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FUNDAMENTALS FOR THE USE OF SAFE AND EFFECTIVE DOSIMETRY IN THE TREATMENT OF AESTHETIC DISORDERS WITH THE ENDOLASER SUBDERMAL LASER TECHNIQUE

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ABSTRACT

Background: Endolaser subdermal technique applied in aesthetic treatments, has a wide range of uses and approaches different body and face areas. Current literature shows a significant lack of dosimetric standardization regarding subdermal laser use for treating aesthetic disorders. **Objective:** This study aimed to describe the fundamentals that guide dosimetric parameters adoption considered safe and effective for endolaser use in such treatments. **Material and Methods:** This study is characterized by exploratory research, presented through a narrative review to highlight the foundations and criteria for an appropriate use of dosimetric parameters while performing endolaser technique. Besides literature review, data regarding a specific method for choosing doses related to the energy accumulation were added. Such method was exclusively developed in Brazil by the authors. **Results and Discussion:** We verified that the dosimetric parameters used, with power (Watts), continuous or pulsed mode of laser emission are extremely important for effectiveness and safety of the method, as well as the total energy accumulated to generate the necessary therapeutic heat in the target area. Therefore, authors established a way of customizing the dosimetry through mathematical calculations based on the physical characteristics of treated region and a specific energy dosimetric range. Thus, we can choose customized, effective and safe doses of subdermal laser in each clinical situation. However, these doses may be higher when the thickness of the adipose tissue is greater than 3 cm. **Conclusion:** Finally, endolaser must be parameterized based on the physical characteristics of each target area to be treated. Adoption of customized dosimetric strategies is necessary to assure safe and effective results.

KEYWORDS: Endolaser; Endolift; Subdermal laser; Laserlipolysis; Dosimetry.

INTRODUCTION

Endolaser subdermal technique used in purely aesthetic procedures, has as one of its main characteristics the use of equipment that emits wavelengths of 1470 nm and 980 nm.[1] Authors reported that laser radiation is transmitted through an optical fiber directly inserted into the superficial subcutaneous tissue.[2, 3, 4, 5], or inserted inside a cannula to facilitate its manipulation in the subcutaneous tissue.[6,7]

This subdermal laser therapy technique aims to generate heat inside the tissues to damage the subcutaneous adipose tissue[8, 9, 10] and/or heat the skin to stimulate collagen production.[3, 11, 12, 13]

The Endolaser may be used in the following aesthetic conditions: facial wrinkles, such as marionette lines, mid-facial and nasolabial folds, periorbicular changes in the eyes, etc.; Rosacea, acne vulgaris, and acne scarring are also indications for facial treatment. In the body, lipodystrophies such as localized adiposities and cellulite are the most used.[8, 9, 14-18]

Due to the variety of indications, as well as the large number of areas treated with endolaser, authors have described several dosimetric protocols.[4, 8, 10, 12, 18], mainly regarding power in Watts. But, in addition to power, the choice of continuous or pulsed laser emission mode is extremely important dosimetric parameters for the effectiveness and/or safety of the method. As well as the total energy accumulated in *Joules*, to generate therapeutic heat.

We verified, therefore, there is an important dosimetric destandardization with the use of subdermal laser in the treatment of the most varied aesthetic dysfunctions. Based on that, this study aimed to describe the fundamentals that guide the dosimetric parameters adoption considered safe and effective for endolaser use in the treatment of aesthetic conditions.

METHODOLOGY

This study is characterized by exploratory research, presented through a narrative review, to highlight the foundations and criteria for an appropriate use of dosimetric parameters during the performance of the endolaser technique used when treating aesthetic dysfunctions. The review explored scientific articles published and available in the following databases: MEDLINE (Medical Literature Analysis and Retrieval System Online), PubMed (National Library of Medicine), SCIELO (Scientific Electronic Library Online) and LILACS (Literature of Latin America and the Caribbean in Health Sciences).

As an inclusion criterion, the selected sources were those which described the use of specific dosimetric parameters related to the subdermal laser use, as well as those that mentioned the techniques involved in obtaining specific doses related to the technique. Sources that did not present a summary, those that were not allocated to scientific journals and did not address the topic of the study were discarded, as well as those that did not support the collection of reliable data.

The bibliographic survey was carried out in Portuguese, English, Spanish and Italian, with the following descriptors: endolaser, endolift, subdermal laser, laserlipolysis, dosimetry.

Besides literature review, it was added data regarding to a specific method for choosing doses related to the accumulation of energy in *Joules*. Such method was exclusively developed in Brazil by the authors, for endolaser technique use to treating aesthetics dysfunctions.

