Laser-Assisted Permanent Hair Reduction with an innovative simultaneous combination of 755-nm and 1064-nm and a square spot shape: a comparative evaluation

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Background

Traditional hair-removal techniques have included shaving, waxing, chemical depilation, and electrolysis. All of these methods result in temporary hair removal. The theory of selective photo thermolysis led to the development of a variety of different laser systems. Photothermal destruction of hair follicles constitutes the fundamental concept of hair removal with red and near-infrared wavelengths, suitable for targeting follicular and hair shaft melanin. Although 694 nm ruby lasers were among the first to be used, alexandrite 755 nm, diode 810 nm and Nd:YAG 1064 nm lasers, as well as a variety of broad-spectrum intense pulsed light sources, are currently more commonly used for the treatment of unwanted hair. All those light sources have been proven successful when ideal anatomical and functional hair follicle conditions and skin pigmentation are encountered but darker skin types, low density, thin and light coloured/white hair shafts may significantly limit clinical success. The most desirable patients for this kind of treatment should have thick and dark, actively growing terminal hair distributed on a light skin. Most of light-emitting light sources proposed for photo-assisted epilation on the market can be safely used in light, skin types 1-3. Expected clinical results should produce a hair reduction near to 75% of the original hair density. Darker skin, skin types 4-6 skin types are more difficult to treat because of the minimal color difference between skin and hair shafts. In these situations the use of traditional light sources such as diode laser, alexandrite laser, and intense pulse light might be associated to the development of excessive "collateral" skin damage, long lasting and even permanent skin hypopigmentation and scarring when conventional treatment parameters are used. To overcome these risks lower fluences and different treatment protocols have been developed inevitably decreasing final hair reduction efficacy. The long-pulsed 1064 nm Nd:YAG laser represents the safest light source for hair removal procedures in dark-skin individuals thanks to its relatively low melanin absorption and deep tissue penetration. It represents the primary treatment choice when hair removal procedures are performed on skin type 6 patients.

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In any case complications might be clinically observed after all laser hair removal procedures and include surface burning discomfort due to micro damage to the epidermal skin layers immediately after laser and light-assisted procedures, scarring and textural changes, pigmentary alterations such as hyper- and hypopigmentations and, more rarely, reticulate erythema and uveitis. Present technologies have some “innate” limitations possibly leading to potential complications, i.e. round shapes of laser beams requiring operators to distribute laser spots with 20-30% overlapping in order to avoid cosmetically unattractive untreated gap areas. This laser delivery technique can potentially increase the risk of excessive thermal damage to double treated skin areas (Figure 1) or, when overlapping is not performed, confetti-like epilation might be observed (Figure 2).

Figure 1

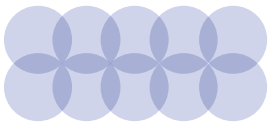
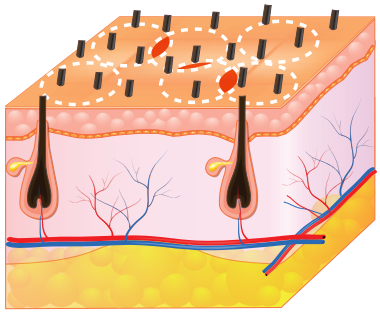


Figure 2



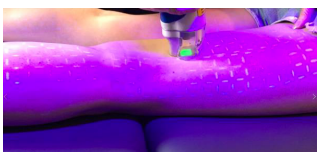
Skin illustration

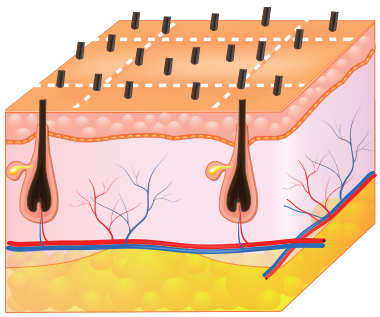
Laser plume generated during hair epilation procedures has been found to represent a potentially dangerous bio-hazard to operators and medical environment, strongly recommending the use of a smoke evacuator associated with efficient ventilation of laser rooms, and micro-filtering facial masks. Smoke evacuators and laser room aspiration systems can also contribute to a significant increase of treatment comfort during epilation procedures thanks to the reduction of burned hair smell that could be quite disturbing to both patients and staff.
In spite of many interesting technical upgrades and innovative treatment protocols proposed by different manufacturers, demand for safer, more comfortable and more flexible solutions is still strong.
The innovative SquareEpil laser platform (BIOS, Italy), proposes some interesting and innovative solutions that can significantly help improving hair removal procedures.

