Seminars in Cutaneous Medicine and Surgery

Laser Lipolysis: Current Practices

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Laser-assisted liposuction (LAL) is a recent innovation within the field of liposculpture. In addition to body contouring, the indications of LAL are skin retraction in areas of flaccidity and fat melting for challenging surgical cases including revisions, areas of dense fibrosity, and large-volume cases. A photothermal effect explains the effects of LAL on tissue, regardless of the wavelength used. Advantages of LAL include reduced bruising, edema, pain, and recovery time. Disadvantages are most often related to thermal effects on tissue, such as skin blistering. Currently, 3 wavelengths, 980, 1064, and 1320 nm, are Food and Drug Administration-approved for LAL. Comparative studies examining the safety and efficacy of LAL have appeared in the medical literature. Technical considerations, emerging technology, and future indications are important to the success and continued development of this procedure.
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Laser lipolysis (LAL), also known as laser lipoplasty or laser-assisted liposuction, was piloted first in Europe and Latin America before gaining acceptance (and Food and Drug Administration [FDA]-approval) in the USA as well as in Japan.[1] The earliest description of LAL was by Dressel in 1990.[2] Shortly thereafter, Apfelberg et al[3] reported on the use of a 1064 nm light source in 51 liposuction patients. The lack of statistically significant improvements or minimization of adverse effects on the laser-treated areas compared to traditional liposuction halted the application for FDA-approval of this device.[2] It would be over a decade before laser technology was introduced through a liposuction cannula,[4] and laser lipolysis found its place among liposuction techniques.

Indications for Laser Lipolysis

Like liposculpture, the main indication for LAL is for body contouring.[5] Beyond this function, the application of laser energy creates other biological effects that result in indications for this procedure. Photothermal energy from LAL melts fat,[6,7] making LAL ideal for some traditionally challenging cases in liposculpture: (1) fibrous areas such as the male breasts, abdomen, and flanks,[6] (2) revisional surgery where tissue is difficult to penetrate or suffers from irregularities,[8,9] (3) small areas of adiposity that may be inadequately removed (e.g., periumbilical fat),[8,10] and (4) large volume liposuction in highly vascularized areas, such as the scapula, waist, and flanks.[8]

In addition to its ability to melt fat, the neocollagenesis afforded by LAL lends itself to areas that require skin tightening. The neck, arm, and abdomen are areas well-suited for this indication.[5-8]

Advantages

The most commonly mentioned advantages of LAL relate to the ease of patient recovery.[5,6,11,12] Compared to traditional liposuction, LAL may diminish postoperative pain, and decrease the extent of edema and bruising following the procedure.[5,6,8,12-14] Laser-induced thrombosis of blood vessels and closure of lymphatic channels may explain the reduction in severity of bruising and swelling after laser lipolysis.[11] Laser-operated liposculpture reduces trauma to the tissue during fat removal, resulting in improved wound healing.[15] As a result, patients have a more rapid return to daily activities.[5,15] All in all, the safety of body contouring using LAL may be increased when compared to traditional liposuction.[12]

Operator as well as patient safety is increased with the procedure. The process of fat emulsification allows for efficient fat extraction with less operator fatigue.[3,9,11] The frequency of touch-up procedures may be decreased compared to traditional tumescent liposuction performed by experienced surgeons.[7]

