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Hair structures are effectively altered during 810 nm diode laser hair epilation at low fluences

Mario A. Trelles [a]; Fernándo Urdiales [b]; Marwan Al-Zarouni [a]
[a] Vilafortuny Medical Centre, Dubai, UAE [b] Instituto Médico Miramar, Malaga, Spain

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SHORT REPORT

Hair structures are effectively altered during 810 nm diode laser hair epilation at low fluences

MARIO A. TRELLES[1], FERNÁNDO URDIALES[2] & MARWAN AL-ZAROUNI[1]

[1]*Vilafortuny Medical Centre, Dubai, UAE,* [2]*Instituto Médico Miramar, Malaga, Spain*

Abstract

Background: Diode lasers with high fluence and cooling technology are effective at removing unwanted hair but are also associated with discomfort and morbidity, especially when treating dark or tanned skins. *Methods*: Thirty patients with skin phototypes IV and V (range: 23–62 years of age; average: 39 years) underwent a single hair removal treatment using a new diode laser (810 nm) technology that incorporates low fluence but very high average power. The treatment technique employed multiple, in-motion, repetitive laser passes on a 100 cm^2 area of the skin. A 5 mm punch biopsy was carried out before and after a single treatment. Tissue samples were harvested and stained with haematoxylin-eosin. *Results*: The physical integrity of hair follicles was altered with inflammatory infiltrate, hair shaft detachment from its sheath, and perifollicular oedema, related to incipient necrosis. *Conclusion*: Low fluence but high average power diode laser technology yields significant changes in hair structure and architecture in patients with dark skin types. The procedure caused low levels of discomfort and was well tolerated.

Key words: *Fluences, hair removal, histology, laser, melanin*

Introduction

Photo-epilation was the most practised medical intervention in 2008 (1). Unwanted hair causes psychological distress due to 'imposed' social rules. Several techniques that use different light devices can be used to remove hair, but there are limitations when treating dark or tanned skins.

When laser epilation is carried out on light skin and dark hair, the rate of success is high (2). The selective absorption of laser light by the hair follicle in the 810–1200 nm spectrum band is expected to cause thermal damage to the hair follicle growth centres–bulge, bulb and papilla. Reports based on histology observations present extensive immediate damage of hair follicles after laser treatment (0–8). Reports on low fluence epilation with IPL devices (9), filterless flash-lamp systems (10), and the alexandrite laser (11) produce partial degeneration of hair follicles and changes such as coagulation in the standard pattern of the neighbouring tissue. Thus, there is a need for an improved method for hair removal which heats the hair follicles to a sufficient temperature for hair removal while delivering a minimal amount of thermal energy to the epidermis (to achieve minimal discomfort).

A new 810 nm diode laser device for hair removal may have clinical advantages for epilation on dark and/or tanned skins due to its very high average power, high repetition rate, albeit at low a fluence, and may be a safer procedure that offers the possibility of achieving high clearance rates of hair removal with low morbidity. In order to evaluate the extent of treatment effects at the level of the hair follicle and to assess the extension of these effects in tissue, we have examined the histology of epilated areas in 30 patients immediately after a single treatment session.

Materials and methods

Patients with phototypes IV and V (15 males and 15 females in each group), ranging from 23 to 62 years

Correspondence: Mario A. Trelles, Instituto Medico Vilafortuny / ANTONI DE GIMBERNAT FOUNDATION, Av. Vilafortuny, 31, E-43850, Cambrils, Spain. Fax: 34 977 791024. E-mail: imv@laser-spain.com

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of age (average 39 years), were enrolled. No patient had undergone any previous photo-epilation and all had dark, thick hair that they regularly epilated using either electric or blade razors.

The study was approved by the Ethics Committees of the Antoni de Gimbernat Foundation.

Patients underwent a single hair removal treatment with the 810 nm Soprano® XL diode laser device (Alma Lasers, Caesarea, Israel). The nozzle of the laser hand-piece incorporates Sapphire Dual Chill Window Technology through which a coolant is in constant circulation. Also, the hand-piece has an adapter to connect a cold air tube that focuses directly where the nozzle is pointed and continuously cools the area of treatment. The window from which the laser emits is 12 × 10 mm in size. The cooling system (Cryo 5; Zimmer ElektroMedizin, Neu-Ulm, Germany) was set to operate at intensity level #5 (high flow of cold air).

The diode laser pulses at a fixed rate of 10 Hz and at fluences varying from 5 to 10 J/cm^2. Lower fluences can be used in darker skin types; 8 J/cm^2 was used in this study. The pulse width adapts according to selected fluences, and ranges from 10 ms for 5 J/cm^2 to 20 ms for 10 J/cm^2. The treatment technique involves moving the hand-piece in a sweeping constant movement. The skin surface for treatment was divided into 10 × 10 cm squares and each received a total of 8 kJ. Thus, each 1 cm^2 of skin received on average 80 J/cm^2 (8000 J/100 cm^2 = 80 J/cm^2). The reason for dividing the treatment area into 100 cm^2 areas was to provide homogenous treatment exposure and to carry out systematic epilation. The hand-piece was moved over the skin at a speed of approximately 10 cm per second.