- The laser platform allows the simultaneous emission of Alexandrite 755 nm laser and Nd:YAG 1064 nm laser
- the square shape of the laser spot, with a wide range of sizes spanning from 2x2mm to 27x27mm, allows to rapidly and effectively cover designated anatomical areas without the need of overlapping and with minimal untreated areas (Figure 3). A novel Wood light activated fluorescent skin marking system helps the operator to follow a more uniform treatment pattern. (Figure 4).
- the built-in smoke evacuator with integrated aspiration holes within the ergonomic handpiece optimizes the active treating space during the laser procedure (Figure 7)
- the dual cooling system consisting of a modulable non-contact chilled air flow generated by a dedicated external source and a chilled metal plate working in contact with the skin contributes to significantly increase patients’ comfort during laser procedures while protecting the epidermis from excessive collateral thermal damage (Figure 7)

Figure 3

Figure 4





Skin illustration

Objective

The objective of this study was to compare the safety and effectiveness of a simultaneous combination of 755-nm Alexandrite and 1064-nm Nd:YAG laser emissions delivered through an advanced square-section optical fiber generating flat-top square spots of different sizes (18x18 mm and 24x24 mm) with a commonly used 755-nm Alexandrite laser source delivered through a round-section optical fiber generating a 18-mm) round spot on various skin types (1 to 5), when used at therapeutically effective fluences. The primary aim of the study was to assess the possible superiority of the combination laser system and its square spots towards the single wavelength round spot laser system. Secondary objectives were focused on the evaluation of treatment comfort as perceived by patients and the ergonomic comfort perceived by operators during laser treatments.

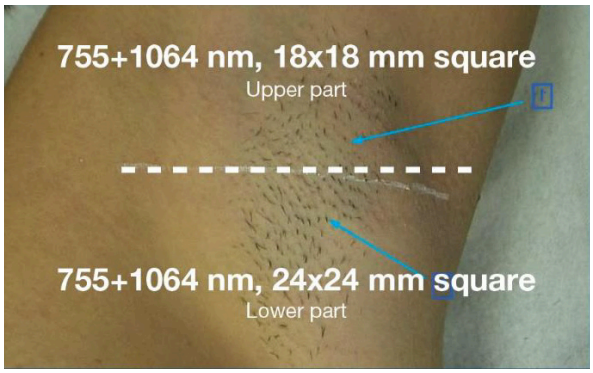
Methods

22 healthy, non-menopausal female volunteers (18-45 year of age – mean 31.6), with different skin types (1-5) were selected to undergo a series of anatomically localized hair removal procedures limited to the axillary regions. Exclusion criteria included recent tanning, hair bleaching, or waxing, light and laser-assisted hair removal 2 months prior to intended laser procedures. Skin type 6 patients were also excluded because of the strict limitation imposed by their skin color to any laser sources but 1064-nm long pulse laser systems which was beyond the aim of our study.
For practical reasons axillary regions were divided in 4 subunits according to standardized anatomical landmarks (fig. 5). One subunit - upper right axilla - was left untreated and served as a benchmark to compare clinical results. The other three subunits were treated according to a standardized laser scheme. The lower right axillary subunit was exposed to a 755-nm laser system (Gentle Lase – Syneron Candela, USA) using a 3-ms pulse duration with a 18-mm diameter round spot and 15-to-20J/cm2. On the opposite side, the two axillary subunits were treated with a simultaneous combination of 755-nm and 1064-nm laser wavelenghts produced by a multi-wavelenght laser platform (SPLENDOR X – BIOS, Italy). The percentage or the two laser wavelengths were adjusted according to the different skin types to be treated.
Skin type 1-2 received 75% Alexandrite and 25% Nd:YAG, Skin type 3-4 50% Alexandrite and 50% Nd:YAG, and Skin type 5 25% Alexandrite and 75% Nd:YAG. A 18-mm x 18mm square spot was chosen for the upper subunit and a 24-mm x 24-mm square spot for the lower. Pulse duration varied according to the hair density and shaft diameter and ranged from 5-to-7ms. Overall treatment fluences varied from 15-to-20 J/cm2 adjusting them in order to reach suitable peri-follicular edema and erythema.

