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Original Research

Effective epilation of white and blond hair using combined radiofrequency and optical energy

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OBJECTIVE: The present study examined the long-term photoepilatory effect on blond and white hair of a combined intense pulsed light (680–980 nm) device with a bipolar radiofrequency component producing electrical current at a depth of 4 mm.
MATERIALS AND METHODS: Thirty-six adult women with white and blond hair (skin phenotypes I–V) were included in the study. The chin and upper lip were treated with four treatment sessions over 9–12 months with long-term follow-up performed at month 18 (6 months after the last treatment). The level of RF energy was 20 J/cm^3, while optical fluences varied from 24 to 30 J/cm^2. Hair counts and photographic evaluation of some sites were obtained at baseline, months 1, 3 and 5 and the final treatment session.
RESULTS: An average hair removal of 48% was observed at month 18 (6 months following the final treatment session). A slightly higher photoepilatory efficiency was noted for blond hair (52%) versus white hair (44%) treatment sites.
CONCLUSION: Combined radiofrequency and optical energy technology may produce effective photoepilation of blond and white hair phenotypes. *J Cosmet Laser Ther* 2004; **6**: 27–31

Introduction

There has been a continued evolution of photoepilatory technology, which has improved the long-term efficacy of laser and intense pulsed light (IPL) source hair removal. These technologies vary from short wavelength ruby (694 nm) and alexandrite (755 nm) sources, which target lighter hair/light skin phenotypes, to longer wavelength diodes (800–900 nm), IPL sources (500–1200 nm) and 1064 nm Nd:YAG technologies for darker hair/dark skin phenotypes.[1–35]

However, the major refractory hair phenotype targeted by these technologies has been red, blond and white hair due to the low intensity of target melanin chromophore in hair follicles exhibiting the aforementioned phenotypes. In this regard, the present study examined the long-term photoepilatory effect on blond and white hair of a new technology which combines an IPL source (680–980 nm), producing optical energies as high as 30 J/cm^2 with pulse durations up to 120 ms, with a bipolar radiofrequency device, which can generate radiofrequency (RF) energy as high as 20 J/cm^3 with a pulse duration as long as 120 ms designed to deliver RF electrical current at a depth of 4 mm, which can target deep-lying follicles capable of producing long-term photoepilation. The theory behind this technology is to deliver a relatively low level of optical energy that is safe for all skin types while compensation for the lack of high laser light intensity is achieved by utilizing an additive energy that is not optical and does not require melanin as a target chromophore, but is selectively absorbed by the hair structure.

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Materials and methods

Thirty-six adult women with white and blond facial hair (aged 38–83 years; mean age 58 years) and skin phenotypes I–V were included in the study (Table 1). Forty-one study sites were selected; 36 sites were on the chin and five sites were on the upper lip or moustache area. Twenty-one sites had blond hair while 20 exhibited white hair.[7] Patients were screened for endocrine disorders, recent Accutane® ingestion, recent sun exposure and scarring tendencies. Discontinuance of any epilatory or bleaching agents for 1 month was mandated prior to treatment. Patients with a history of previous laser, IPL or electrolysis treatment were excluded from the study.

Informed consent from all participants was obtained and the body site to be treated was identified and photographed. No topical anesthetic agent was applied to treated body areas.

The study group of patients received four treatment sessions over a period of 9–12 months and results were monitored 18 months after the first treatment or 6 months after the last treatment.

The target area was shaved prior to treatment. Sequential digital photography using identical lighting, patient positioning and camera equipment (Fujifilm FinePix S2 Pro Digital SLR Camera, Tokyo, Japan) were obtained of all treatment sites at baseline and 1, 3 and 6 months after the last treatment. A thin layer of transparent gel was used for cooling and skin hydration. Light pressure was applied via the applicator to the treatment site in order to ensure good coupling of electrodes onto the skin surface. Contact cooling ($-4°C$) was provided via incorporation of a cooling chamber head in the treatment tip.

The level of RF energy was set at 20 J/cm^3 in all study patients in a short pulse profile mode. The range of fluences used in the study protocol was 24–30 J/cm^2, depending upon skin phenotype. Test pulses were carried out on an area adjacent to the study site to determine the level of optical energy suitable for each patient. Pulses were placed in an adjacent minimally overlapping pattern over the entire study site. Multiple passes were carried out to a maximum of four passes unless there was persistent erythema that lasted more than a few minutes after each pass was completed.

