Continuing Medical Education

# Non-laser energy sources on rejuvenescence: part II

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## ABSTRACT

Pulsed light devices have been introduced in dermatology simultaneously to the lasers. Based on the emission of photons that target the melanin, hemoglobin and water in the collagen, their technology differs completely from lasers. The current devices contain many security items, making the treatment effective and safe. New technologies were developed to combat flaccidity: radio frequency based on the emission of electrons, and infrared light devices. The photodynamic therapy has also been more recently applied for rejuvenation with the aim of stimulating the collagen.

**Keywords:** pulsed light, intense pulsed light, radio frequency, infrared, rejuvenation.

## INTRODUCTION

Pulsed light (PL) devices emit photons that are absorbed by certain components of epidermis and superficial dermis. This technology has been used since the 90s, after the discovery of the theory of selective photothermolysis.[1] Over the years, the devices have been modified, keeping the original physical characteristics but improving performance and safety. Until now PL is widely used because it executes many simultaneous actions and it has a good cost–benefit ratio for the doctor and the patient.

During this development, technologies with functions different from lasers and PL have been introduced: radio frequency (RF) and infrared (IR). Although they have the same proposed therapies, RF emits electrons and is based on tissues impedance while IR is a light that operates in near-infrared range, being well absorbed by the water contained in the dermis structures.

Devices that combine the PL + RF or RF + IR technologies in the same tip were developed recently to achieve a better result. The technologies of RF and IR are under evolution, although still far from ideal.

Also in the group of treatments using light, dynamic phototherapy that uses photosensitizing substances followed by the application of light for treating some malignant and pre-malignant skin lesions was introduced in the treatment of photoaging. This technique is still in its early stages.

## PULSED LIGHT (PL)

PL devices emit a polychromatic light (with many wavelengths), neither collimated nor coherent, thus a diffused light. It differs from lasers, which are collimated, coherent rays, always with a single wavelength. To this extent, the PL treats melanocytic[2] and vascular[3] lesions, and stimulates neocolagenesis[4,5] because of its several wavelengths (usually 500 to 1200 nm). However, its action is more limited than the lasers because it is not coherent or collimated. The lasers concentrate more energy in one shot, producing more intense and localized heat, and promoting more selective and intense changes in the target.

There are various PL devices (Table 1), and recent studies with 19 of them6 show that many fail to release the proposed energy, interfering in the interaction of light with tissue. PL devices for home use (home devices), available through the internet, are ineffective, and there are reports of burns on their improper use.

The PL devices differ much among themselves as:

1 - Level of energy: The majority reaches 25 to 40 J/cm$^2$. Some reach 50 J/cm$^2$, and only one has a maximum flow – 70 J/cm$^2$.

2 - Type of pulse: They may be simple (single), double or triple. They can be fired in short-term (5 to 20 ms) or long (40 to 100 ms). They can also be intense or soft (smooth pulse) depending on how the energy is released.

3 - Pointer cooling: It is a very important safety item. The use of the cooled sapphire pointer is the current tendency, although many machines do not have this item.

4 - Use of interface products to improve treatment performance: Frozen gels with different degrees of viscosity or less thick solutions may be used. Some require no interface.

The first pulsed light to be used was the Photoderm®. It has high fluencies, triple, double or simple pulses, which can be rapid or intense, and many cut filters (from 515 to 755 nm) used in accordance with the phototype and the depth of the chromophore to be reached in the skin. The filters block the shorter wavelengths. This device needs iced gel for its application and has a difficult learning curve because its parameters are numerous and very variable. In spite its effectiveness, side effects were reported by many users, always related to excess energy released, causing burns that result in hyper- or hypopigmentation (almost always temporary but sometimes permanent). Hypertrophic and atrophic scars were described in extreme cases.

Technology has been changing gradually, and today the 3rd and 4th generations of these devices have cooled pointers (usually using sapphire), and pulses have become softer (smooth pulse); in other words, they remain in the same level of temperature from start to end, within the safe thermal limit of skin.