Two specific clinical goals make LAL a superior choice to

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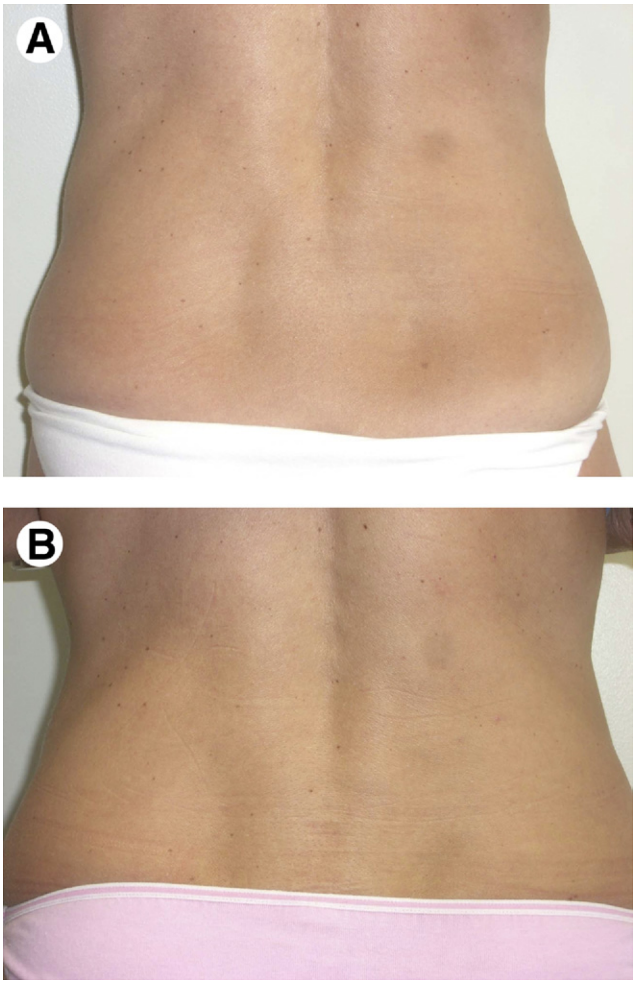

Figure 1 (A) Preoperative view of low back of 58-year-old female. (B) Three months postoperative view of low back after laser lipolysis to the low back and hips with the CoolLipo system (1320 nm) at 12 W and 50 Hz.

liposuction. When the primary goal of a surgical intervention is to treat skin laxity rather than body contouring, LAL is the appropriate choice for inducing collagen production and subsequent skin contraction.[5,10-12,16] In larger volume cases of body contouring, LAL may facilitate volume debulking by liquefying the fat before aspiration as well as decreasing blood loss during the procedure.[3,8,11] Clinical results following LAL are illustrated in Figs. 1-3.

Disadvantages

Several drawbacks exist in performing laser lipolysis. Although LAL has been used successfully as a sole procedure for body contouring, some physicians assert that LAL is not a substitute for conventional liposuction, but a complement to it.[8,10] Undercorrection after LAL may result from inadequate cumulative energies used, as many studies do not calculate this parameter.[8,11] As with any new technology, there is a significant learning curve associated with LAL,[8] although the slope is relatively steep in experienced hands.[10] Therefore, results after LAL vary, with some studies demonstrating no improvement over traditional liposuction.[12]

As earlier generation and most contemporary LAL devices require 2 steps—first for the tissue to be treated with the laser, followed by a separate aspiration step—procedure time is increased.[8,12] The innovation of dual-functioning cannulas, allowing simultaneous laser firing and suction, resolves this issue.[17] Finally, the cost of additional laser equipment is a barrier to entry for some practitioners.[10]

