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IMPORTANCE OF TEMPERATURE CONTROL DURING THE SUBDERMAL ENDOLASER TECHNIQUE UTILIZATION

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ABSTRACT

***Introduction**:* Endolaser is a technique that uses 1470 nm and 980 nm laser beams to reduce subcutaneous fat and tone the skin, in addition to promoting additional aesthetic effects. It can be performed using an optical fiber directly inserted into the superficial subcutaneous tissue or through a cannula to facilitate its manipulation in the subcutaneous tissue. Precise temperature control during the procedure may be performed to ensure therapeutic efficacy and avoid thermal injuries. ***Objective**:* This study aimed to describe the importance of temperature control during the use of the endolaser subdermal laser in the treatment of aesthetic conditions, in order to optimize the technique, assure good results and avoid thermal injuries during and after the procedure. ***Materials and methods**:* This study is characterized by exploratory research, presented through a narrative review, to highlight the need and/or importance of rigorous control of skin temperature during the endolaser technique applied in the treatment of 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 (Literatura da América Latina e Caribe in Health Sciences). Furthermore, it was added to this study a survey of some cases of thermal injuries identified after the use of the endolaser technique that occurred in Brazil in a multicentric manner, in order to describe the authors' experience in approaching this type of adversity which occurred due to the lack of suitable means to control the temperature as long as the procedure takes place. ***Results**:* It was found that controlling skin temperature during the subdermal laser technique has broad support in the literature, both in surgical and outpatient (non-invasive) procedures. Despite this, there are reports of authors who perform the endolaser technique with lower doses, giving up adequate instruments for monitoring skin temperature. We also verified that adequate control of skin temperature during the use of the endolaser is crucial to avoid burn injuries. The safe temperature identified on the skin during the procedure, considered safe and effective, is around 40 to 42ºC. ***Conclusion**:* We conclude, therefore, that controlling skin temperature during the endolaser technique, using appropriate instruments is necessary so that the professional might be sure of the effects arising from the technique (heating or not of the skin), and beyond, this can prevent burn injuries.

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INTRODUCTION

The endolaser subdermal laser technique, when used for aesthetic purposes, has its foundations based on the Endolift™ technique (LASEMAR1500™ machine, Eufotons.r.l.). That approach became known worldwide for using a laser beam with a wavelength of 1470 nm emitted through an optical fiber inserted into the subdermal tissue with the purpose of reducing subcutaneous fat and/or toning the skin through neocollagenesis [1-3]. The aesthetic endolaserhas as its main characteristic the use of wavelengths of 1470 nm and 980 nm with the same therapeutic objectives [4], and might be performed using an optical fiber directly inserted into the superficial subcutaneous tissue [1, 3, 5, 6] or still inserted inside a cannula to facilitate its manipulation in the subcutaneous tissue [7, 8]. This subdermal laser therapy technique may improve facial wrinkles and expression lines in the glabellar region, as well as improve the skin texture and tone in the whole face. To achieve this, it is capable of stimulating collagen growth, increasing the thickness of the dermis and making the underlying skin firmer and free from injuries [9, 10]. Furthermore, it is indicated for various lipodystrophies such as localized adiposities and cellulite [11-13] and also for some specific situations, such as improving the aesthetics of the mandibular edge, "marionette lines", "chin double", middle facial and nasolabial folds, periorbicular changes of the eyes [14], rosacea [15], acne vulgaris, acne scar [16, 17] and others. The several subdermal laser techniques use the photothermal effect to produce their results, both in the main surgical techniques, for example, laser-assisted liposuction [18-20], and also in the non-surgical technique [2, 4, 7]. Thus, temperature control during endolaserapplication is the main way of obtaining the intended therapeutic effects, in addition to avoiding adversities and complications. Therefore, it is understood that temperature control is essential for endolaser procedures once the controlled and safe heating of the target treatment area is desired [4]. This study aimed to describe the relevance of temperature control during endolaser subdermal laser application in the treatment of aesthetic conditions. Consequently, it optimizes the technique, assures good results and avoids thermal injuries during and after the procedure.