The most modern machines have a smooth and single pulse at the same pointer (from 500 to 1400 nm), with a flow peak of 70 joules/cm$^2$ at an early shot and gradually decreasing. Therefore, with the same pointer and no filters exchange it is possible to treat vascular and melanocytic lesions and to promote mild neocolagenese in one shoot, provided that rays beyond 700 nm are absorbed by water. These features make the treatment faster and safer, reducing its side effects as well.

Some new equipments associate PL with radio frequency and some others with skin vacuum (photo – pneumatic effect) in an attempt to improve the final result.

The best indications:

1 - Superficial melanocytic lesions such as lentigo and ephelides. Although the melasma pigment is superficial, the use of PL in this case is controversial because there are other more suitable technologies.

2 - Vascular lesions, specially telangiectasias presented in rosacea and classic photoaging in the form of poikiloderma of Civatte.[7,8] For the removal of larger vessels, they require long pulses (50 to 100 ms) and high fluency (50 to 70 J/cm$^2$). Face and hands are the safest places for this treatment and present the best results.9 When located in the neck and forearms, such injuries should be treated with caution, using lower fluencies and further sessions. The lower phototypes (I to III) have better response and require fewer treatments as they have less melanin in the epidermis, absorbing less diffuse heat.

Advantages: Easy application, mild post-operative, good cost-benefit ratio when the indication is accurate.

Limitations/disadvantages: A few sessions are required (3 on average) to reach the goal. Hyper- and hypochromia resulted from burns are still the most important side effects. It is more frequent and severe in the tanned skin, which is a formal contraindication to this procedure. It should not be recommended for reduction or elimination of rhytides.

Technique: The use of anesthetics is not necessary. They can cause vasoconstriction and decrease in hemoglobin at the application site, minimizing the results. It is mandatory to wear glasses to protect the physician and the patient, and contact solution or gel, according to the standards for each device. Shots must be made throughout the treated area with or without overlap. Before, during and after the treatment, cold compresses application is realized in order to reduce the skin temperature. After the procedure, the patient may immediately return to his routine.

Expected results: Overall decrease of the skin oxidation, with color improvement and gradual disappearance of spots and lentigo according to the number of sessions. Slight improvement in the texture and minimum change of rhytides.

## RADIO FREQUENCY (RF)

The therapeutic use of RF began in 1920, when electrocautery was introduced by Bovie and Gusting. In 1950, neurosurgeons used it to cause specific lesions in the central nervous system during a surgery. In 1960, the ablative nodal RF was considered effective and safe for treatment of cardiac arrhythmias. Ablative radiofrequency is also useful for the treatment of small skin lesions.

Recently, the nonablative RF was introduced for the treatment of facial and body flaccidity, localized fat, gynoid lipodystrophy, and scars from acne by volumetric heating in the deep dermis and in subcutaneous tissue.[10] The first unit that came to our dermatology market produces monopolar RF. It volumetrically heats the deep tissue, while the skin is protected through a cooling process.[11] The heating produces an immediate contraction of collagen by breaking the molecule hydrogen bridges. The thermal damage then causes

Table 1 – Pulsed light devices and technical characteristics

| | Fluência J/cm² | Duração do pulso ms | CP de onda nm |
|---|---|---|---|
| Harmony® Alma | 30 | 10,12 e 15 | 515-950 |
| Formax® Sharpligth | 25 | 0,5 a 200 | 415-960 |
| Photosilk® Deka | 30 | 2,5 e 4 | 500-850 |
| Dermapulse® Industra | 18 | S/D/T | 390-750 |
| BBL® Sciton | 30 | 2-500 | 420-1400 |
| Active IPL® Bioset | 22 | 10 | 420-1100 |
| Limelight® Cutera | 40 | 60 | 520-1100 |
| Quantum SR® Lumenis | 45 | 25 | 560-1200 |
| Lumenis One® Lumenis | 40 | 100 | 515-1200 |
| System Line® Bioset | 16<br>56 | 30<br>40 | 390-1200 |
| eMax® Syneron | 45<br>+RFb 25 | NR | 580-980 |
| Skin Station® Radiancy | 65 | 10 | 420-1200 |
| Starlux® Palomar | 70 | 500 | 500-1200 |