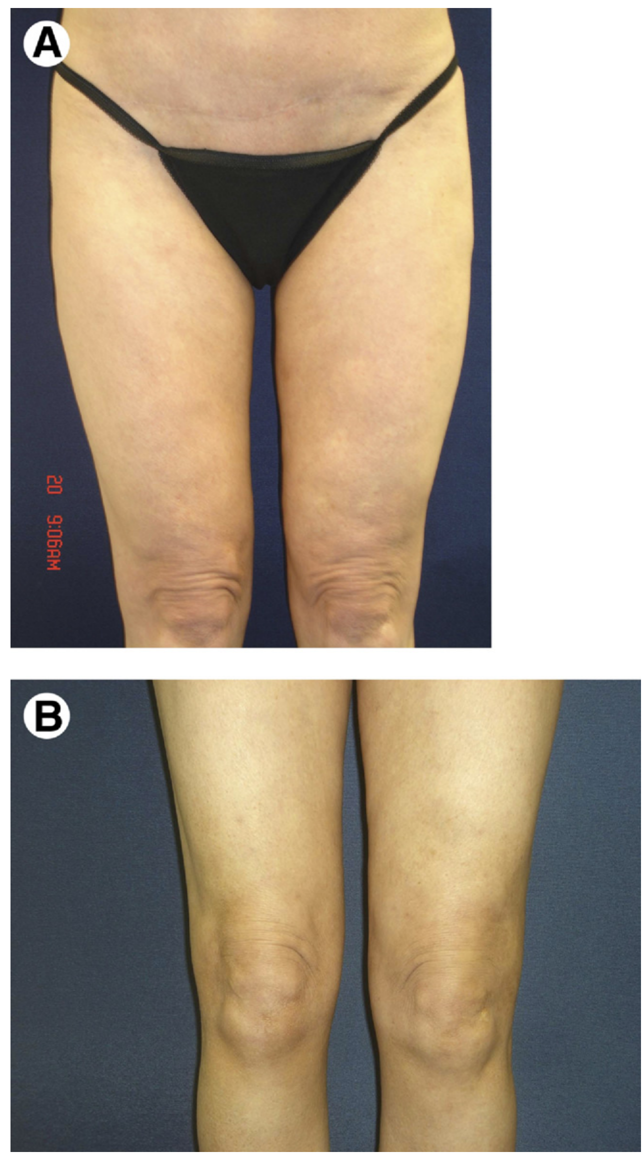

Figure 2 (A) Preoperative view of the anterior thighs in a 54-year-old female. The patient was most concerned with skin laxity and irregularity. (B) Four months postoperative view of the treatment area demonstrating improved skin irregularities and decreased skin flaccidity. The right thigh was treated with SmartLipo (1064 nm) at 6 W, 40 Hz, 3600 total Joules for 10 min. The left thigh was treated with CoolLipo (1320 nm) at 6 W, 20 Hz, 3624 total Joules for 10 min.

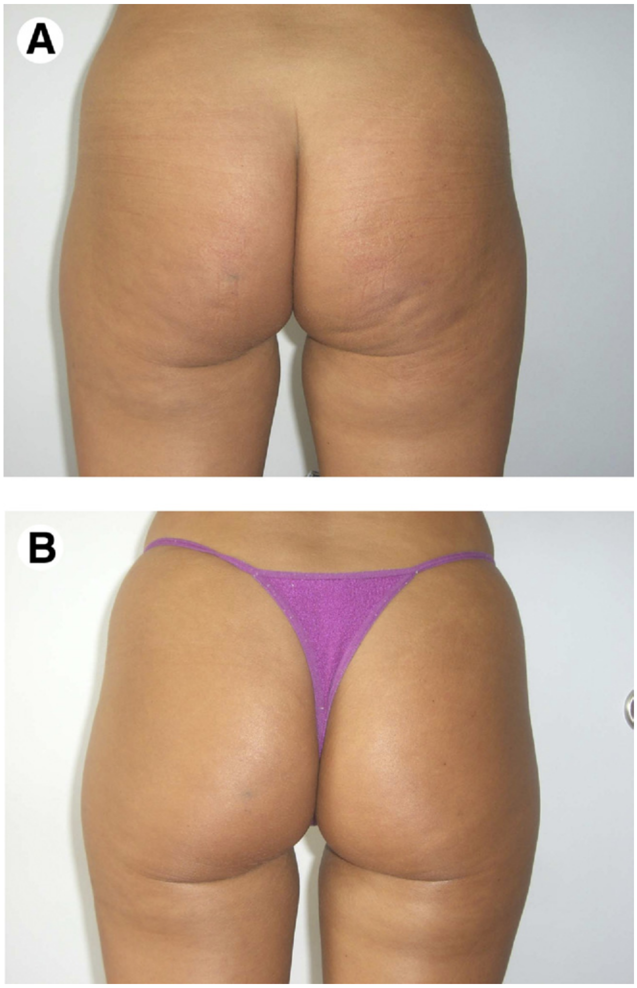

Figure 3 (A) Preoperative view of the buttocks area of a 30-year-old female concerned with skin irregularity of the buttocks region. (B) One-month postoperative view of the buttocks after treatment with CoolLipo (1320 nm) at 12 W and 50 Hz.

