

Laser Lipolysis With a 980 nm Diode Laser

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ABSTRACT

Laser lipolysis is recognized as an effective, non-surgical solution for fat removal and body reshaping. Its appeal lay in the procedure's ability to treat localized fat deposits and correct body asymmetries with apparent decreased risk compared to traditional liposuction. The energy emitted by the laser uses volumetric heating to destroy fat cells, contract skin and stimulate collagenesis. Although devices of five different wavelengths are FDA approved for lipolysis, it has been found that the 980 nm diode laser is consistently successful in inducing the required fat-heat and skin-heat interactions necessary for optimal results. Although laser lipolysis is not intended to replace traditional liposuction, it offers patients a procedure that yields similar benefits with fewer complications and faster recovery.

INTRODUCTION

Laser lipolysis is designed to provide selective adipose damage, while simultaneously facilitating fat removal, enhancing hemostasis and increasing tissue tightening. The procedure is increasingly gaining recognition as an effective, non-surgical solution for reshaping specific body areas. Laser lipolysis should not be regarded as a replacement for traditional liposuction, nor should it be seen as an alternative to a traditional weight loss regimen. Its role is to treat localized fat deposits (e.g., hips, flanks, etc.) that have shown resistance to diet and exercise. In addition, laser lipolysis can be used to correct body asymmetries (e.g. asymmetry of the knees, male breasts, etc.) or irregular contour (e.g. due to prior liposuction).¹⁻³ Historically, lasers have been used to target relatively small structures, such as blood vessels and pigment; fat deposits represent a much larger target and require a different focus. Targeting adipose tissue requires one to heat a large volume of tissue; therefore, it is crucial that the wavelength used can propagate adequately into the tissue allowing for enough absorption to maintain sufficient control of the heated area. The heat generated in the fat should transmit to the skin in order to maximize the controlled heating of the skin. The controlled temperature rise in the skin is necessary to achieve optimal skin contraction. Finally, the ideal wavelength should also have the ability to seal small blood vessels which minimized blood loss during the procedure.^{4,5}

The Science of Laser Lipolysis

Skin-Heat Interaction

Ever since the introduction of CO₂ lasers for skin resurfacing in the early 1990s, the process leading to skin tightening has been further elucidated. Whenever a controlled, reversible thermal injury is created, the body's response is to release mediators responsible for the healing process. In turn, fibroblasts are stimulated to generate and lay a bed of newly formed collagen. As more and more collagen is produced, the skin thickens and

becomes more pliable leading to skin contraction.⁶ A threshold temperature needs to be reached in order for collagen production to occur. There is a delay of many months after the procedure before the tightening becomes apparent.

Fat-Heat Interaction

The extent to which fat is heated and the amount of time the heat is maintained can significantly alter a clinical endpoint. At temperatures below 45°C, any damage done to fat cells is fully reversible and sustained modifications will not be achieved. Between 45°C and 65°C, the cell membrane—though not ruptured—is permanently damaged and will gradually be absorbed by the body through macrophage activity. This process, known as adipocytolysis, is a process that occurs over roughly 90 days, leading to an overall clinical improvement over time. Imparting temperatures above 65°C will rupture cell membranes and cause triglycerides to seep into interstitial spaces, allowing for removal via aspiration or gradual endogenous reabsorption. It is unclear how long the fat needs to be exposed to the appropriate temperature range, but it is believed that the amount of heat exposure can alter the end result. The favored mechanism of action for laser lipolysis is a thermal impact and ideally one should aim to heat the fat to a temperature between approximately 45–65°C to yield optimal results.⁷

Volumetric Heating

As previously mentioned, fat often represents a large volume of tissue, requiring the laser to interact with a sizeable target at any given time during therapy. To effectively treat this massive chromophore (more truly represented as hydrated fat, due to the influx of tumescent fluid), the tissue absorption needs to be low enough to have an in-depth effect within the desired target. However, it is equally important to ensure the absorption isn't too low, ultimately requiring excessive power levels to raise the tissue temperature to the appropriate therapeutic levels. Dependency on power levels for an increase in temperature can

result in insufficient control over the laser interaction with the surrounding structures, creating more uncertainty and risk in performing the procedure. This duality of “little, but enough absorption” accurately describes short infrared (IR) wavelengths, particularly 980 nm. Thus far, only near IR wavelengths can achieve controlled volumetric heating in hydrated fat.

