Combination of 810 nm high power diode laser with conducted bi-polar RF energy for hair removal

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Introduction

In the past decade the diode laser has proven to be an excellent tool for non-invasive hair removal. The right choice of parameters along with technical superiority on flash-lamp pumped solid state lasers made them the natural choice for hair removal application [1-2].

810 nm is an ideal wavelength for hair removal, due to the high penetration depth, and at the same time not compromising melanin absorption. Penetration depth of the 810 nm is about 3 mm and therefore can target major parts of the hair follicle down to the papilla. Melanin absorption is lower than the Ruby laser (694 nm)[3] or Alexandrite laser (755 nm), and is therefore suitable to treat darker skin types.

For effective hair removal the laser energy has to be pulsed in order to selectively heat the hair follicle to coagulation temperature, while preserving the surrounding tissue. In theory the optimal pulse duration should be longer than the thermal relaxation time of the skin and shorter that the thermal relaxation time of the hair follicle. Choosing the right pulse duration is extremely important as it controls the efficacy and safety of the hair removal procedure. Pulse durations up to 350 msec are ideal for hair removal, and can be easily generated by high power diode lasers.

Another but not least important point that has made diode lasers popular for hair removal is that diode is a solid-state technology and therefore highly reliable and lasting for millions of pulses.

The disadvantages of diode lasers are typical to all other light sources and laser devices used for hair removal. Hair with little amounts of the pigment melanin does not respond to treatment due to a low absorption in the hair shaft. As a result a limited amount of heat is generated at the hair follicle and the clinical results on light color hairs are poor. The same observation was usually found when treating fine hair. In addition, the treatment of dark skin is still associated with a risk of adverse effects due to high absorption of the epidermal melanin.

The objective of this paper is to present a clinical study with a device that combines diode laser and conducted radio frequency current, using the technology of Electro Optical Synergy - elos. The device used for the study is the Comet, manufactured by Syneron Medical Ltd., Yokneam, Israel.

elos technology

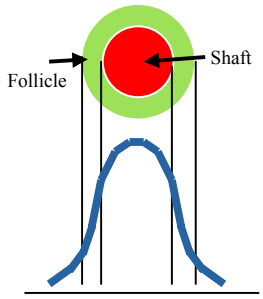
The Comet is a device that combines two forms of energies – diode laser light energy (optical) and conducted radio-frequency (RF) energy, which are applied to the tissue simultaneously.

By using two different types of energies, one can reduce the optical energy to a level that is safe even for dark skin. Treatment efficacy is not compromised due to the addition of conducted bi-polar RF energy that selectively heats the hair follicle. The conducted RF selectivity mechanism is not affected by the absorption of skin melanin (epidermal safety), nor the hair shaft melanin (efficacy on light and fine hair as well)[6-8].

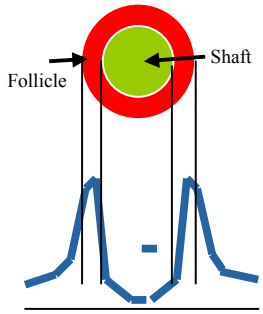
The 810 nm diode laser pulse heats the hair shaft through a selective absorption of energy by the melanin in the hair shaft. Heat is then dissipated to the follicle and damages it. The hair shaft therefore acts as a heat exchanger (figure 1a). The conducted RF energy selectivity mechanism is different than the light and is not dependent on the shaft melanin concentration. The RF field for the bi-polar system is controlled by impedance properties of tissue impedance; the current will always flow through the area of minimal impedance between the electrodes. There are two major factors that control the tissue impedance: Material - the hair shaft contains mostly keratin which is not conductive, therefore the RF current is forced to go around the shaft and heat the follicle directly (figure 1b); and Temperature - as the

temperature increases, the impedance or resistance is decreased. The laser is creating a preheated area inside the tissue and the RF field is focused into this preheated area due to its lower impedance versus the surrounding tissue. This translates into direct heat at the target follicle. Figure 1c shows the combined affect of light and RF on the hair shaft and follicle. The heat profile is uniform across the target and therefore results are excellent and risk is minimal.

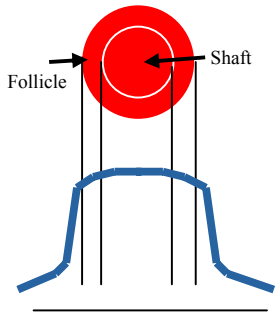
Long term multi-site clinical trails on hair removal have proven that the Comet is safe and shows superior results for removal of unwanted hair.



1a. shaft is heated by the light



1b. Follicule is heated by the RF



1c. conbine heat profile

Figure 1 Temperature profile of the hair structure

The theory then behind the Comet is based on the principle of selective thermolysis[5]. According to this principle the parameters of optical and RF energy (spectrum, exposure duration, and energy density) are chosen and optimized to selectively destroy the hair follicle without damaging the surrounding tissue.

Optical properties of the Comet: The light source that is utilized in the Comet is a high power 810 nm diode laser. This is the most suitable laser for depilation due to optimal penetration depth and melanin absorption. Optical energy density can reach as high as 50 J/cm^2.