Mechanism of Action

Two properties must be considered in determining the efficacy of laser lipolysis given a particular device—the wavelength used and the energy delivered.[5] Unique chromophores are more selectively targeted depending on the wavelength, and the energy used will determine the thermal effect on tissues.

Different wavelengths have been selected for laser lipolysis in an attempt to specifically target fat, collagen (water), and blood vessels. According to the theory of selective photothermolysis, these chromophores will preferentially absorb laser energy on the basis of their absorption coefficients at specific wavelengths. Various wavelengths, including 924, 968, 980, 1064, 1319, 1320, and 1344 nm have had been evaluated for interactions within the subcutaneous compartment. Some wavelengths have unique advantages. The 924-nm wavelength has the highest selectivity for fat melting,[12] 1064-nm targets oxyhemoglobin providing vessel coagulation,[14] and 1320 nm has a more deeply penetrating wavelength with concentrated energy transfer, decreasing the chance for collateral tissue damage.[12]

Photoacoustic,[9] photomechanical, photostimulatory, and photothermal effects are theorized mechanisms of action in laser lipolysis.[5,18] Most of these hypothesized actions are either secondary to, or have been replaced by, the idea that heat-generated effects on tissue is the primary mode of action in LAL. For example, Khoury et al[19] asserted that photoacoustic ablation lends to thermal damage, although photoacoustic damage is difficult to evaluate histologically. Likewise, photostimulatory effects on tissue are secondary to photothermal effects.[5]

Thus, the favored mechanism of action for LAL is a purely thermal effect,[9,14,20,21] a term coined "photohyperthermia."[9] Thermal effects after LAL include the following: coagulation of collagen fibers, thrombosis of vessels, damage to nerve endings, and reversible (tumefaction) and irreversible damage (lysis) to adipocytes depending on the energy used.[1,9,15] At low laser energy, intra- and extracellular sodium and potassium balance is altered, resulting in adipocyte tumefaction.[1,15] Eventually, heat generated in the tissue from laser energy results in cellular membrane degradation (adipolysis) secondary to protein denaturation.[15] Some authors believe thermomechanical effect also plays a role in LAL, as laser treatment on fat tissue results in adipocyte rupture.[1,22]

A recent mathematical model of laser lipolysis using 2 systems—1 with a 980 nm wavelength and the other with 1064 nm—demonstrated skin contraction due to a heating effect. Mordon et al[22] demonstrated that bioheat transfer initiated from laser light resulted in collagen remodeling. In other words, laser light energy is converted into heat energy within the adipose layer. This diffuses to the dermis and eventually to the skin surface. According to the mathematical model, temperatures of 48°C-50°C must be reached within the dermis to induce collagen contraction and resultant skin tightening.[12,16,22] Depending on the study, a dermal temperature between approximately 50°C and 70°C translates to a skin surface temperature of approximately 40°C-41°C.[12,16,22]

Damage is energy-dependent.[1,10] Three thousand joules of energy resulted in significant irreversible damage compared to an area treated by lower energy (1000 J).[15] The dose-dependent relationship between laser energy and thermal damage has been duplicated by other histologic studies.[1,16,19]

Increasing energy creates not only adipocyte changes but also tissue fibrosis.[14] Collagen damage from thermal damage promotes collagen remodeling, leading to increases in skin tone and texture. These effects continue to improve for 3-6 months after the procedure.[8,16]