RESULTS AND DISCUSSION

1. Choice of emission regime: continuous or pulsed

1.1. Continuous laser

This type of operation is characterized by a laser beam continuously emitted (duration over one second). In other words, energy is pumped into the active laser-producing medium at a rate such that the emission of the laser beam is maintained uninterruptedly (Fig. 1).[13, 19, 20]

In the endolaser technique, continuous mode has a high capacity for tissue damage and is desirable to quickly reach the dose of accumulated energy (in *joules*). In our clinical practice, we recommend its use for body conditions treatment that involve both the skin and subcutaneous tissue. But it may even safely be used with in submental fat and the cheek region (middle 1/3 of the face), as long as it is possible to control the speed of energy accumulation and the local temperature.

1.2. Pulsed laser

Pulsed lasers emit radiation in regular pulses (Fig. 1). These pulses might be very long, on the order of milliseconds (1ms = 10-3sec)[20], or shorter such as microseconds, nanoseconds, picoseconds or femtoseconds.[19]

Regarding endolaser subdermal technique, the use of pulsed laser is normally indicated for treating aesthetic disorders involving skin of the face, once it may result in less damage to the tissue adjacent to the target site of laser irradiation, mainly to nervous structures, Furthermore, energy accumulation is slower and allows greater control over the increase in temperature, generating greater safety.

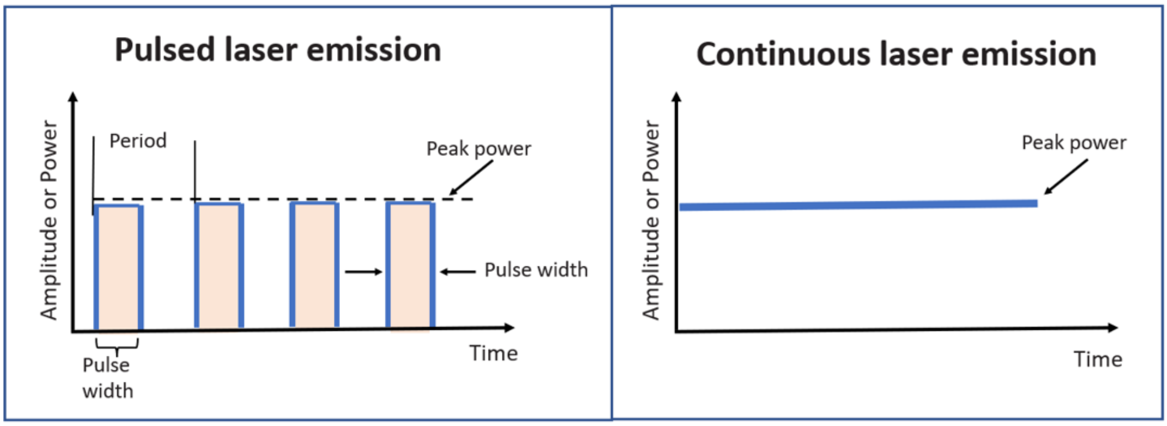

Figure 1. Schematic showing the structural differences of continuous and pulsed laser emission.

2. Adjustable parameters in the pulsed laser

2.1. Length (width) of the pulse

This term is used for pulsed lasers. It refers to the time that each laser pulse lasts, or its total width represented on the horizontal axis of a graph (abscissa) (Fig. 1). It is one of the most important items in pulsed mode adjustments and is fundamental to achieving the desired clinical effect.

When the laser beam reaches the tissues and is absorbed, a thermal effect will be generated, then the heat generated is dissipated from the absorption site, mainly by diffusion. Large objects lose heat more slowly than small objects. There is a characteristic time for this called thermal relaxation time, which is the time it takes for an object to cool down, equaling to the environment temperature after being heated (Zeroth Law of Thermodynamics). If an object is heated for longer than its thermal relaxation time, there is a greater possibility that the heat may reach adjacent structures with the risk of forming areas of thermal injury.[21]

As already reported, the pulse duration is measured in time units and regarding endolaser, most equipment adjusts the pulse duration in milliseconds or microseconds (Fig. 2), so the correct adjustment of the pulse duration associated with power adjustment, which allows adequate thermal relaxation are crucial to avoid abnormal thermal injuries and assure good results in facial treatments with endolaser. Authors[8, 12, 22, 23] reported the use of pulsed mode in subdermal laser procedures, adjusting pulse times (ON Time) around 25 ms and interval between pulses (OFF Time) from 50 to 75 ms, both for facial and body applications.

2.2. Frequency or pulse repetition rate

This adjustment is characterized by the number of pulses (or cycles) per second and, therefore, is also associated with the pulsed mode in some endolaser devices (Fig, 2), in addition it might be used as a safety item to avoid excessive energy accumulations causing injuries. It is commonly associated with adjusting the duty cycle and/or pulse duration[24] and is measured in Hertz (Hz).

When we know the pulse times (ON Time) and the interval between them (OFF Time) we can calculate the frequency by dividing the unit value by the complete cycle time (On Time + Off Time) (Fig. 2).

$$\text{Frequency (Hz)} = \frac{1}{\text{On Time} + \text{Off Time}}$$

Figure 2: Formula for calculating frequency from pulse time On Time and interval Off Time.