Figure 5

Right axilla

Left axilla



A total of four laser sessions were performed at 40-day intervals.

Standardized digital photography, and quantitative digital analysis of superficial dermal hemoglobin and epidermal melanin were performed to assess clinical outcomes and potential side effects. Images were taken immediately before laser treatments, at the end of laser irradiations, and 5-minutes after the conclusion of the treatments. Hair units of each axillary subunit were digitally counted during the last follow-up visit scheduled 40-days after the 4th session. Hair reduction percentages were calculated for each axillary subunit comparing data with those registered on the upper L axillary subunit left untreated during the whole duration of the study. Perifollicular edema and transient hypopigmentation were observed and evaluated 5 minutes after each treatment.

Subjective evaluation of pain sensation experienced on the three anatomical areas exposed to the different laser treatments was collected interviewing patients immediately after sessions. Patients were asked to indicate the level of discomfort on a linear pain assessment graphic scale. An evaluation of the clinical efficacy observed by patients on each treated area was also obtained through a five-grade questionnaire (1=totally unsatisfied to 5=totally satisfied) 45 days after the last laser session.

The operators were also asked to evaluate their degree of satisfaction regarding the main technical and ergonomic characterisitics of the SquareEpil platform through a 5-grade questionnaire at the end of the 4 treatment sessions. (Figure 6).

Figure 6

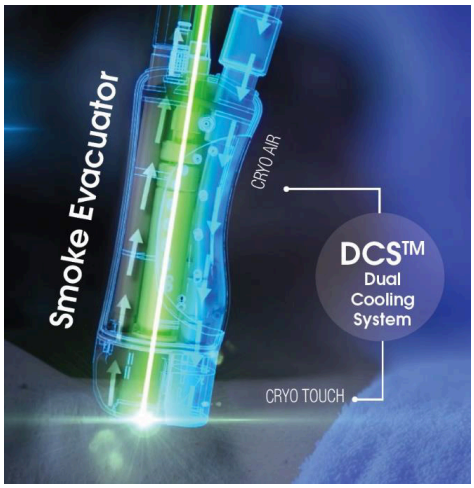
General Ergonomics	Rating				
Shape	1	2	3	4	5
Main Laser case motility	1	2	3	4	5
Laser storage cabinet	1	2	3	4	5
Suspending arm	1	2	3	4	5
Laser switch on & off	1	2	3	4	5
Touch screen operation	1	2	3	4	5
Icon and TX setting	1	2	3	4	5
Physician-Laser interface	1	2	3	4	5
Pre-set parameters	1	2	3	4	5
Handpiece	1	2	3	4	5
Handpiece accessories	1	2	3	4	5
Handpiece optics	1	2	3	4	5

1. Completely dissatisfied
2. Partially dissatisfied
3. Minimally satisfied
4. Moderately satisfied
5. Completely satisfied

Materials

All “pure” 755-nm laser treatments were performed on lower halves of right axillary regions using a GentleLase system (Syneron Candela, USA) operating with a round spot shape. Epidermal cooling was obtained through the activation of the built-in DCDTM cryogen spray cooling technology for 30 ms before each laser pulse. All “hybrid” 755-nm+1064nm laser treatments were performed on the upper and lower halves of left axillary regions using a SquareEpil laser platform (Bios, Italy) operating with a square spot shape. Epidermal cooling was obtained activating a continuous flow of chilled air generated by a dedicated external Biocooling 6 system (Zimmer, Germany) set at 5-6 air output level. Chilled air was delivered to treated anatomical areas through a direct hose access located within the laser handpiece. A direct skin contact cooling was also provided through a chilled metal plate located at the very tip of the laser handpiece (Figure 7).
All clinical photographs were taken using a high definition digital camera (MEDICAM 800 HD-FotoFinder Systems GMBH, Germany). Skin analysis (melanin – hemoglobin – texture) was performed using an Antera (Miravex, LTD Dublin, Ireland).