METHODOLOGY

This study is characterized by exploratory research, presented through a narrative review, to highlight the need and/or importance of rigorous control of skin temperature during the endolaser technique applied in the treatment of 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 (LiteratureofLatin America and Caribe in Health Sciences). As an inclusion criterion, it wasselected that sources which mentioned the use of appropriate mechanisms to control the temperature of the treated area or that described the techniques involved in controlling localized hyperthermia. Sources that did not present a summary, those that were not allocated to scientific journals and did not address the topic of the study, as well as those that did not support the collection of reliable data were discarded. The bibliographic survey was carried out in Portuguese, English, Spanish and Italian, with the following descriptors: Endolift, Endolaser, Subdermal Laser, Laserlipolysis, thermography. In addition to the literature review, this study included a survey of some cases of thermal injuries identified after ofendolaser technique use that occurred in Brazil in a multicentric manner, in order to describe the authors' experience in approaching this type of adversity that occurred due to the lack of adequate ways to control the temperature during the procedure.

RESULTS AND DISCUSSION

Photothermal effect: Regarding endolaser technique, the photothermal effect (Photohyperthermia) is the most important point, as this effect leads to adipocyte damage and/or heating and retraction of the skin. Photothermal effects take place when laser light is absorbed by a target chromophore and results in specific biological reactions arising from local hyperthermia. Laser-tissue interaction might cause vaporization or ablation of the target and lead to thermal damage to adjacent tissue. This thermal injury is proportional to the heat level generated in the tissue and the duration of exposure [21]. When high-power lasers are used, the photothermal effect on tissues can only be achieved if the light is absorbed and converted into thermal energy. Therefore, this biological effect will depend on the real temperature reached in the chromophore or target tissue, as well as the period of time that the target will remain at the respective temperature. Finally, tissue effects will also depend on the heat conduction from the target to the surrounding tissue, meaning that the damage achieved in the tissue will depend on the accumulated energy density, pulse width/duration and the heat conduction generated [22]. Generally, when laser energy is converted into heat in tissues, thermal diffusion begins. However, heat diffusion through tissues will depend on the thermal properties of the irradiated material. Thus, the phenomenon of thermal relaxation (cooling) might be influenced by some factors, such asthermal coefficient of the target tissue, the properties of the tissue or surrounding fluids, and the temperature differential between the irradiated and non-irradiated tissue, in other words, thermal equilibrium (Zeroth Law of Thermodynamics) [23]. However, depending on the duration and the peak value of the tissue temperature reached, different effects such as coagulation, carbonization, vaporization, and melting may be obtained. For thermal decomposition of tissues, especially when using transcutaneous lasers, it may be necessary to adjust the laser pulse durationto minimize thermal damage to adjacent structures (those that are not characterized as target tissue). Therefore, for shorter laser pulse duration than the thermal relaxation time of the irradiated structure, the heat will not even diffuse to a certain optical penetration depth, however, when the pulse time is greater than the thermal relaxation time (Table 1), heat might diffuse to a multiple of the optical penetration depths. So, there can be thermal damage to tissues adjacent to the total tissue volume that has been injured by laser absorption [24]. These concepts may be closely associated with endolaser if we consider the laser thermal confinement in the subcutaneous tissue with some wavelengths, as well as its thermal diffusivity (Zeroth Law of thermodynamics).

Table 1. Thermal relaxation time related to target tissues used as a basis for transcutaneous laser therapy [21, 25]

THERMAL RELAXATION TIME RELATED TO TARGET TISSUES	
Target	Thermal relaxation time
• Hair follicle (200 micrometers)	• 40 milliseconds
• Blood vessel 0.1 mm in diameter	• 10 milliseconds
• Blood vessel 0.8 mm in diameter	• 300 milliseconds
• Epidermis (50 micrometers)	• 1 millisecond
• Red blood cell (7 micrometers)	• 20 microseconds
• Erythrocytes	• 2 microseconds
• Melanosome (0.5 micrometers)	• 0,25 microsecond
• Melanocyte (7 micrometers)	• 1 microsecond
• Tattoo particle (0.5 to 100 micrometers)	• 20 nanoseconds to 3 milliseconds
• Epidermis (100 to 200 micrometers) (Dermoepidermal junction 10 micrometers)	• 25 to 100 milliseconds
• Collection of nerve cells (100 micrometers)	• 10 milliseconds