Histologic Findings

The histologic findings from human tissue models support the photothermal effect of laser lipolysis, regardless of laser wavelength. In 2002, Badin et al[8] found the immediate cellular changes after laser treatment of subcutaneous tissue to include ballooning and rupture of fat cells with reduced bleeding due to vessel coagulation. At 3 months after treatment, histologic studies demonstrated new collagen formation and remodeling.[8]

Additional histologic studies using and comparing wavelengths of 980, 1064, and 1320 nm all provided similar evidence for the dose-dependent nature of cellular changes after LAL.[1,15,16,19,23] Cadaveric studies as well as ex vivo and in vivo studies first showed reversible cellular damage seen as cellular ballooning (tumefaction). Further energy delivery resulted in cell membrane destruction and irreversible cell lysis. Laser treatment also caused thermal damage to collagen fibers, vessel thrombosis, and reduced areas of bleeding compared to liposuction treated areas.[1,15,23] Liquefaction of adipocytes, carbonization of tissues, and finally epidermal injury was observed only at the highest energy settings.[1,16,19,23]

Invasive Laser Lipolysis Technology

Devices of 3 wavelengths have been FDA-approved for use in the U.S. for laser lipolysis—980 nm (continuous wave), 1064, and 1320 nm.[5] All devices described for use in LAL in the medical literature are discussed below, and currently available platforms are outlined in Table 1.

Carbon Dioxide Laser

The carbon dioxide laser (wavelength 10,600 nm) was used briefly during the early development of LAL.[24] The ablative laser was used during neck and jowl liposuction to create platysmal tightening, dermal remodeling, and fat vaporization. Although the clinical results in skin tightening were impressive, the large submental incision necessary for introduction of the laser to the subcutaneous layer was a major drawback of the procedure.

Diode Laser

924/970 nm Multiplex System

According to unpublished data,[12] the 924 nm wavelength has a high specificity for fat, while the 970 nm targets collagen to promote tissue tightening. When used together, the dual wavelength system did not increase operating time. Furthermore, a quick recovery time was observed with a decrease in postoperative ecchymoses compared to traditional liposuction.[12]

980 nm Device

A recent study by Reynaud et al[11] reported on the effects of a 980-nm diode device (Pharaon, OSYRIS, Hellemmes, France) for use in LAL. The laser system consists of a 600 μm optical fiber contained within a rounded 1 mm microcannula. The laser is fired in a continuous mode at energy settings from 6 to 15 W depending on the treatment area. Fat lysate may be aspirated or removed by manual surgeon massage after laser treatment. Five hundred thirty-four procedures were performed in 334 patients over various locations. There were no serious adverse events although most patients experienced ecchymoses that resolved within 1 week. Patient satisfaction was high, with 58% of patients very satisfied, and 22% re-

Table 1 Devices Used in Laser Lipolysis

Trade Name (Manufacturer)	FDA-Approval Date	Wavelength (Nm)	Laser Type	Fiber Size (μm)	Power (W)	Pulse Duration (μs)	Repetition Rate (Hz)	Pulse Energy (mJ)
SlimLipo (Palomar, Burlington, MA)	April 2008	924, 975	Diode	1500	30	Continuous	Continuous	N/A
Lipotherme (Osyris/Med Surge advances, Dallas, TX)	Not FDA-approved	980	Diode	600	25	Continuous	Continuous	N/A
SmartLipo (Cynosure, Westford, MA)	October 2006	1064	Nd: YAG	300, 600	18	100	40	150
LipoLite (Syneron, Yokneam, Israel)	May 2008	1064	Nd: YAG	550		100-800	50	<250-800
SmartLipo MPX (Cynosure, Westford, MA)	October 2006	1064 1320	Nd: YAG	600	20, 12	150	40	500 300
CoolLipo (CoolTouch, Roseville, CA)	January 2008	1320	Nd: YAG	200, 320, 500	20, 25	100	20-50	
ProLipo (Sciton, Palo Alto, CA)	July 2007	1064	Nd: YAG	600-1000	20 (25 outside US)	10-100	50	800
ProLipo Plus (Sciton, Palo Alto, CA)	December 2008 March 2009 (higher energy system with 1319 nm)	1064 1319	Nd: YAG	600-1000	30-40 (1064 nm) 20-40 (1319 nm)	10-250	60	800

FDA, Food and Drug Administration. Adapted from Goldman et al[5] and Parlette et al.[12]

porting they were satisfied with the procedure. Patients were able to return to normal daily activities within 24 hours. Physicians observed a reduction in contour irregularities and immediate skin retraction during the procedure.

