment [22]. Our study has shown that the SET setting was more effective than the Nd:YAG setting at the 3, 6 and 9 months follow-up, and the alexandrite setting at the 9 months follow-up. These differences may be attributed to the combination of skin type, hair color and anatomical area treated. According to Ross and Domankevitz [21] the alexandrite laser demonstrated the greatest hair reduction in lighter hairs, and the Nd: YAG achieved the best results if the hairs and skin type were darker.

Adverse events were minimal and transient. Other studies reported transient adverse events following treatment with Alexandrite,

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Nd:YAG lasers and simultaneous treatment with the two lasers, which included perifollicular erythema and edema [19, 22], singed hairs [22], first-degree burns [19], bullae [20], hyperpigmentation [19, 20], and hypopigmentation [19]. These side effects were transient and resolved within 2 to 7 days of onset. Ross and Domankevitz [21] reported that micro-crusting that appeared 3-5 days after treatment with blended 755/1064 nm laser tended to be linked to the amount of Alexandrite energy and the darkness of the skin. They also reported that pain tended to be proportional to the percentage of Nd:YAG in the beam as well as to the thickness and darkness and of the hair [21]. Davoudi et al. [20] reported that pain severity during treatment with both lasers and in subjects treated with the alexandrite laser was significantly greater than in subjects treated with the Nd:YAG laser. In contrast with other reports [20], in the current study combination treatment did not cause a higher rate of adverse events. Moreover, the unique combination of the 2 wavelengths in one simultaneous emission allows the treatment to be performed while maintaining high energy at a relatively low penetration level. The cooling system contributes to the overall comfort as demonstrated in Figure 7.

The limitations of the study include the following: Treatments were provided in predefined time intervals for all treated areas. Although the hair cycle differs in various body areas, this was not addressed differently in the protocol design. Also, the study design didn't include a comparable structure to support the superiority of the combined treatment compared to the single wavelengths in terms of performance. Moreover, different wavelength combinations were used in different patients, on different areas of the body, and not a split surface comparison. Nevertheless, each subject could experience the difference in single emission compared to dual emission, per skin type limitations. Laser hair removal is a known effective and safe method to reduce hair count, so each comparison made will have to be between baseline and final observation, and not comparing directly between each mode.

5 | Conclusions

Laser hair removal using a single laser source was considered to be safe and effective, while being the optimal manner for reducing undesired hair levels. This prospective study demonstrates the robustness and versatility of a device that allows the use of Alexandrite and Nd:YAG lasers – either alone or in combination, according to skin type and treatment area.

The results of the study particularly demonstrate the efficacy of the SET mode in its ability to permanently reduce unwanted hair levels at higher percentages and with greater patient satisfaction, compared to single wavelength treatment with either 755 or 1064 nm. Additionally, this technology demonstrated a good safety profile across a wide range of skin types (from type I to VI) with a reasonable level of pain tolerance and without long-lasting side effects.

Acknowledgments

We thank Lumenis for supporting this study.

Ethics Statement

This study received ethical approval from the Sterling Institutional Review Board.

Conflicts of Interest

Dr. Ugonabo has no relevant conflicts of interest to disclose. Drs. Chapas and Rohrer are investigators and consultants for Lumenis.

Data Availability Statement

Deidentified data collected as part of this study are available upon reasonable request to the corresponding author.

Endnotes

[1] The treated area for each body part was predefined to demonstrate the efficiency and not to provide a full treatment for the entire body part.

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