® Fluency J/cm² Duration of pulse ms CP wave nm

a subepidermal inflammatory reaction, stimulating the synthesis of new collagen that gives greater firmness to the skin, subsequently. This method provides volumetric heating temperatures between 65-75°C, enabling the distribution of large amounts of energy in the dermis, without coagulation or burning at the interface between the electrode and the skin.[12]

The RF technology has continued to be developed and improved. Some unipolar and bipolar RF devices have emerged, which makes the method more dynamic. Besides skin heating, they promote the mobilization of the treated tissue. The bipolar RF provides surface heating between 2-4 mm in the dermis, while the heat at the unipolar RF can reach 20 mm, i.e., the hypodermis. There are modern devices that use tri- and hexapolar RF, making a higher flow of electrons in the applied surface and generating more heat (Table 2). Its mechanism of action is similar to the monopolar RF. The intense heat reaches the dermis and subcutaneous tissue leading to a subepidermal inflammation, which causes the conversion of fibroblast in fibrocytes with consequent neocolagenesis. In the beginning the existing collagen diminishes by protein denaturation, through breaks of hydrogen bridges, and after several treatments there is skin thickening. In subcutaneous tissue, there is a retraction of fat septa and blood and lymphatic circulation increase in the treated surface.[13] Since the technology involves electrons, the use of protection is not necessary.

Advantage of the technique: It is a non-invasive method, and it doesn't keep patients away from their routine. One or more sessions are proposed, depending on the symptom. For the fight against aging it is an excellent method to be combined with other techniques such as PL or IR. The technique shows low rates of side effects.

Disadvantages and limitations: The result is very variable and depends on individual reaction, although severe flaccidity shows no results to the method. Some devices require consumables, which raises the procedure price for the physician and the patient. The technique to be used depends on the equipment adopted, and the epidermal temperature control (with skin temperature meters) is necessary if the unit has no cooling. The knowledge of the skin traction vectors is needed, where the energy should be focused, for better results. The method cannot be used in patients with pacemakers, metal implants, or prostheses.

Side effects: Temporary erythema is the most common side effect. Blisters can occur, especially in areas over bony prominences. The blisters can turn into scars. Rare cases of lipoatrophy were reported. Pain and paresthesia are not common but they can occur.

Expected results: Tonicity increase of facial or extrafacial skin with the contraction of collagen fibers. The facial contour becomes more remarkable. Photographic documentation should be made in order to demonstrate to the patient, since the remodeling of collagen is slow and barely visible. New equipments with technology based on ablative fractional radio frequency are being developed.

## INFRARED (IR)

The interest of people in seeking the improvement of facial and body flaccidity without submitting to plastic surgery has significantly increased in recent years. As a result of this need, the industry is producing equipment to improve flabbiness without interfering in the patient daily routine.

Devices that promote nonablative rejuvenation are available with different methods of application, but with the same goal, which is to improve the damage caused by exposure to sunlight and time. Lasers and PL are already present on the dermatologist's practice to treat signs of photoaging (lentigo, telangiectasia, and rhytides) and also to slightly act in the production of new collagen fibers. RF has better indication for flaccidity. Subsequently, the technology that uses infrared

light to improve the facial or body flaccidity was put at our disposal. In this technology, a light that operates in the range of short infrared is emitted, generally from 800 to 1350 nm. There is low absorption of these rays by hemoglobin and melanin at this range of wavelength. Thus, there is a penetration in the desired target, which is the water in deeper skin structures, promoting the contraction of collagen with minimal changes in the epidermis. Although they are based on different physical principles, the IR light mechanism on collagen is similar to that of RF. The generated heat arrives in the dermis at between 65-75°C, where it is retained for a period of time promoting an attack to collagen fibers. The inflammatory process that transforms the subepidermal fibroblast in fibrocytes and leads to rearrangement of the collagen, after multiple treatments, will give greater thickness, firmness, and definition to the skin.[14,15]

Table 2 – RF devices and technical characteristics

| | | |
|---|---|---|
| **THERMACOOL®** Solta | Monopolar | Static application mode |
| ACCENT® Solta | Bipolar e unipolar | Dynamic application mode |
| ReFIRME® Syneron | Bipolar | Static application mode |

®: Device name and company.