See an example of calculation using the formula (Fig. 3) with the ON Time settings of 50 ms and the OFF Time of 50 ms, but before calculating, these values must been converted into seconds once the frequency is measured in this unit of greatness. Therefore, it must been used the values of 0.05 seconds for ON Time and OFF Time in this example: F(Hz) = 1 ÷ 0.05 + 0.05 = 1 ÷ 0.1 sec = 10 Hz.

2.3. Duty Cycle

In pulsed lasers, the maximum power level of each pulse is commonly the same as that obtained when using continuous mode. The useful proportion of the laser beam (%) during laser transmission by the equipment in pulsed mode is called Duty Cycle (Fig. 4). According to some authors[25], duty cycle (DC) may be calculated by dividing the ON Time by the complete cycle time (On Time + Off Time), and multiplied by 100% (Figure 3).

$$\text{Duty Cycle} = \frac{\text{On Time}}{\text{On Time} + \text{Off Time}} \times 100\%.$$

Figure 3: Formula for calculating the Duty Cycle from the On Time pulse time and Off Time interval

Thus, if would be also used the ON Time of 50 ms and the OFF Time of 50 ms as adjustments (0.05 sec after conversion), it will have the following calculation: DC = 0.05 ÷ (0.05 + 0.05) x 100 = 0.05 ÷ 0.1 sec x 100 = 50% Duty Cycle.

We emphasize that the Duty Cycle adjustment is not commonly found in endolaser equipment, but when it occurs, many professionals have many doubts about the settings, mainly because such adjustments available in these equipments normally do not include On Time and Off Time, but only Duty Cycle and Frequency. This often compromises the performance of the equipment and the treatment's results once professionals end up choosing random and inappropriate parameters when they opt to use the pulsed mode, or else use the continuous mode for all treatments, including on the face. In these cases, using a variation of the formula described in Fig. 3, On Time = Duty Cycle x (On Time + Off Time) ÷ 100, we can obtain the On Time value, and in terms of adjustments this can bring us closer than several authors recommend[8, 12, 22, 23] when using pulsed mode (25 or 50 ms of On Time). In our clinical practice, when it is only available the Duty Cycle and Frequency adjustments on the equipment, we found that once adjusting frequency at 10Hz, the value adjusted in the Duty Cycle will correspond to the On Time value, based on the variation in the afore mentioned formulation.

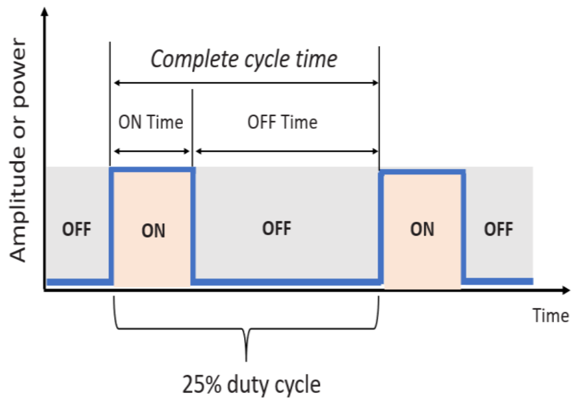

Figure 4. Schematic showing the emitted pulses (ON) and the intervals between them where there is no laser emission (OFF), as well as the duty cycle.

3. Power and energy accumulation

3.1. Power (Watts)

Laser power is the energy release rate, or the amount of light energy emitted by the device every second. It is measured in Watts (W) and is equivalent to 1 Joule per second (1W = 1J/s), that is, it might be represented by the formula where the average laser power is equal to the output energy during a certain exposure time: Power (W) = energy (J) / time (s).[19, 26]

With regarding to endolaser, when pulsed mode is chosen, the power adjusted in the equipment corresponds to the peak power, in other words, it is not the real power delivered during the treatment. So, if wants to calculate the average power, it must been used the following formula: PotMed = Pulse energy (J or mJ) x Pulse frequency (Hz)[19], which represents the value actually delivered.

In the clinical practice of the endolaser, power adjustment plays a very important role in the safety and effectiveness of the treatment, as commonly in facial treatments the power levels are lower (normally not exceeding 4 Watts), but in the body the doses are higher and, sometimes, exceed 7 Watts, depending on the skill and dexterity of the professional. However, in these cases we recommend that skin temperature control systems be used (for example, thermographic cameras and/or infrared thermometers) avoiding burns, as how much the greater the power, the faster energy accumulation will be and the greater the local heating rate. Nevertheless, we emphasize that when the treatment involves only the subcutaneous tissue, where the optical fiber is positioned deeper, it requires great attention since there can be intense deep heating without the skin showing any increase in temperature detectable by thermographic instruments. It because of probable thermal confinement with little diffusion of the heat generated to the skin, especially when using the 1470 nm wavelength.