Diode lasers such as the 980 nm laser lipolysis device may offer an advantage of increased power and efficiency (by approximately 30%) compared to other wavelengths.[1] This is particularly interesting given that the coefficient of fat absorption of both the 980 and 1064 nm wavelengths were found to be very similar.[1] However, with higher energy and continuous pulsing comes at an increased risk of tissue damage and subsequent scarring. Carbonization of adipose tissue has been documented using the 980 nm device.[5]

The only FDA-approved 980 nm device for LAL is Lipotherme (MedSurge Advances, Dallas, TX).

Nd: YAG Laser Devices

1064 nm Device

The 1064 nm wavelength targets oxyhemoglobin, allowing for efficient vessel coagulation.[14] Dermal collagen-bound water and fat also absorb the laser wavelength but less efficiently than the longer 1320 nm wavelength, particularly at increasing tissue depths.[12,21] The thermal energy spread is diffuse, causing bulk heating of the treated tissues.[16]

Apfelberg et al[3] reported in 1994 on the first 1064 nm laser device for use in LAL. In a clinical trial intended for a new device application to the FDA, this study consisted of 51 patients treated with a 1064 nm Nd: YAG laser (Heraeus Lasersonics, acquired by Laserscope, San Jose, CA) during liposuction. Fifteen of these patients had split area treatment with LAL and conventional liposuction.[3] The system incorporated a 600 μm fiber contained within a 4- or 6-mm cannula. A chilled saline infusion was required to flow through the cannula chamber to cool the tip during the procedure. No clear benefit for LAL was demonstrated in clinical improvement or patient discomfort.[3] Furthermore, no statistically significant difference was found in postoperative edema or ecchymosis between either treatment side, although there was a trend toward superior results on the LAL-treated side.[2] Although the device may have reduced surgeon fatigue during the procedure, the 5 participating physicians commented the system was cumbersome to use.[3] Given the lack of benefit of LAL using this device, FDA-approval was not pursued.

In October 2006, the SmartLipo device (Cynosure, Westford, MA; DEKA, Calenzano, Italy) gained FDA approval for the “surgical incision, excision, vaporization, ablation, and coagulation of soft tissues” as well as for LAL.[5,6] The 1064 nm Nd: YAG SmartLipo device currently delivers a maximum energy of 18 W, increased from the original 6 W output. The optical fiber has been increased from 300 to 600 μm, and treatment is usually administered at 150 mJ/pulse, 40 Hz, with a 100 ms pulse width.[5]

As the SmartLipo device has been on the market the longest, the largest body of published literature accompanies this laser wavelength. Two studies have observed high patient satisfaction after treatment with this 1064 nm Nd: YAG platform. Dudelzak performed LAL on the arms of 20 patients, and all patients were “very satisfied” with their results despite modest arm circumference reductions that did not differ from traditional liposculpture.[25] Lack,[26] in a comparative cohort study of 46 patients, found patients had higher treatment satisfaction scores with the 1064 nm device compared to tumescent liposuction, and another study demonstrated a 37% subject-rated improvement 3 months after LAL.[10]

Several other studies have examined the safety and efficacy of LAL using the 1064 nm wavelength. In a noncomparative study of 245 patients undergoing LAL, Badin et al[8] found less trauma, bleeding, and swelling after LAL compared to their personal experience with liposuction. Both Sun et al[14] and Kim and Geronemus[10] reported no serious adverse effects after case studies of LAL in 35 and 29 patients, respectively. In terms of efficacy, visible skin retraction, significant cosmetic improvement, and a dose-dependent response leading to higher MRI-measured volume reduction has been reported in clinical studies.[8-10]