Advantage of the technique: Since it is a nonablative method, the patient returns to his activities immediately after application. It works well in mild flaccidity. It can be combined with other dermatological procedures (botulinum toxin, filling with hyaluronic acid), and there are rare side effects, among which burning is the most common.

Disadvantage of the technique: It requires multiple treatment sessions with a very variable individual response. It does not act in intense flabbiness.

Technique: It depends on the equipment used. Most require cooling epidermal to prevent burns. More than one shot may be performed in the same place where the heat is the goal. After reaching the ideal temperature, this heat must be kept for at least 3 minutes.[16] There is a new device for IR which causes high heat in the skin. For this purpose, besides the whole cooling mechanism of protection, it also presents a division of energy released. You should always take care in areas with bony prominences, as they reflect the intense heat and may generate burns.

Side effects: There may be blister formation, changes in pigmentation, and scars. Pain and transitory redness are common and they vary from individual to individual.

Expected results: The skin shows healthier aspect and the facial and body contours become smoother. The level of satisfaction with the outcome is good but we must always have an exceptional photographic documentation. It is important to make clear to the patients that the stimulation of collagen has variable individual responses and that the technique has limited results.

## PHOTODYNAMIC THERAPY (PDT)

PDT is a therapeutic modality that has been used in the treatment of various malignant tumors in different areas of medicine. It is a therapy that induces cytotoxicity of proliferating cells through a source of light. For this to occur, a photosensitizing agent, light, and oxygen are required.17

In 2001, there was the approval of the 5-delta aminolevulinic (ALA) stick (Levulan Kerastic® – Dusa Pharmaceuticals – USA) by the FDA for the treatment of actinic keratoses, while in 2001/02 the methyl aminolevulinate hydrochloride (Metivix® – Photocure® – Galderma) was approved by the FDA and the European Union for treatment of actinic keratoses, superficial and nodular basal cell carcinomas (up to 2 mm deep), and Bowen Disease.[18,19] ALA and its lipophilic derivative (MAL) easily penetrate the abnormal keratinized tissue. Topically administered, it is converted into photoactive porphyrins (PPIX) through heme biosynthesis, with production and preferential uptake by neoplastic tissues. Protoporphyrin IX (PPIX) is the intermediary porphyrin with photodynamic activity and, when activated by light, it emits intense red fluorescence. It has peak absorption in the Soret band and other minor peaks (in red band), particularly at 635 nm.

Table 3 – Infrared devices and technical characteristics

| | | | | |
|---|---|---|---|---|
| TITAN ® Cutera | 1100-1800 nm | Cool Pointer | 45 J/cm² | Until 8 ms |
| DEEP® Palomar | 825- 1350 nm | Coll and Fractionated Pointer | 175 J/cm² | Until 10 ms |

®: Device name and company.

Recently, PDT has been used to enhance regeneration, and its mechanism of action for this function is not yet fully clarified. It is likely that a non-specific immune response has been involved.[20]

For the method implementation, the product is applied on clean skin. MAL may be occluded, and for the ALA application it is not necessary. The time that the product should be maintained on the skin depends on the desired effect, and

it ranges from ½ to 3 hours. The larger the time, the greater the outcome and side effects in the postoperative period. Pain occurs at the time of application, which can be attenuated with cold water or other ways of cooling. After the treatment, sunscreen should be applied, and the patient receives the explicit recommendation to avoid sun, so that small quantities of product remaining on skin do not potentiate the side effects. There may be mild or severe erythema according to the time of product and light exposure. The most used devices for light emission are LEDs (light emitting diodes); although some authors use pulsed light. Some home LEDs (home devices) can now be found on the internet.