Thermal confinement is characterized by the concentration of heat close to the laser irradiation source or the tip of an optical fiber, and different wavelengths mightshow different ways of dissipating or accumulating local heat. Authors [26] compared the thermal effect of three wavelengths on subdermal tissue (1064 nm, 1320 nm and 1444 nm), at a depth of 10 mm, and observed that there was a minimum thermal diffusivity at 1444 nm that is the heat dissipation through the tissues was much lower with this wavelength compared to the others. By the other side, thermal confinement was highest at 1,444 nm, intermediate at 1,064 nm and minimum at 1,320 nm. The authors also found that greater thermal confinement led to greater structural damage to the irradiated adipose tissue. In another study [27], during body contouring treatment, the authors reported that significant thermal injuries far away from the area irradiated with subdermal lasers with a wavelength in the range of 1444 nm are unlikely. It becausethat sites are places where there be large fat volumes, and so there is great thermal confinement making it difficult to dissipate heat to areas remote from the treatment site. By the other side, when using the endolaser in facial treatments (and even in the submental region) where the adipose layer is not thick, it is believed that there is a great potential for undesirable thermal injury. Additionally, in cases where the wavelength of 1470 nm is used, very close to the 1444 nm used in the mentioned study, the heat confinement in this case will happen in areas with little adipose tissue and may then cause high heating of delicate structures anatomically close to the irradiation source (mainly nerves). Therefore, to optimize treatment in areas with few adipose tissues, it is recommended to use low powers and/or low energy concentration for avoiding relevant thermal injuries, especially when endolaser has a wavelength of 1470nm.

Treatment temperature: Thermal damage is what is wanted when using subdermal laser emitted through fiber optics, and it is through the increase in internal temperature that the adipose tissue is damaged and heat the skin in order to modify its collagen structure. However, we emphasize that when performing the endolaser technique, strict control of the local temperature is necessary both to avoid complications and to avoid underdosing the energy and thus generating poor aesthetic results. Additionally, in our practice we have seen that when we do not reach the appropriate temperature in the skin (40°C to 42°C) there is no change in collagen and, on the other side, if the temperature recorded on the skin is around 44°C to 45°C, the risk of thermal injury is high. Using heat as an object of thermal trauma to adipocytes is very well described in the literature [18, 19, 28, 29] as well as heating skin collagen. However, in clinical practice, subdermal heating by laser radiation should be monitored by using effective temperature measuring equipment to obtain a controlled thermal effect and avoid injuries, mainly due to burns [4]. Many professionals have handled simple infrared thermometers, commonly used in radiofrequency equipment to control skin temperature (Figure 1).

Figure 1. Infrared thermometers used by professionals who apply the endolaser technique

We recommend caution and prudence when handling these instruments, as in addition to their inaccuracy they do not measure the temperature of the entire treated area. In our clinical practice, we recommend severe control of the external temperature using infrared thermography equipment (Figure 2). The thermographic camera is the most recommended instrument for analyzing and controlling skin temperature at the treatment site [7, 8, 30]. The reason is it provides greater vision of the thermal environment through specific thermal imaging, besides greater precision in temperature measurement. And thus, assures greater vigilance over the hottest areas, so if there are overheating points in remote locations, such as close to the pertuit and or far from the tip of the optical fiber emitting the laser, the professional will be able to identify them and prevent thermal injuries to the skin. Currently, it is used cameras that continuously track the hottest points in the thermal image, this supports greater control and safety in the course of procedure, since it is not necessary to constantly move camera to find out the highest temperature locations. Some temperature parameters have been described in publications using the Endolift™ (1470 nm) [2], as well as in the subdermal laser using cannulas [7, 8, 31], and also in laser liposuction surgical procedures [30, 32], and all stand as the basis for the endolaser procedure with regarding to aesthetics. Studies have shown that during the use of the subdermal laser the skin surface temperature should never exceed 40°C [2]. But, others have also mentioned that the skin may reach borderline temperatures of 41°C and 42°C [8, 30, 32].