However, using IR wavelengths is not straightforward. 1064 nm is poorly absorbed in fat, and can therefore affect large volumes with minimal selectivity posing risk to surrounding structures. At moderate power levels, the volume of tissue involved is so large that the rise in temperature is insufficient. High power levels will cause significant temperature increases, but the lack of selectivity means that this can also affect surrounding structures. In contrast, 1320 and 1440 nm wavelengths are highly absorbed in fat, affecting only a small volume of tissue at any given time. This results in very high temperature gradients being achieved over small volumes creating hot spots in adipose tissue. Though beneficial for targeting fat, the high temperatures generated can potentially damage the fiber tips and overheat the tumescent fluid resulting in skin burns.

To achieve skin tightening, temperatures of 48–50°C must be reached within the dermis to induce collagen contraction.^{8,9} Efficacy is dependent on properly targeting the desired chromophore, and ultimately using the correct energy to induce preferential damage; the dose-dependent relationship between laser energy and thermal damage is well established.¹⁰ Water, as with CO₂ and other skin rejuvenation lasers, is the main targets in the case of skin tightening with laser lipolysis. Water has a moderately high absorption peak at 980 nm, whereas at both 920 and 1064 nm, the peak decreases by a factor of 3. Conversely, the peak at 1320 nm is five times higher than that at 980 nm, making 1320 extremely efficient at dermal heating, but also more difficult to control, between these different IR wavelengths. Therefore, accurately targeting water and increasing energy creates not only adipocyte changes, but also dermal collagenesis.⁷ Collagen injury from thermal damage promotes collagen remodeling, leading to increases in skin tone and texture.

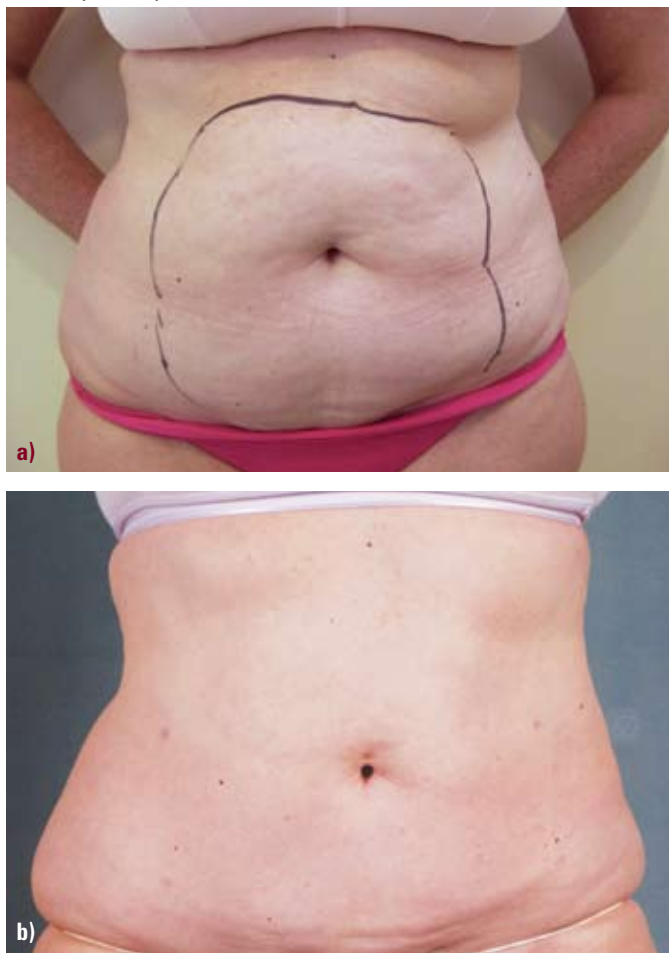
Putting this together, there appears to be two wavelengths best suited for lysis and lipolysis: 920 and 980 nm. Since 1064 nm is relatively poorly absorbed by adipocytes, it results in poorly controlled interactions with surrounding structures. In contrast, 1320 nm is too highly absorbed in fat, resulting in rapidly elevating temperatures in small volumes potentially creating hot spots. The preferred wavelength may be 980 nm, as there is a greater potential for skin tightening without the increased risk of severe superficial thermal damage. Although the authors prefer the 980 nm laser, many practitioners successfully utilize 1064 and 1320 wavelengths. Combination wavelength devices should also be considered. These devices offer the unique ability to capitalize on the advantages that each wavelength has to