Conducted bi-polar RF properties of the Comet: The Comet can generate bipolar RF energy as high as 50 J/cm^3.

Pulse duration: As discussed in the introduction the optimal pulse duration for safe and effective hair removal should be longer than the thermal relaxation time of the skin (~ 10 msec) and shorter than the thermal relaxation time of the hair follicle (up to 350 msec). The Comet laser and RF pulses are set ideally at the middle of this range. With pulse duration of 150 – 200 msec the Comet has proven to be extremely effective in coagulating the entire hair structure and achieving permanent damage to hair follicles. In figure 2 we can see a hair follicle treated by the Comet at high magnification. The shaft inside the follicle is not totally evaporated, while the follicle is completely destroyed.

Figure 2: hair follicle treated with Comet 30 J/cm^2 laser and 30 J/cm^3 RF. The follicle pulled out of the skin and shown in x40 magnification.

Damage to skin and surrounding tissue is minimal as a result of the optimized parameters used.

Study objectives

The aim of this multi center clinical study was to evaluate a new method and device for hair removal, the Comet utilizing elos – Electro Optical Synergy. The main idea behind the method is to decrease optical energy to the level that is safe for all skin types, while compensating for the decrease in light by utilizing an additional energy that is not optical, but is selectively absorbed by the hair structure. The other key requirement for the selected energy was that it would not effect the melanin of the epidermis. Conducted bi-polar RF energy was applied through the electrodes embedded in the system's applicator and brought into contact with the skin surface. The geometry of the electrodes has been optimized to provide an energy penetration depth of several millimeters.

Procedures

Patients

45 male and female patients ages 21-53 years old with Fitzpatrick skin types II-VI and with various hair colors were selected for the study. Table 1 below, shows the distribution of patients by skin type.

Table 1

Skin Type	Number of patients
II	6
III	15
IV	13
V	7
VI	4

A variety of body sites were treated: legs, bikini line and axilla, as well as backs (of men).

Informed consent of all participants was obtained and the body sites to be treated were identified and photographed. A baseline hair count was obtained. The target areas were shaved prior to treatment. The treated area was cooled during the treatment by cold air (Zimmer cryo 5) to minimize post treatment erythema, and also reducing any pain associated with the procedure. No topical anesthetic cream or other anesthetic was applied.

In the study, the laser energy density range used varied from 30 to 42 J/cm^2, while the RF energy range was 30-40 J/cm^3.

Treatment technique and protocol

A thin layer of clear conductive gel was applied to the treatment site. Pressure with the applicator was lightly applied in order to ensure good coupling of the electrodes to the skin surface. Treatment overlap of up to 20% was acceptable.

Laser energy density was set according to skin type. Conducted RF energy density was set according to the body location, hair thickness and density as well as pain tolerance of the patient.

Each patient received three treatment sessions with bi monthly intervals. A follow-up was preformed six months after the third treatment. Pictures were taken and a hair count was preformed at the follow-up session.

Results

Immediate response

The Comet system uses a lower peak power level of optical energy, which prevents hair shaft evaporation, in contrast to other purely optical devices. RF energy mainly effects the hair follicle and combines with the optical energy causing it to coagulate. Effective cooling protected the epidermis from erythema and only perifollicular blanching was observed after the treatment. In most cases, perifollicular edema and erythema were delayed, appearing after 10 to 15 minutes.

Follow-up observation

During the first week post treatment no significant hair reduction was observed. This was the expected response due to the time it takes for the hair to expel out of the follicle. Maximum reduction in hair was observed from 2 weeks to 2 months after a single treatment.

Assessment of hair clearance

Study patients were observed 6 months after the third treatment. A clinical examination and hair count was employed to access the efficacy of the treatments. Clearance (see Table 2 below) was calculated as the ratio between the value of the baseline hair count taken immediately pre-treatment and the value obtained at the 6-month post-treatment hair count.

Table 2

Site	Average Clearance
Axilla	72%
Bikini Line	78%
Legs	75%
Back	65%

Figure 3 shows a typical before and after photo of Axilla of a 30 years old female with skin type III and coarse black hair. Treatment settings: Laser 36 J/cm^2, RF 34 J/cm^3.

Figure 3: before (upper) and 6 months After (lower) third Comet treatment

Conclusions

The Comet with elos technology represents a new and exciting approach to existing hair removal methodologies. The current study of a combination of conducted RF and optical energies for hair removal, as delivered by the Comet, showed that an energy pulse strong enough to cause the destruction of the hair follicle can be safely delivered without damaging the surrounding tissue.

The treatments were well tolerated by the subjects when using concomitantly Zimmer air cooling, none of whom required topical or other anesthesia. The only post-treatment side effect observed was a transient erythema, which resolved within a few hours.

The efficacy, absence of adverse side effects, and treatment tolerance by the patients, shown in this clinical study, established that the combination of conducted bi-polar RF energy and optical energy, as delivered by the Comet hair removal system, is an excellent methodology for permanent hair reduction in a broad cross section of the population.

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