Best indication: Facial aging associated with actinic keratoses. It is indicated for patients who in the past had multiple exposures to sunlight without photoprotection. Acne and hyperpigmentation are also good indications. It can be used as photodiagnosis since PpIX accumulates in the cells with dysplasia and, even when they are not visible to the naked eye, the regions with higher accumulation of PpIX become red fluorescent with blue LED light or Wood light.

Advantages of the technique: The relative simplicity and elegance of the method has attracted the interest of the dermatological community and promoted great enthusiasm in the professionals already practicing it. Recently, the use of LEDs in PDT has been increasingly promising. These devices are smaller, cheaper and require little maintenance when compared to laser. Furthermore, they provide enough energy to activate the photosensitizing drug and generate less local heat. When the treatment goal is only rejuvenation without actinic keratoses, intense pulsed light can be used.

Disadvantages and limitations: The most expected adverse effect after PDT with systemic agents is the photosensitivity. Soon after the administration of topical drugs (ALA or MAL), the patient must avoid light during the period of 24 hours. The use of sunscreen can minimize this side effect. Pain and burning may occur during the session and may be improved with ice or cool air. The photosensitizing devices are relatively expensive.

Technique: It consists of two steps. In the first one, the photosensitizing agent preferentially accumulates in tumor cells after topical administration. In the second one, 30 minutes to 3 hours after applying the product, the area to be treated is exposed to wavelength light which coincides with the absorption spectrum of the photosensitizing agent.[17,18]

Expected results: The results are highly satisfactory. It can be even used in more advanced aging cases. More treatment sessions may be necessary in order to achieve the goal. S&CD

Table 4 – LED devices and technical characteristics

| | |
|---|---|
| GENTLEWAVES® Light Biocience | Yellow light |
| MULTIWAVES® Industra | Blue, yellow, red light, and high power red light |
| AKTILITE® Photocure | High power red light |

®: Device name and company.

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# Questions

**1 - The pulsed light spectrum of action is characterized by:**
a - low wavelength
b - narrow wavelength
c - wide wavelength
d - high wavelength
e - restrict wavelength

**2 - The chromophores that absorb most of pulsed light radius are:**
a - water and large vessels
b - deep melanocytic pigments
c - water and melanin
d - melanin and hemoglobin
e - water and deep melena pigments

**3 - It is a safety criteria for pulsed light:**
a - pointer with large diameter and single pulse
b - pointer with small diameter and triple pulse
c - short duration of the pulse
d - cooled pointer
e - small pointer and triple pulse

**4 - The pulsed light is:**
a - coherent
b - collimated
c - narrow band
d - diffuse
e - coherent and wide band

**5 - The best indications for pulsed light:**
a - surface pigments removal
b - resurfacing
c - dermal pigments removal
d - neocolagenesis promotion
e - collagen contraction

**6 - The radiofrequency involves:**
a - collimated photons
b - electrons
c - photons and electrons
d - noncollimated photons
e - collimated electrons

**7 - Infrared and radiofrequency have in common:**
a - type of technology
b - the same electromagnetic spectrum
c - contraction of collagen fibers promotion
d - type of eye protection
e - improvement of skin pigmentation

**8 - The most important side effect of radio frequency and infrared is/are:**
a - burns with blisters
b - hipercromia
c - hipocromia
d - hypertrophic scars
e - striations

**9 - The most involved substance in dynamic phototeraphy is:**
a - photoporphyrin VI
b - photoporphyrin IV
c - photoporphyrin IX
d - photoporphyrin XI
e - photoporphyrin XII

**10 - For skin rejuvenation, the dynamic phototherapy is considered:**
a - an alternative
b - a method of election
c - comparable effects with fractional ablative lasers
d - compared effects with medium/deep peelings
e - compared effects with phenol peeling