Despite this understanding, there is no consensus among the different authors when describing the use of specific powers for treating aesthetic conditions using the subdermal laser. In table 1 we see a variety of these dosimetric parameters for different areas of the body according to the experience and protocol of different authors. However, we believe that the most important parameter for obtaining good treatment results and safety with the use of endolaser is the energy accumulated in *Joules*, as regardless of the power used in the procedures, local heating (subcutaneous fat and dermal tissue) will guide the therapeutic effects and the absence of complications during the use of endolaser.

Table 1. Diversity of powers described by different authors using the subdermal laser.

STUDIES	POWER (Watts) AND WAVELENGTH (nm)	INDICATIONS
Oliveira de Moura et al, 3023[4]	4 to 6 W (980nm)	Various face and body treatments
Nilforoushzadeh et al, 2023[8]	5 to 8 W (1470nm)	Reduction of fat in arms and abdomen
Dias et al, 2023[10]	4 to 8 W (1470nm)	Wrinkles and sagging eyelids
Sadoughifar et al, 2023[12]	2 W (1470nm)	Wrinkles and sagging eyelids
Zerpa & Suárez, et al, 2023[13]	6 W (1470nm)	Face and neck rejuvenation
	2 to 3 W (1470nm)	Wrinkles in lower eyelid
Borges et al, 2023[18]	3 W (980nm)	Rosacea
Li et al, 2020[27]	3 to 6 W (1470nm)	Keloid and hypertrophic scar

Advíncula et al, 2023[28]	2,5 to 3 W (1470nm) (Association with Microfocused Ultrasound)	Rejuvenation of face, jowls and neck
Ilaria et al, 2023[29]	2 to 2,5 W (1470nm) (Association with calcium hydroxyapatite and hyaluronic acid)	Facial harmonization and aesthetic improvement of the double chin
Saran et al, 2023[30]	2,5 to 4 W (1470nm)	Face and neck rejuvenation
	2, 3 to 5 W (980nm)	Fat reduction and aesthetic improvement in cheeks, neck, jowls, jaws
Nilforoushzadeh et al, 2024[34]	3,5 to 4 W (1470 nm)	glabella wrinkles
Nilforoushzadeh et al, 2024[35]	3 to 3,5 W (1470nm)	Neck wrinkles
Benar & Benar, 2024[36]	3 W (1470nm) (Association with polylactic acid)	Facial harmonization and aesthetic improvement in the submental region

3.2. Energy (J)

Energy is the amount of power (Watts) deposited in the tissue in a given time interval. It is measured in *Joules* (J) and is the parameter that triggers thermal response of the tissue according to the amount of light energy (Power) delivered by the device through the optical fiber. It is represented by the formula: E(J) = power (W) x time (s).[26]

In continuous mode (CW) the energy deposit is much faster than in pulsed mode (PW), therefore using continuous mode in some places on the face (for instance, forehead, periorbicular region of the mouth and eyes) is not recommended since even at low powers, energy deposited is faster than in pulsed mode. And also, this will require a lot of attention from the professional to avoid burns or nerve damage. On the other hand, in body areas the use of pulsed mode might delay doing the procedure, as the energy accumulation occurs slowly in larger areas.

Energy's accumulation has long aroused enthusiasm and concern among many researchers who use and study the subdermal laser, as there are many variables that may interfere in dosimetry and treatment results, especially the size of the treated area. Because of that, authors commonly mention the amount of deposited energy in *joules*, however they do not mention the size of the area where the energy was delivered. And this characterizes a very important bias in clinical practice, as the larger the area, the lower the concentration of energy delivered. Table 2 shows some reports from authors who used the subdermal laser mentioning the amount of energy deposited during the treatment but did not mention the size of this area.

Table 2: Diversity of energy accumulation (*Joules*) described by different authors using the subdermal laser.

STUDIES	DEPOSITED ENERGY (*Joules*)	ENERGY ACCUMULATION AREAS
Nilforoushzadeh et al, 2022[31]	600-800 J	Upper eyelid and eyebrows
Dell'Avanzato, 2022[2]	80 J	Lower eyelid
Nilforoushzadeh et al, 2022[32]	600-800 J	Lower third of the face (Jowl) and submental
Longo et al, 2022[33]	800 J (in average)	Lower third of the face (Associated with photobiomodulation)
Nilforoushzadeh et al, 2022[11]	600-800 J	Forehead
Markabayeva et al, 2022[23]	7000 J	Periumbilical, flanks and culottes
Sadoughifar et al, 2023[12]	100-130 J	Upper eyelid
Borges et al, 2023[18]	1.000 J	Middle third of the face/cheeks
Advíncula et al, 2023[28]	800-1.000 J	Middle and lower third of the face, submental and neck (Associated with Microfocused Ultrasound)
Ilaria et al, 2023[29]	350 J (in average)	Face and submental (Association with calcium hydroxyapatite and hyaluronic acid)
Nilforoushzadeh et al, 2024[34]	150 J	Glabella
Nilforoushzadeh et al, 2024[35]	400-500 J	Neck
Benar & Benar, 2024[36]	2.000 J	Lower third of the face and submental (Associated with polylactic acid)