Figure 2. Thermography equipment used in the course of subdermal laser procedure during the qualification course in the Endolaser technique (Marcio Moreira Clinica Estética, Maringá-PR, Brazil)

Authors [30] compared the increase in skin temperature using three types of subdermal laser: 1320 nm (4.5 J/cm2/°C), 1064 nm (6 J/cm2/°C), and a "dual- wave" (MultiPlex - 7.5 J/cm2/°C). They concluded that superficial subdermal heating (approximately 5 mm below the skin) during laser lipolysis should limit the skin surface temperature to 42°C, regardless of the kind and dose of laser used. The authors also identified that superficial treatment with surface temperatures above 47°C (simultaneously reaching 50°C and 55°C at a depth of 5 mm) normally induced dermal and epidermal lesions causing blisters above 58°C. Below this threshold, focal collagen changes and dermal inflammatory response were found in many samples without epidermal injury. In a studyMordon et al., [8], by using a mathematical model, they analyzed the internal and surface temperature of the skin by comparing two types of laser: Nd:YAG (1064 nm) and diode laser (980 nm). With 6 W of power and using a cannula to direct the optical fiber movement (forward and backward movements (100 mm/s)) identified a temperature on the skin surface of around 41°C (maximum) similar for both, and also found that the temperature increases in the lower dermis region (48°C to 50°C) was enough to induce skin hardening. Still regarding the internal temperature, it fluctuated between 45°C and 47°C and the external temperature was around 40°C to 42°C during laser liposuction (1064 nm and 1320 nm), and there was significant skin retraction. The authors further identified that obtaining a uniform subdermal temperature of 45°C produced a surface skin temperature between 40°C and 42°C. According to the study, these surface temperatures correlated with a dermal heating of around 70°C, which is considered ideal for increasing skin contraction through selective collagen denaturation [32]. Kamamoto et al.,[7] used a thermographic camera to analyze the skin temperature during a subdermal laser procedure with optical fiber and cannulas (980 nm) and found that the average temperature in which caused skin burn was 45°C (defined as the exact moment when an opaque plaque appears on the skin). Still, authors also reported that the safety interval in the thermoguided technique was set between 36 and 40°C, being adopted as a target for the subdermal laser application. Despite understanding the need to control skin temperature during the endolaser, there are authors who did not mention the use of any skin thermal control instrument [33-35]. In these cases, they prioritizedin their care or studies the pulsed mode of laser emission, low powers and fewaccumulation of energy (Joules), thus generating safety for the procedure. Regarding this energy Joules accumulation in the target area, this must be enough to damage the adipose tissue and heat (or not) the skin of the treated area, therefore, dosimetric protocols may be adopted that estimate an adequate amount of energy to achieve therapeutic objective. As an example, authors [34] used a power of 6 to 9 Watts, pulsed emission mode and accumulated an average of 7000 Joules of energy in the subdermal tissue with a 1470nm laser for the treatment of the periumbilical region, flanks and culottes.

Figure 3. Two cases of burns resulting from the use of endolaser. In both cases there was no skin temperature control, and they occurred in the city of Maringá-PR, Brazil.

Another study [33] reported that a power of 2 Watts was used on the eyelid, pulsed mode and an average accumulation of 100 - 130 Joules in each eyelid, with the aim of reducing skin sagging. In the forehead region, authors [10] deposited 600 to 800 Joules of energy to reduce wrinkles. However, despite the understanding that when knowing a certain energy accumulation protocol (considered suitable for each region and/or therapeutic goal), based on our clinical practice, we recommend, to use some ways of controlling the skin temperature.Even when aware of this type of standardization, especially when the treatment'sobjective is skin heating in a controlled way.