Another pulsed 1064 nm Nd-YAG device became available for LAL in the US market in May 2008. Lipolite (Syneron, Yokneam, Israel) consists of a variable pulse system (pulse width of 100-800 ms) with a maximum power of 12 W, maximum pulse energy of 800 mJ/pulse, and repetition rate up to 50 Hz. Energy is delivered by a 550 μm fiber ensheathed within a 1.2 mm microcannula. Like the SmartLipo system, aspiration must be performed in a separate step after LAL.

1320 nm

This wavelength is efficiently absorbed by fat and water[12,16] and is the longest wavelength used for LAL, targeting mostly dermal and subcutaneous collagen, water-containing adipocytes, and collagen bound water.[21] The 1320 nm device may provide less collateral tissue damage, as energy deposition to tissues is concentrated around the laser tip.[12,16] Because of its preferential targeting of collagen, the 1320 nm laser device may allow for greater tissue tightening.[12]

The 1320 nm device was FDA-approved in January 2008 and marketed as CoolLipo (CoolTouch, Roseville, CA). CoolLipo delivers a maximum of 25 W through a 500 μm fiber. The pulsed firing is delivered with a 100 ms pulse width at 20-50 Hz.[5] A dual port microcannula allows both LAL and aspiration to occur simultaneously.

One study has examined the clinical effects of the 1320 nm device to the 1064 nm and multiplex (1064 + 1320 nm) devices.[17] Mild to moderate improvement in skin laxity was noted in 10 patients undergoing laser lipolysis of the arms, abdomen, flanks, or thighs with the 1320 nm device at 10 W, 40-50 Hz, followed by aspiration.

Multiplex Devices

A more recent technological development within the field of LAL is the 1064/1320 nm multiplex device (SmartLipo MPX, Cynosure, Westford, MA). This incorporates sequential firing of the dual wavelengths, although either wavelength can be fired alone.[5] The newer platform also includes a handpiece with motion-sensing feedback, termed “SmartSense,” allowing an automatic shut-off mechanism when maximum temperatures are reached. The platform can fire up to of 20 W at

1064 nm and 12 W at 1320 nm[5] through a 600 μm fiber contained within a 1.0-1.5 mm microcannula.

The scientific premise for combining the 1064 and 1320 nm wavelengths is to exploit their individual properties and allow for them to act synergistically, particularly with regards to hemostasis. The 1320 nm wavelength converts hemoglobin to methemoglobin.[12] The 1064 nm not only targets oxygenated hemoglobin, but has a great affinity to methemoglobin, thereby enhancing the effects of the 1320 nm firing.[12]

A three-arm treatment study was recently conducted, comparing the SmartLipo MPX device, to either wavelength alone for LAL of various body areas. Woodhall et al[17] found the multiplex device to provide significantly better clinical improvement in skin laxity than the other 2 devices. Two of 20 patients receiving treatment with the multiplex device sustained thermal burns, and in both cases intraoperative skin surface temperatures exceeded 40°C.

A second multiplex device is also available from Sciton (Palo Alto, CA) as ProLipo, incorporating the 1064 and 1319 nm wavelengths. The ProLipo 1064 nm platform has been approved since July 2007. The 1319 nm component was initially FDA-approved on December 1, 2008, with a higher energy system gaining FDA approval on March 6, 2009. The newest platform can deliver a maximum energy of 40 W for both the 1064 and 1319 nm wavelengths. The 1064-nm wavelength was selected in this multiplex system for its affinity for oxyhemoglobin, whereas the 1319 nm wavelength has high absorption of water. In addition, the company reports that the energy produced from the 1319 nm wavelength concentrates around the fiber tip and targets fibrous septae by damaging associated collagen. The multiplex system may use differential blending of wavelengths to exert more vascular effects which the 1064 nm wavelength predominates or more skin tightening effects by favoring the 1319 nm wavelength.