4. Authorial dosimetry

With the expansion of subdermal lasers using for the treatment of aesthetic disorders in Brazil, it has been seen a huge evolution in application techniques through a particular learning curve for each professional who is willing to undertake this type of therapeutic resource. And during this process, we found a lot of authorial work, most of which had no basis or foundation in specific literature (totally *off label*) and which ended up causing many complications, as described by Borges et al.[1]

When analyzing tables 1 and 2, we see that it is not common in the world literature to describe standardized methods for the use of subdermal lasers regarding dosimetric parameters associated with power (Watts) and accumulated energy (*Joules*) What is found seems be personal protocols of researchers, professionals in their clinical practice and equipment manufacturing companies. And the main reason that make it difficult to standardize is the size and depth diversity of the subcutaneous tissue areas treated with the subdermal laser. For instance, when authors[23, 35] only mention the use of 7,000 *Joules* in the periumbilical region or 400 - 500 *Joules* in the neck, it is not clear the exact size of these treated regions. This makes it complex to reproduce the treatment in other patients, as depending on the size of the treated region, there may be excessive, and even dangerous, dispersion or concentration of energy and consequently heating excessive tissue.

As the endolaser subdermal technique is based on heating the subcutaneous and dermal tissue to achieve its therapeutic objectives, we understand that the generation and control of heat in the target area is the main way of action to achieve these objectives. Thus, controlling the amount of energy in *Joules* accumulated in the target treated area becomes the main measure to be adopted during the endolaser procedure, as it is this accumulation that will determine the effects of the treatment. However, authors[37] reported that power control can directly interfere with aesthetic results since the power used is directly related to the total accumulated energy and the temperature rise in each treated area. Furthermore, we also include as one of the important adjustable parameters, the choice of continuous and pulsed laser emission mode, as depending on the mode used, associated with the emission power, the energy deposit will occur at a greater or lesser speed. This is important. for the safety of the procedure since depending on the treatment location, either the face (smaller, more sensitive areas) or the body (larger areas), the energy deposit must occur in a more controllable and, consequently, safer way.

Mordon et al.[6] showed a mathematical model that explained the relationships between the chosen power, the accumulated energy and the temperature reached. Still, they highlighted the need for adequate control of energy accumulation for treating such adipose tissue volume with the laserlipolysis technique. The authors further reported that it may be normally observed a 5 cm^3 reduction in fat volume with 3,000 *Joules*, and with 20 cm^3 fat volume reduction can be obtained with 12,000 *Joules*.

The Helmy Method, proposed by Ali[38] provides for safe and effective detailed calculations of laser energy parameters, to be used as a basis for seeking some type of standardization when choosing safer energy doses. and effective during the endolaser procedure.

And this method seeks to determine the volume of fat in the target area to personalize the treatment according to the individuality of each patient. To this purpose, are taken the following measurements: width, length (on the skin) and depth or thickness of the subcutaneous tissue of the region to be treated (using ultrasound, adipometer or caliper). Therefore, the formula applied to calculate fat volume in the target area is Length × Width × Thickness (cm) and from this formula, the amount of laser energy required for individual treatment is calculated based on Havenith's data. Havenith's formula uses an individualized model of human thermoregulation to simulate a response to thermal stress applied to fatty tissue. In practice, 2.51 joules of laser energy are needed to arise the subcutaneous temperature of 1 gram of fat by 1°C.[39] However, as the physical density of fat is 0.9 g/1 cc, the amount of *joules* required to heat this specific amount of fat becomes 2.51 × 0.9 = 2.259~2.3/1 cc.[38]

For example: if a temperature boost of 8°C is required from the base body temperature of 37°C, then the ideal heating dosage might be achieved at 45°C. Thus, the mathematical equation can be carried out as follows: Volume × 2.3 × 8°C (desired temperature increase). The result is expressed by the total number of *joules* needed to heat each treatment area.

There is many questioning about would be the ideal increase in temperature in fatty tissue in order to guarantee damage to adipocytes. Authors[41] reported that, because the components of the lipid bilayer of cell membranes are held together only by hydration forces, this lipid bilayer would be more vulnerable to damage caused by increased temperature. With an increase of just 6°C above the base body temperature (37°C), in other words, whether the temperature in the subcutaneous tissue reaches 43°C the integrity structure of the lipid bilayer is lost, and adipocyte cell damage is inevitable.

4.1. *Fundamentals for creating dosimetric methodology*

Given the lack of parameters that could determine the adoption of a customized dosimetry for each anatomical region or aesthetic condition treated with the endolaser, we direction guidance for the conscious use of a safe and effective dosimetry using the subdermal laser, both in the treatment of localized fat, or skin retraction, or both aesthetic dysfunctions. Therefore, it was initiated an observational study by measuring the area of the skin (width x length) and dividing this region by the total value of accumulated energy. After collecting retrospective data from medical records (20 patients), the total energy accumulated was divided by the size of the target area and identified an average energy accumulation of around 30 to 35 *Joules* for each centimeter of treated area (measured superficially on the skin) (Table 3).