A baseline hair count was obtained manually by two independent observers marking terminal hairs under 6× magnification with an apochromatic optical loupe (Nikon) within a well-defined 3 cm^2 region. The following reference landmarks were utilized: lip (mid-philtrum), chin (mid-mandibular notch/mid-lower lip vermillion border) in order to achieve uniformity of sequential hair counts.

Percentage hair reduction was defined as the average number of terminal hairs present at each defined time interval compared with the average number of terminal hairs at baseline. Hair counts were taken after each treatment session, at months 12 (following the last treatment) and 18 (6 months following the last treatment).

Subjective patient reports and adverse effects were also recorded at each follow-up visit. A patient satisfaction scale was instituted at the last follow-up visit. The following scale was utilized: grade I –no improvement; grade II – mild improvement; grade III – good improvement; grade IV – excellent improvement.

	Number of patients ($n=36$)
Skin type	
I	2
II	16
III	12
IV	4
V	2
Anatomic location ($n=41$)	
Chin	36
Lip	5
Hair color	
Blond	21 (patient treatment sites)
White	20 (patient treatment sites)

Table 1
Demographic profile of the IPL/RF study population (36 patients).

Results

During the first week after the treatment, no significant hair reduction was observed. Maximum reduction in hair counts was observed at 6–8 weeks after each treatment.

Hair density was decreased from treatment to treatment as noted by both patients and investigators. An average clearance of 48% was observed at month 18 (6 months following the final treatment session) (Figure 1). A slightly higher photoepilatory efficiency was noted for blond hair (52%) versus white hair (44%) treatment sites (Table 2). Upper lip and chin sites had comparable hair removal efficiency. Two patients had minimal response (less than

(A) *(B)*

Figure 1
(A) Before combined intense pulsed light (IPL)/radiofrequency (RF) white hair removal; (B) after combined IPL/RF white hair removal (four treatments; month 18 (6 months following last treatment); optical energy = 26 J/cm^2; RF energy = 20 J/cm^3).

Hair type	Month 12	Month 18
Blond hair	54%	52%
White hair	48%	44%

Table 2
Mean hair removal efficiency in the IPL/RF study population (four treatment sessions).

10% mean hair reduction). These two patients were older and had coarser whiter hairs.

A total of 67% of patients graded their improvement as good or excellent, with the majority noting good or no improvement.

Side effect profiles noted in this study were minimal. Transient hyperpigmentation requiring no therapy was noted in 8% of patients; 14% of patients had mild persistent erythema, which resolved within 24 hours.

Results showed no significant dependence on skin color, as lighter and darker skin types responded similarly to treatment.

Discussion

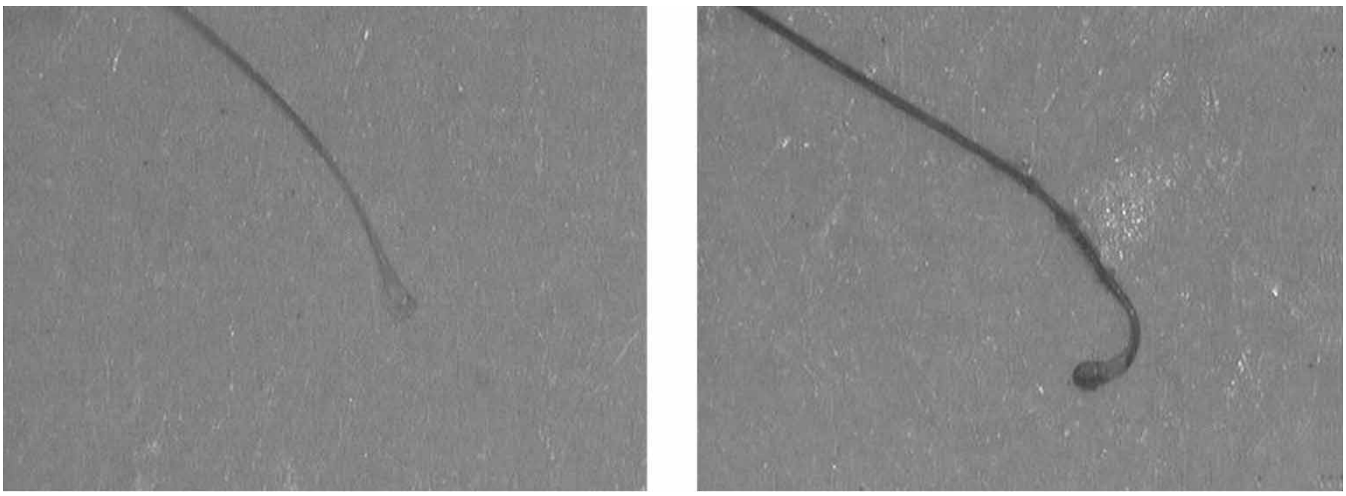
Hair color is genetically determined by the presence of the black-brown pigment melanin and the yellow-red pigment pheomelanin. There is no simple arithmetic relationship between eumelanin/pheomelanin ratio and hair color, but the highest levels of eumelanin occurs in black hair and the highest levels of pheomelanin are appreciated with red hair. Eumelanin absorbs red or infrared light more than pheomelanin and it is the black-brown pigment granules in the matrix cells and hair shaft that provide the primary target chromophores. Thus, it is not surprising that previously reported studies confirm that photoepilation is less effective for red, blond and white hair, where diminution of melanocytes is associated with a lower amount of target chromophore.