offer, as some prove to be superior in absorbing fat, where as others provide better dermal absorption; this is a combination that may optimize the modality's efficacy.

Laser Lipolysis—Technology

Devices of five wavelengths have been FDA-approved for laser lipolysis: 980 nm (continuous wave), 975, 924, 1064 and 1320 nm and all have been successfully used to performed laser lipolysis.³ The LipoTherme system, which is a diode laser, emits a continuous wavelength of 980 nm. Diode lasers do not require significant electrical power, relying on 110 V outlets for even high-power systems. Diode lasers are made up of microscopic layers of semi-conductor material alternatively polarized positively and negatively. They emit laser light when their polarity is inverted through electrical stimulation. Because they are excited directly through an electrical current, diode lasers are extremely efficient systems, with a typical efficiency (the ratio of electrical energy required to power the laser versus the light power being emitted) of 30–40%. In contrast,

FIGURE 1. Example of laser lipolysis. **a)** Before and **b)** six months after in the upper and lower abdomen with 980 diode laser. Photograph courtesy of Amy Forman Taub, MD.



traditional lasers rely on conversion of electrical power into non-coherent light (a flashlamp) that then excites the laser material. This extra step in the conversion of electrical power into light results in substantial energy losses and accounts for the much lower (5% or less) efficiencies achieved with traditional systems. It also means the box itself must be larger not only for the actual mechanics, but also for adequate cooling.

In one study, Reynaud et al.⁵ quantified both, the total energy used in specific areas, as well as patient satisfaction. A total of 534 laser lipolysis procedures were performed on 334 patients. The areas treated included the hips, thighs, abdomen, buttocks, chin, arms and back. Mean cumulative energy was area-dependent, ranging from a minimum of 2200 J (knee) to a maximum of 51,000 J (abdomen). Contour correction and skin retraction were observed almost immediately in most patients. Patient satisfaction was very high. Ultrasound imaging demonstrated collagenous and subdermal bands prior to laser lipolysis, which subsequently dissolved following lipolysis therapy indicating this might be a useful treatment for cellulite. Adverse effects included mild erythema in 17% of cases at one week, three cases of paresthesias at three months, and one report of skin necrosis at prior surgical site near the umbilicus.

Laser Lipolysis Versus Liposuction: The Battle Continues

Laser lipolysis is an outpatient procedure performed in a standard room under local (tumescent) anesthesia with sterile technique. One to two mm incisions are made to allow for the passage of the laser and aspiration cannula. The laser melts fats more evenly (although good technique allows this to be so), as opposed to making numerous channels as in traditional liposuction. The aspiration process in laser lipolysis requires less effort due to the liquefied fat. This ensures reduced contour irregularities and makes the procedure far less traumatic, leading to minimal bruising and downtime. Laser-induced thrombosis of blood vessels and closure of lymphatic channels may explain the reduction in severity of bruising and swelling after laser lipolysis as well.⁵ Less trauma and bruising lead to faster recovery with most patients being able to return to work in two to three days.