SPLENDOR X handpiece illustration



Results

20 out of 22 patients completed the study. Two patients dropped out because of the impossibility to respect their treatment schedule. Both laser systems were able to achieve a progressively significant hair count and hair thickness reduction with a good persistence of clinical results 45 days after the last laser treatment. Clinical results of all treated areas were compared with the untreated axillary segment and corresponding hair density reductions percentages calculated accordingly. All patients showed a slightly higher hair reduction after the simultaneous irradiation of 755-nm + 1064-nm compared with 755-nm alone. Hair reduction was higher when 24x24-mm square pulsed were used. Average hair density reduction of 80.2% was observed on “pure” 755-nm 18mm round spot Alexandrite areas. Combination laser treatments (755-nm Alexandrite + 1064-nm Nd:YAG) were able to achieve a hair density reduction of 86.3% when 18x18-mm square spot was used and 87.9% reduction when 24x24-mm square pulse was selected. (Figure 8 and Figure 9).
Concerning complications and side effects, two of the 11 Fitzpatrick skin type III-IV patients enrolled in the study developed significant transient post-inflammatory hyperpigmentation within the area treated with “pure” 755-nm Alexandrite laser requiring topical steroid treatment. Minimal transient post-inflammatory hyperpigmentation was observed on the two areas treated with the 755-nm + 1064-nm laser combination. Reactive skin pigmentation resolved spontaneously without any topical treatment. No other complications were observed 45 days after the the last laser treatment.
Pain-related laser-assisted epilation is a major issue for patients seeking this kind of procedures. Our study confirmed an increased painful sensation on the areas treated by 755-nm laser alone (78.8% of patients) compared to those exposed to the combination of the two 755-nm and 1064-nm wavelenghts. (Figure 10)
Post-treatment subjective satisfaction based on a 5-point scale scored an average of 4.25 on “pure” 755-nm Alexandrite treated areas. Satisfaction values of 4.65 and 4.70 were reported on combined 755-nm and 1064-nm with 18x18-mm square spot and 24x24-mm square spot respectively. (Figure 11).
Physicians general operative satisfaction was reported quite high (Figure 12). Round spot laser delivery was considered relatively longer compared to square spots. Buit-in smoke and laser plume aspiration ergonomically designed within BIOS handpiece significantly contributed to decrease the unpleasant odor generated by hair-shaft photo-thermal vaporization during treatments adding to patient and operators’ comfort. Perifollicular edema was also observed earlier (1-min average) on areas treated with the combination of 755+1064-nm compared to sites treated with ”pure” 755-nm."