The results of this study indicate that combined RF and optical energy is an effective method of photoepilation for white and blond hair (Figure 2). It is generally accepted that white hair is unresponsive to light systems operating in the red and near infrared spectrum.

The thermal damage time (TDT) varies with the diameter of the hair shaft and follicle, and the temperature of the hair shaft or matrix.[1] For medium to coarse hairs (50–125 microns) the TDT is 170–1000 ms.[1,2] The use of super-elongated pulses should theoretically be a more efficient way to produce pan-trichodestruction.[25] This mechanism of injury may be advantageous for treating blond or red hair where optical coupling to lower levels of black-brown granules is diminished. Few such technologies with super-long pulses are presently available for clinical usage. For white hair without pigment for optical coupling, even a super-long pulse is likely to be effective.

With any pulse width, optical energy targets melanin and heating of the hair follicle occurs from the inside and proceeds outwards. In contrast, RF energy heats the hair follicle from the outside in and requires no chromophore. For gray or white hair where there is little or no melanin, the optical component of the electromagnetic pulse plays a minor role. It is hypothesized that there is non-specific preheating of the follicle acting as a macroscopic structure absorbing light. The preheating reduces the impedance and facilitates the concentration of RF current within the outer layers of the follicle. This progression of outward to inward heat transfer is likely responsible for the injury ensuing to the germinative area of the hair follicle which results in the hair removal efficiency that is clinically noted in this setting. This mechanism of injury should also theoretically provide effective epilation when the target chromophore is reduced, as with blond or red hair as shown in the present study.

Other lasers being studied based on this concept include the super-long pulsed 810 nm diode laser.[36,37]



(A) (B)

Figure 2
(A) After intense pulsed light (IPL) white hair removal (optical energy = 20 J/cm^2; no radiofrequency (RF) energy); (B) after combined IPL/RF white hair removal (optical energy = 20 J/cm^2; RF energy = 20 J/cm^3).

Other techniques used to target white hair include photodynamic therapy utilizing a photosensitizer such as 5 amino-levulinic acid, which also leads to non-chromophore targeting of pilosebaceous structures.[38] Melanin encapsulated liposomes (Meladyne) have also been studied as an exogenously introduced target for non-pigmented white, grey and light blond hair. Six-month follow-up studies utilizing the diode laser showed 75–100% hair reduction after three treatment sessions in 90% of treated patients. However, these results have never been substantiated by other investigators (Personal communication).

The 48% hair removal efficiency observed 6 months following a third monthly treatment session reported in the present study population suggests that combined RF and optical energy offers a favorable alternative to this previously difficult to treat patient management subgroup. However, it should be noted that the epilatory efficiency of this technology, as demonstrated in the present study, is not as advantageous as pure laser sources utilized for the removal of darker hair skin phenotypes. The slightly higher photoepilatory efficiency of 52% noted for blond hair versus 44% noted for white hair might be expected based upon the potential synergistic effect of combined chromophore targeting and non-selective RF heating. The poorer response noted in two elderly patients with coarse white hair may be expected in view of the larger surface area of heating required for this phenotypic population.

Conclusions

Further comparative studies looking at the effect on hair RF alone versus light and RF are needed.

Integrated RF and optical energy technology represent a new effective photoepilatory technology for the long-term removal of blond and white hair phenotypes. It is hypothesized that this technology in this patient population is based primarily on thermal damage induced by the RF component. Although results may not be quite as efficient as with chromophore-targeting primarily light-based technologies, it does offer a new approach to this previously refractory group of photoepilatory individuals.

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