Using these dosimetric parameters caused the incidence of several cases of steatonecrosis, persistent edema, local fibrosis, prolonged pain and severe post-treatment hematomas in the majority of patients.[1] These episodes led us to review these dosimetric parameters and there was consensus among the clinical staff to reduce them to avoid the afore mentioned complications. The decrease followed personal criteria (estimates to ensure greater safety and avoid complications), in addition to some findings in the literature on the subdermal laser technique.[2, 12, 17, 28]

In our clinical practice, we have evolved our understanding about the most appropriate dosimetry for the use of the aesthetic endolaser by reducing the power and energy accumulation previously used (Table 3), and began to use the pulsed mode more (T.On 50 ms and T. Off 50 ms) than continuous, especially in facial services. In table 4 it is described some of the cases treated with the new dosimetric understanding about subdermal laser, in which was delivered 20 to 25 *Joules* of energy for each square centimeter of target area.

Table 3: Retrospective analysis of clients' medical records (partial) seen in an aesthetic care outpatient clinic using the subdermal endolaser – Average energy delivered: 30 to 35 J/cm^2.

TREATMENT AREA	MODE	AREA SIZE	POWER	TOTAL ENERGY	ENERGY PER cm^2
CULOTTE/FLANK (FAT)	CONTINUOUS	7x10=70 cm^2	7W	2.200 J	31,4 J/cm^2
CULOTTE (FAT + SKIN)	CONTINUOUS	15x18= 270cm^2	8W 9W	12.000 J	44,4 J/cm^2
BACK (FAT + SKIN)	CONTINUOUS	16x17= 272cm^2	10W	10.000 J	36,7J/cm^2
CULOTTE (FAT)	CONTINUOUS	7x20=140cm^2	8W	4.500 J	32,1 J/cm^2
ABDOMEN (FAT)	CONTINUOUS PULS 50/50ms	10x12=120cm^2	8W	3.000 J	25,0 J/cm^2
					Medium Energy: 33,99 J/cm^2

Table 4: Retrospective analysis of clients' medical records (partial) treated in an aesthetic care clinic using the subdermal endolaser– Average energy delivered: 20 to 25 J/cm^2.

TREATMENT AREA	MODE	AREA SIZE	POWER	TOTAL ENERGY	ENERGY PER cm^2
PALPEBRA (SKIN)	PULSED (50/50ms)	1,5x4,5= 6,7cm^2	3W	150 J	22,3 J/cm^2
DOUBLE CHIN (SKIN)	CONTÍNUOUS	5x14/2=35 cm^2 (TRIANGLE)	3W	800 J	22,8 J/cm^2
FLANK (FAT)	CONTÍNUOUS	Esq 22x7=154cm^2 Dir 21x6=126cm^2	5W	3.500 J 2.960 J	22,7 J/cm^2 23,4 J/cm^2
1/3 MIDDLE OF THE FACE (SKIN)	PULSED (50/50ms)	6 x 6 = 36 cm^2	3 a 4 W	900 J	25 J/cm^2
					Medium Energy: 23,34 J/cm^2

To put this new methodological understanding into practice, we initially determine the size of the target area by taking width and length measurements on the surface of the skin (Square, rectangle or triangle) (Fig. 5). Then, we multiply the value obtained when calculating the area by a value between 20 and 25 *Joules* to know the amount of total energy indicated for that area.

After obtaining the total energy to be delivered, it was marked (or redo) the vectors that serve as a guide for the laser energy distribution (Fig. 5 and 6), then the total energy value was divided by the number of vectors so that energy does not concentrate more in one region than another (heterogeneous distribution of energy). Thus, favoring the emergence of steatonecrosis, as described by Borges et al 1]. Practical example: rectangular area measuring 10 x 15 cm, total area of 150 cm^2; it is multiplied this value by 20 to 25 *Joules*, so the energy accumulation will be between 3,000 and 3,750 *Joules*.

The decision about which value between 20 and 25 *Joules* we should multiply by the size of the target area must take into account the thickness of the subcutaneous tissue, the treatment targets (fat, skin or both), and the aesthetic condition to be treated (facial or body). However, this dosimetric view should not be rigid in terms of its applicability as in some cases, it is possible to multiply the size of the target area by 18 *Joules* in more sensitive areas, such as the lower eyelid. Or multiply by 27 *Joules* when treating areas with a large thickness of adipose tissue (over 3 centimeters thick). This dosimetric method has been validated in a multicentric manner in several care locations for aesthetic conditions in Brazil since October 2023. All investigations of complications arising from the use of this methodology has demonstrated that only a few cases of peripheral nerve injury (marginal nerve mandibular) have been reported by few professionals. We believe that this type of complication is associated with the deepening of the optic fiber reaching the nerve area as well as anatomical variation, exposing the nerve in unusual locations reached by the endolaser heating.