Figure 8

Hair reduction %

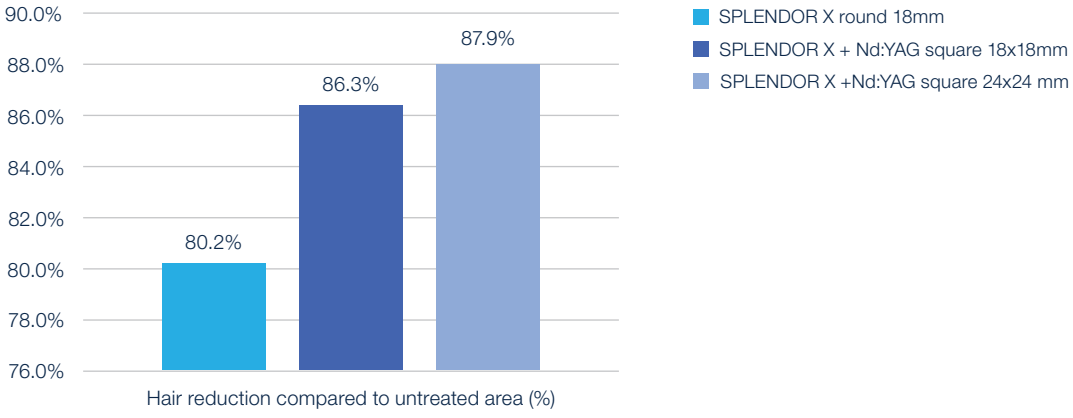


Figure 9

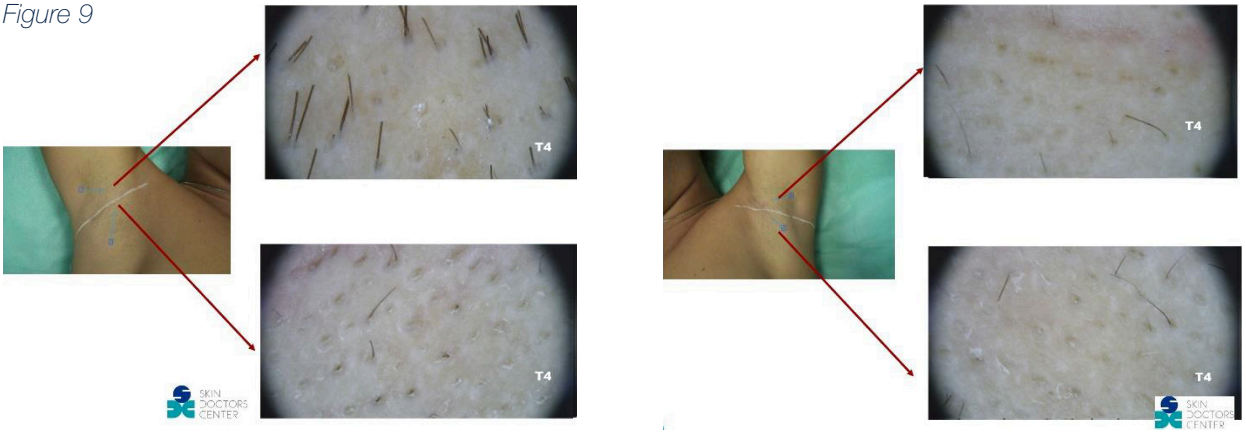
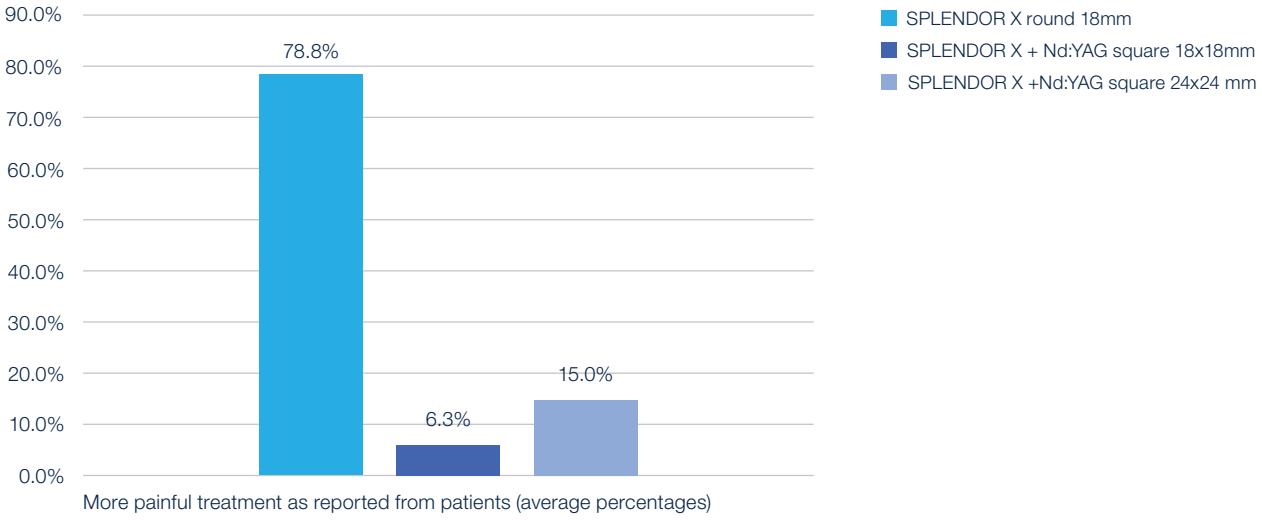