Laser lipolysis, as opposed to traditional liposuction, also allows for the induction of new collagen production and subsequent skin contraction.³ The cutaneous response to the reversible thermal injury from the laser results in an inflammatory response that initiates collagen production. In time, the skin gets increasingly tighter, naturally adjusting to the shape of the body. Liposuction masters argue that "proper" liposuction, i.e. more superficial liposuction, which also damages the dermis, results in tissue tightening as well. A recent study demonstrated convincingly that there was 54% more tightening of the skin with laser than without.¹¹

Diode lasers, such as the 980 nm laser lipolysis device, may offer an advantage of increased power and efficiency as compared to other wavelengths.¹² Caution must be taken however, as with higher energy and continuous pulsing comes at an increased risk of damage and subsequent scarring.¹²

Laser Lipolysis—The Procedure

The procedure itself is not all different from traditional liposuction, except that an extra step (the laser) has been added between tumescent and aspiration. Patient preparation is similar to that of the tumescent liposuction technique—patients are marked in a standing position as well as are prepped under sterile conditions. Patients are typically given a sedative, and less commonly, some physicians will use spinal or general anesthesia. Note that while the extra step suggests additional time will be required, at least some of that time will be gained back during the aspiration phase as liquefied fat is much easier to extract from the body. Current technology uses 1- to 2-mm optical fibers inserted through small cannulas to transmit the laser into the subcutaneous tissue (Figures 1a and 1b).³

Laser Lipolysis—Potential Pitfalls

Proper understanding of the laser system is necessary to reduce potential risks. One must be prudent with respect to energy levels, as thermal skin injury can occur if the energy delivered is too highly concentrated.⁵ Adverse events include burning the skin with or without skin retraction, uneven skin texture or contour, and the removal of too little fat or too much fat. Some other disadvantages include the cost of the laser and the necessary, but variable, training time. There has also been concern regarding the possible risk of increased circulating triglycerides and free fatty acids as a result of improper aspiration while treating large areas. This could potentially have a negative impact on hepatic and renal function. In response to that concern, two studies established that there is no significant increase in concentrations of free fatty acids following laser lipolysis, concluding there is no potential risk of inducing renal or hepatic toxicity in patients that undergo laser lipolysis.¹³ Based on clinical studies conducted thus far, the overall complication rate is low. In a study involving 537 patients who underwent 1064 nm laser lipolysis, there were only 5 reported cases of complications (4 skin burns, 1 local infection) yielding a complication rate of 0.93%.² Laser lipolysis is a rapidly expanding field of interest with enormous potential to radically change the paradigm of liposculpture. As experience and technology grow together, safety will likely become less and less operator-dependent.

Laser Lipolysis—The Future

Techniques, uses and new devices for laser lipolysis will continue to develop as this therapeutic modality evolves. There is an intense interest in using lasers for the treatment of cellulite, a condition for which clinicians can offer very little to patients

and one which continues to be a frustrating aesthetic problem for many women. Even traditional liposuction affords only minimal improvement of cellulite, and can potentially worsen its appearance.¹⁴ In one study, a 1064 nm Nd:YAG system (Smart-Lipo) was combined with subsequent fat transfer to treat Curri grade III-IV cellulite of the hips, buttocks, thighs and abdomen. Although 84.6% of patients rate their results as good to excellent, it is unclear to what extent the laser played a role in this or whether the laser alone would have been similarly effective.¹⁴ Future, large-scale studies are necessary to determine if laser lipolysis is a reasonable treatment option for cellulite. Additionally, laser lipolysis has had some success in treating uneven contour from previous liposuction.

Within the last three years there has been a rapid increase in new devices on the market. These second-generation models offer more wavelength choices and higher power levels. Larger areas can be treated faster, and these new lasers can be used in conjunction with traditional liposuction as well as can be used for skin tightening/remodeling. As new machines emerge, we may see those with real-time visual feedback of energy delivery, or devices that allow simultaneous suction/laser discharge. Clearly, the future is bright for this effective cosmetic modality.

DISCLOSURES

Dr. Taub has received honoraria and reduced equipment from Osyris Medical, USA.

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