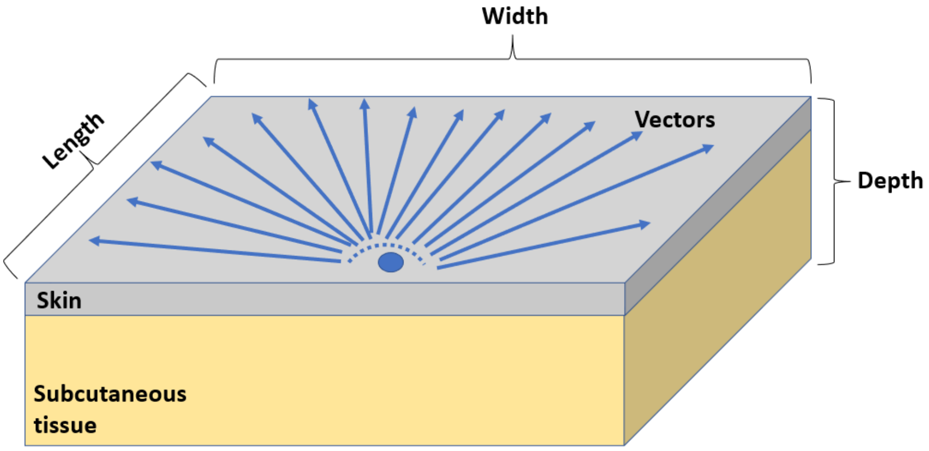

Figure 5: Scheme illustrating the measures to be taken to obtain the treatment area and marking the vectors that will serve as a guide for distributing the laser energy.

Currently, we have sought to evolve this dosimetric methodology based on the Helmy Method described by Ali in 2018.[38] This study provided a suitable method for calculating the actual *joules* needed for each treated area, which allowed good fat emulsification and skin firming at the same time safely. As previously stated, the author determines the fat volume in the target area, for this he includes the measurement of the depth of the subcutaneous tissue in the calculation of this volume (Fig. 5), and multiplies it by the *constant* (2.3 *Joules*) required to increase the temperature by 1°C in 0.9 g/1 cc of fat, and by the number of degrees you wish to increase the local temperature from the base temperature (37°C). Practical example: Supposing there is a treatment area measuring 10 cm wide, 15 cm long and 3 cm thick, aiming to increase the temperature by 6 degrees from the base temperature (37°C). The calculation of the fat volume would be: 10 x 15 x 3 = 450 cm^3; and to calculate the total energy (*Joules*) to be delivered to this target area using Helmy's formula it would be: Volume x Constant x Desired temperature increase, that is: 450 cm^3 x 2.3 x 6 = 6,210 *Joules*.

The study[38] also showed that energy values obtained with the Helmy method were used for treatments involving accumulation of subcutaneous fat and local sagging skin, in other words, the energy should heat part of the deep fat and the skin sequentially. To do this, the author advised it should be delivered only 60% of the total energy calculated in the deeper planes, aiming for lipolysis in this region. If we used the example calculated in the previous paragraph, it would be delivered 3,726 *Joules* in the deep fat (60% of 6,210) and 2,484 *Joules* just below the skin (40% of 6,210) to generate skin retraction.

However, we found that the Helmy technique has its amount of energy excessively calculated when used in the treatment of large fat deposits. Furthermore, the technique was validated in procedures performed in surgical centers using a large amount of tumescent anesthetic solution and, therefore, with more aggressive characteristics, which differs from the outpatient endolaser for aesthetic purposes. Despite this, the evolution of our methodology, it has also been based on the sequential delivery of energy when the focus is to reduce the mass of deep fat and warm the skin in the second treatment session. To do this, we initially suggest calculating the size of the treatment area based on measurements obtained only on the skin (base x height or side x side), then we measure the thickness of the adipose tissue (ultrasound or adipometry), when this is appropriate. less than 3 cm we multiply the value of the target area calculated initially by a value between 20 and 25. However if the thickness of the subcutaneous fat amount to be treated is greater than 3 cm we multiply the value of the target area by 27 or 28 *Joules* (or even 30 *Joules*), in this case we were able to deposit 60% of this value in the deep subcutaneous tissue and the remaining 40% in the immediately subdermal region, as suggested by the Helmy Method.

In Fig. 6 to 8 it is shown some treatment results where authors' methodology was used. In addition, it illustrates the marking of the target area with the location of the vector map to assist in the treatment.