Figure 10

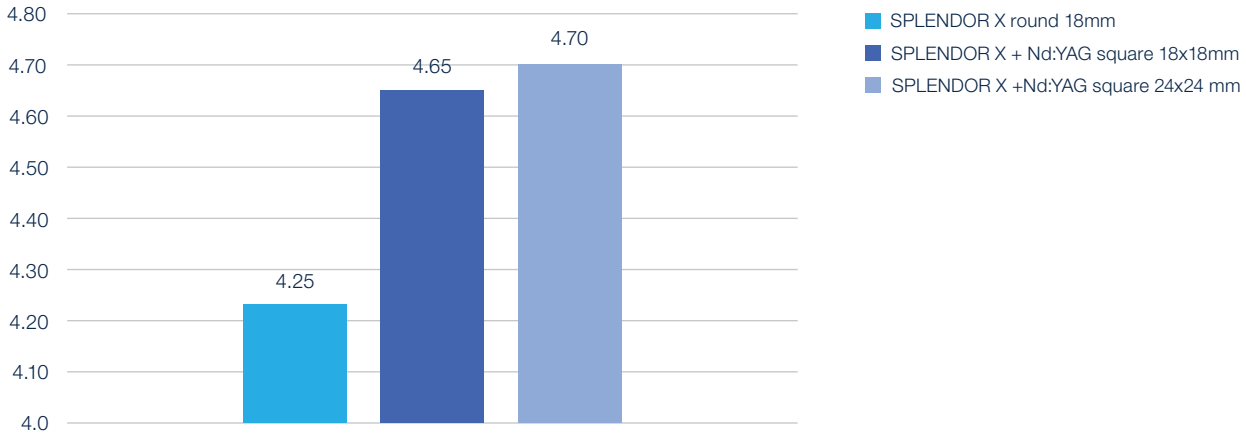
More painful treatment, average percentages



More painful treatment as reported from patients (average percentages)

Figure 11

Patient clinical satisfaction, index



Patient reported clinical satisfaction from 1 (Completely dissatisfied) to 5 (Completely satisfied)

Figure 12

Ergonomic evaluation by laser operator (average on 4 days of treatments) From 1=absolutely unsatisfied to 5=totally satisfied	
Shape	4.5
Main Laser case motility	4
Laser storage cabinet	4.25
Suspending arm	4.75
Laser switch on & off	5
Touch screen operation	5
Icon and TX setting	4.75
Physician-Laser interface	5
Pre-set parameters	7.25
Handpiece	4.75
Handpiece accessories	4.75
Handpiece optics	4.75

Conclusion

The innovative simultaneous combination of two of the most popular wavelengths used in laser-assisted epilation procedures (755-nm and 1064-nm), delivered through a square-section optical fiber, has shown to generate significant advantages over a widely used short pulse 755-nm laser system operated with 18-mm round spot and therapeutic fluences ranging from 15-to-20J/cm2. The dual wavelength laser platform used in this study (SPLENDOR X – Bios, Italy) was able to achieve a higher percentage of hair reduction with less pain, better efficiency due to minor peripheral laser-spot overlapping, earlier observation of post-laser perifollicular edema, increased patient and operator comfort during treatment, and higher overall post-treatment satisfaction. These positive clinical findings could be explained by the simultaneous “multilayer photothermal” effects generated by the two different wavelengths penetrating within the dermis at different depths. Hair shafts at their most vulnerable stages of their cycle could be effectively reached by this laser combination.

Pure 755-nm Alexandrite pulsed laser irradiation, associated with a non-contact epidermal cooling system, induced a slightly higher pain perception during treatments probably due to the shallower intradermal penetration of this specific wavelength conditioning a photo-thermal “core action” closer to superficial pain-sensitive nerve receptors.

Operators greatly appreciated the possibility of modulating photo-thermal tissue effects due to the easy “titration” of the emission parameters of each of the two different wavelengths during laser pulses. This specific technical feature was considered extremely useful when treating patients with different skin types. Square laser spots greatly improved treatment speed and efficiency when compared to conventional round spots. This technical choice could be extremely useful particularly when larger anatomical areas are considered for treatment. One of the most important issues of modern laser systems is the ergonomic “concentration” of essential accessories within a well designed handpiece to facilitate laser operation during treatments. The Square-Epil laser platform (Bios – Italy) comes with a very functional ergonomic handpiece with an efficient dual-epidermal cooling devices, a built-in smoke evacuation system, and a ultra-fast, magnetic laser optics attachment.

Data collected in our preliminary comparative study are very promising, potentially opening new perspectives on present laser/light- assisted epilation scenarios. Further investigations will be needed to identify optimal clinical effectiveness and the best combinations of the two laser wavelengths to be safely used on different skin types.