Areas of epilation were four side burns, 12 axillae, four bikini lines, six legs and four arms. Treatment areas were shaved and thoroughly cleansed with soap and water. Then, a thin coat of gel at an ambient temperature was applied to the skin surface for the purpose of facilitating the sliding of the laser nozzle over the skin at the time of treatment. During treatment, tissue temperature progressively increased. The end point for stopping laser passes was when intense erythema, pain or a burning sensation was present or when an accumulative energy of 8 kJ was attained. Patients were told to expect a heat sensation and were asked to advise the therapist when they felt unbearable pain or an intolerable heat sensation. The purpose of the treatment was not to burn the skin but only to reach levels of tolerable pain or intolerable heat sensation. In order to have a reference of the temperature achieved, skin temperature was measured during treatment with an infra-red (IR) surface thermometer (IR Surface Thermometer A28886; Zenit Measuring/Testing Instruments™, USA). At the time of treatment, the temperature never exceeded 42°C. Presumably, due to the high average power and depth of penetration of the 810 nm diode, the tissue temperature in the dermis was higher, as well as at the level of the hair follicle, due to its significant higher density in melanin content acting as a chromophore conductor for the 810 nm laser emission. Once patients felt minor pain and/or a heat sensation (12), the hand-piece was moved to the neighbouring area, continuing the epilation procedure.

Once total fluence was achieved in the whole area of treatment, a 5 mm punch biopsy was carried out in the same manner as it was performed prior to the start of treatment. A local injection of 0.5 ml of lidocaine, without vasoconstrictor, was administered. Samples were processed and stained with haematoxylin-eosin and were examined by an independent pathologist, who was requested to comparatively evaluate the changes occurring before and after treatment.

Results

The post-treatment epidermis was of normal configuration, and the keratin layer was intact with no identifiable changes. The samples of seven patients had some epidermal–dermal junction contraction, represented by more noticeable papillary crests in the dermis together with cytopathic and vacuole changes at the keratinocyte level (Figure 1). Moderate oedema, particularly in the dermis, was visible in its superficial layer. The dermis appeared normal and viable. Hair shafts detached from hair sheaths with perifollicular oedema, related to incipient necrosis, clearly visible due to the darker colour of the staining. There were variations in the standard physical integrity of hair follicles with inflammatory infiltration. None of these changes were present in the pre-treatment samples (Figures 2 and 3). Perifollicular oedema was clearly visible in all samples, together with signs of haemorrhage between the collagen fibres located at stroma level, representing a trauma which could be responsible for the epilation effect. Low-fluence laser epilation caused anatomical changes in the follicle that compromised its integrity.

Discussion

Safety and efficacy standards are not well established for laser hair removal in patients with a dark skin type. Methods to destroy hair follicles while keeping the epidermis alive are needed. We found that an 810 nm diode laser delivering a very high average power at a low fluence altered hair structure. While the changes were not dramatic, clinically there were fewer and finer hairs in the treated areas. Patients reported delayed regrowth at follow-up 1 month after treatment. A

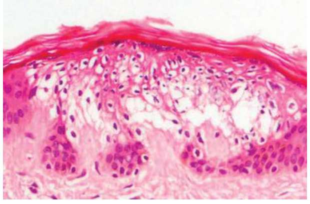

Figure 1. Skin × 125 H&E. Cytopathic and vacuole changes at the keratinocyte level are clearly seen.

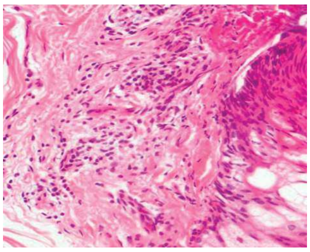

Figure 2. Skin × 400 H&E. Perifollicular oedema and peribulb thermal damage, represented by darker staining, and polymorphic nuclear cell inflammatory infiltration are noticed respecting the integrity of the neighbouring tissue.

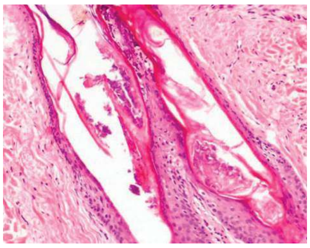

Figure 3. Skin × 250 H&E. Images of haemorrhaging are seen in between the collagen fibres at the stroma hair level.

Figure 4. Skin × 400 H&E. Perifollicular oedema is clearly noticed as a consequence of thermal effects.

Figure 5. Skin × 400 H&E. Presence of hair disruption with detachment from its shaft. Peri-isthmic fibrosis is observed together with inflammatory infiltration.

single session with the low-fluence, high pulse rate, 810 nm treatment can produce effective epilation.

Although the fluence of each individual pulse delivered is relatively low, the rapidly delivered pulses collectively effectively heat the patient's dermis. Since the hair follicle is in thermal equilibrium with the surrounding tissue and it is more sensitive to heat, it is more prone to thermal damage with repetitive, prolonged laser exposure. Thus, once the sub-dermal layer is significantly heated and the temperature at the hair follicle is sufficiently high, only a few additional high-rate pulses of low fluence are needed to raise the temperature of the hair follicle to an effective temperature to impair the function of its biological elements. More-over, melanin in the hair follicle acts as a chromophore, providing a degree of selective heating. Because an excessive heat gradient may cause pain, once the sub-dermal layer is sufficiently heated, individual pulses should only provide enough energy to the hair follicle to achieve a critical temperature to impair the function of biological elements and hair growth.

Some follicles were damaged in their outer root sheath, others appeared with lesions of the inner root sheath, and others were of normal aspect. This may be attributed to a different volume and degree of heat in contact with the target, which is translated into oedema (Figure 4). Also, heat propagation from dermis to epidermis may be responsible for cytoplasm changes and vacuole formation at the level of keratinocytes, as observed in practically all 'immediately after' samples (Figure 5).

The 810 nm diode laser causes significant thermal damage and histological alterations to the hair follicle but not to the epidermis, even in patients with dark skin types. This may have important clinical implications for the dark-skinned population seeking a safe and effective hair removal procedure.

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