Lack of temperature control and adversities: Authors [4] described a series of complications arising from the use of endolaser that occurred in Brazil. One of these complications mentioned was burns, and the main reasonfor this kind of injury was the lack of skin temperature control. In our clinical practice, we have seen that the Zeroth Law of Thermodynamics, associated with thermal diffusivity, means that the temperature reached with the endolaser equipment in operation does not keep stable after it is turned off. In other words, the temperature initially reached continues to increase for a few seconds up to 2 degrees beyond that achieved during laser emission. Itmight be very dangerous, as based on the literature [30, 32], many professionals activate the subdermal laser, raising the skin temperature to 42°C, but when they turn off the equipment, the temperature rises to 45°C causing significant skin and subcutaneous tissue burns. During the endolaseruse, it is recommended controlling the skin temperature in each region or vector, until it reaches a maximum of 39°C. From that moment, the laser emission must be interrupted, but keeping monitoring skin temperature for a few seconds to make sure it does not exceed 42°C. According to some authors [31], if the skin temperature exceeds 42°C, cold "packs" should be applied to the treated area to avoid injuries due to overheating of the skin. During endolaser clinical practice, the most common injury resulting from the lack of control of skin temperature is burns.[4] Authors [36] reported that 1.5% of their patients presented thermal burns to the eyelid skin during the use of subdermal laser using a cannula, and the injury took place when the local energy deposit was greater than 500 Joules. According to Borges et al., [4] specific burns may occur along the path where the optical fiber is moved (Figure 3) as well as when it is introduced. Authors also reported that the region close to the optical fiber introduction port is what suffers the most. The reason is it is where the retro-withdrawal movement of optical fiber converges during laser emission, following the vectors direction towards the port, inducing large accumulation of thermal energy (Figure 4).

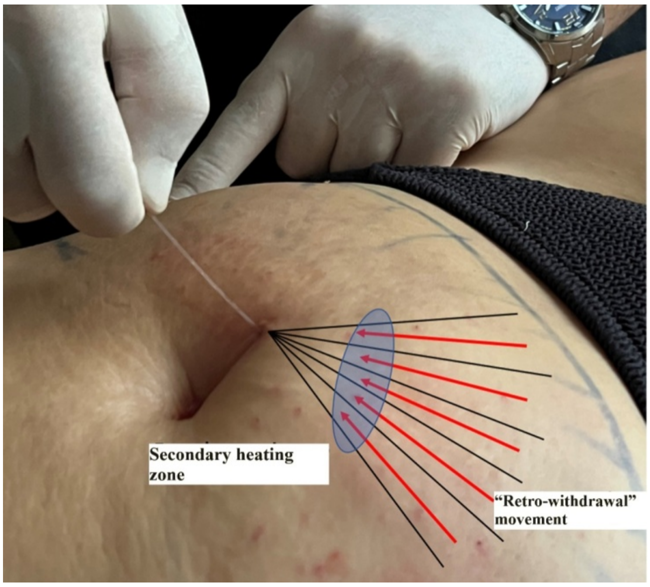

Figure 4. Vector map indicating the treatment region (black), direction of the convergent retro-withdrawal movement of the optical fiber during treatment with subdermal laser (red arrows), and representation of the secondary heating zone close to the pertuit (blue circle). (Extracted with allowance from Borges et al.[4])

Regarding the management of burns, it is recommended as a non-pharmacological treatment the following the use of ozone therapy (local gas injection (concentration of 10 micrograms), ozone bag, ozonized oil, rectal insufflation, etc.); low power laser (670nm); Red and blue LEDs; microcurrents; ultrasound etc. Depending on the condition, special care may be necessary for the burned area such as debridement, which may be mechanical or chemical. In this last case, hydrogel with alginate may be used for dry lesions and alginate fiber for wet lesions. A relevant point is that the devitalized tissue must be removed as it represents adangerous source of contamination, in addition to delaying healing [4].

CONCLUSION

As a conclusion, it was found that the literature is extensive in describing the control of skin temperature during the use of the subdermal laser technique, both in surgical and outpatient (non-invasive) procedures. Although the authors have found reports statingthat researchers and professionals use the subdermal laser without instruments for controlling skin temperature, using lower powers and energies, they understand that endolaser technique presents itself safer and more optimized when supplied with suitable temperature control mechanisms, as the necessary parameters are obtained to understand the real effect expected after heating the skin. Therefore, authors concluded that controlling skin temperature during the endolaser technique by using appropriate instruments, is necessary so that the professional might be sure of the effects arising from thismethodology (heating the skin or not) and furthermore, may prevent burn injuries.

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