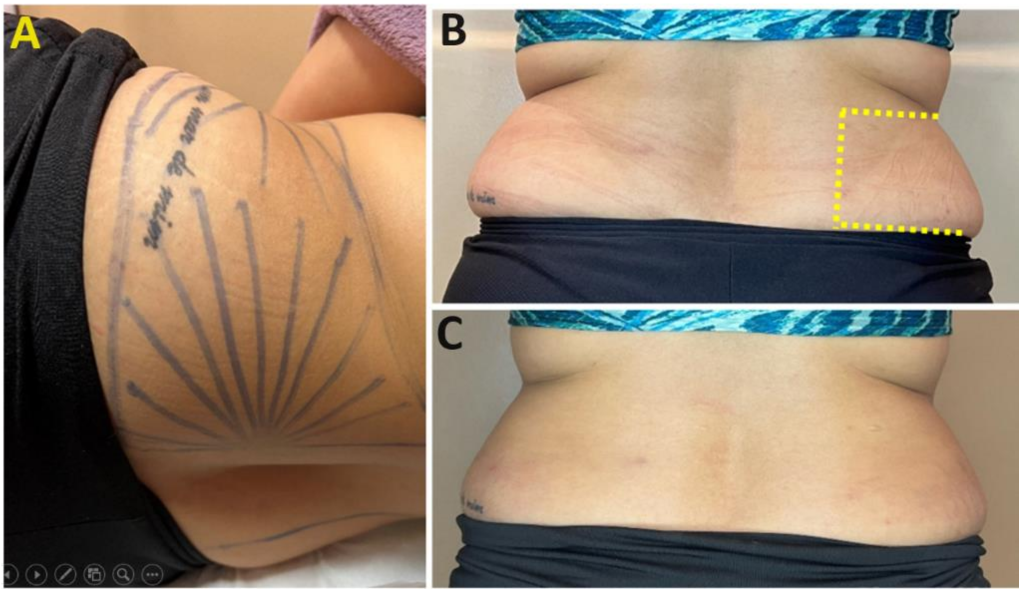

Figure 6. A and B) Marking of the total target area and the vector map. C) Result obtained with 2 treatment sessions to reduce fat located on the flanks. Here, the following dosimetric parameters were used: Power 8 Watts, continuous mode, 2 treatment subareas measuring 120 cm² x 20 J = 2,400 *Joules* in each subarea.

Figure 7. Result obtained with 1 treatment session to reduce superficial subdermal fat and retraction of the abdominal skin. Here, the following dosimetric parameters were used: Power 7 Watts, continuous mode, 4 treatment sub-areas measuring 100 cm² x 25 J = 2,500 *Joules* in each subarea, distributed across 20 vectors (125 *Joules* per vector).

Figure 8. Result obtained with 1 treatment session to reduce sagging in the upper eyelid. In that session, the following dosimetric parameters were used: Power 3 Watts, continuous mode, treatment area measuring 6.7 cm² x 22 J = 147 *Joules* in each area distributed in 2 vectors.

Finally, we highlight the relationship between energy accumulation associated with increased skin temperature. According to Mordon et al.[4] using a mathematical model for thermal analyzes applying the subdermal laser, the temperatures reached inside the lower dermis (1.5 mm) and the reticular dermis (0.5 mm) were respectively 44° C and 42°C, while on the surface of the epidermis the temperature measured was 41°C. This shows us that if the objective is to retract the skin, the amount of energy deposited must be sufficient to increase the skin temperature from the base temperature (37°C).

Therefore, when it is applied our dosimetric methodology, where the objective is only to retract the skin, we calculate the size of the area, multiply the value initially obtained by 20 *Joules* and distribute the total value of *Joules* by the number of vectors. However, if during energy delivery to each vector we do not reach the appropriate temperature for skin retraction, we increase the number of *joules* up to the limit that would be calculated if we multiplied the size of the area by 25 *Joules*. On the contrary, if we reach the appropriate skin temperature before delivering the total amount of *Joules* calculated for each vector, the laser application is stopped and changed the energy delivery to another vector.

CONCLUSION

Authors understand there is a need for some type of standardization for choosing the amount of energy necessary to cause adipocyte damage and heating of the skin using the subdermal laser as due to the variety of physical characteristics of the treated individuals (location and sizes of the target area) we can adopt a single standard dose for everyone (mainly in terms of power and energy). Therefore, it must be analyzed the individual characteristics of those who will undergo endolaser treatment in order to adopt techniques to estimate the particular dosimetric parameters for each treated individual.

Therefore, we have established a way of customizing the dosimetry of the aesthetic endolaser through simple mathematical calculations, based on the physical characteristics of the region to be treated (mainly the size of the target area) and a specific energy dosimetric range (between 20 and 25 *joules*).Tthus, we are able to choose customized, effective and safe doses in each clinical situation for the treatment of aesthetic dysfunctions using the subdermal laser. However, we understand that these values may be higher (27 or 28 *Joules*) when the thickness of the adipose tissue is greater than 3 cm.

As a conclusion, endolaser must be parameterized based on the physical characteristics of each target area to be treated, and therefore, the adoption of personalized dosimetric strategies is necessary to assure more efficient and safe results. Thus, avoiding the use of common and equal doses. for anyone seeking subdermal laser treatment.

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