Technique

Patient work-up and preparation is similar to that of the tumescent liposuction technique. Patients are marked in a standing position. Patients are prepped in a sterile manner and typically given a light sedative medication by the oral, intramuscular, or intravenous route. Less commonly, some physicians will perform LAL under spinal or general anesthesia.[5]

Laser lipolysis may be performed independently or in combination with traditional liposuction. In most cases, tumescent anesthetic fluid similar to the Klein formulation is infiltrated in the area to be treated. After infiltration is complete, a baseline temperature is taken with an infrared temperature sensor and small adit sites are created by a direct puncture technique using a number 11 surgical steel blade. The microcannula housing the laser fiber is inserted under the skin into the fat compartment. With currently-used devices, the laser fiber tip must be advanced outside the cannula tip, usually by 2-3 mm.[8]

Some practitioners begin laser lipolysis in the deep fat compartment first, then move more superficially within the adipose layer in a fan-like motion. A red aiming beam (HeNe) is visible under the surface of skin, with the intensity increasing as the laser light becomes more superficial. Protective eyewear should be used by all individuals in the operating room during the entire procedure. The cannula is moved in a to-and-fro manner in a fanning pattern at a velocity of approximately 100 mm/s. Some authors stress the need for slow movement of the cannula through the tissue, to maximize laser-tissue interaction.[8] The operator's dominant hand is used to propel the cannula back and forth within the treatment area, whereas the nondominant hand is placed on the skin surface for tactile feedback on the skin surface temperature.

Typical starting temperatures at the skin surface are 26-28°C. Serial temperature readings are taken during the procedure, and treatment discontinued in a given area when the skin surface temperature registers 38°C-40°C or when there is a complete loss of resistance during cannula advancement, signaling emulsification of the fat, whichever endpoint is reached first. At this clinical endpoint, the skin feels moderately warm to the touch.[11] Areas with a thinner dermal and adipose layer (eg, submental area) will reach the target temperature more quickly, and special care must be taken in treating such areas.[16] Some of the available technology now take thermal readings at the cannula tip as well as provide skin surface temperature readings through an infrared thermal monitor screen (SmartLipo MPX).

After laser lipolysis is complete, the emulsified fat may be removed by aspiration with traditional liposuction or extrusion through incision sites by gentle physician massage.[14] One system (CoolLipo) has integrated cannulas that allow for LAL and aspiration simultaneously. Aspiration continues until the appropriate body contour is reached. A pinch test is used at the conclusion of the procedure to test for any contour irregularities.

Adit sites are left open for drainage and wound dressings applied in a manner similar to traditional tumescent liposuction. Patients wear compression bandages or garments between 3 and 30 days depending on the area treated.[8] Patients may resume daily activities as tolerated, usually within 24 hours. Pain management usually requires only acetaminophen, and occasionally a codeine-containing medication. Patients can usually resume vigorous physical activity within 7 days. Postoperative physiotherapeutic treatments or lymphatic drainage massage are used by some to accelerate patient recovery and enhance the clinical result.[5,18]

Complications/ Adverse Effects/Precautions

The complication rate after LAL is extremely low in well-trained hands, estimated at 0.93% according to a prospective trial in 537 patients.[7] Ecchymoses, edema, and pain are the most commonly-experienced adverse events,[10,18] similar to those expected after liposuction and usually mild in severity. Paresthesias and hyperpigmentation have also been reported.[5,10] Rare side effects similar to liposuction-related complications are also possible, including seroma, infection, neuropathy, and minor contour irregularities.

Some of the most common adverse effects related to LAL are often secondary to the heat produced by the laser fiber. If the laser energy is inappropriately high, or the local temperature rises above 47°C, the likelihood of a thermal burn increases.[5] In this same study of 537 patients using a 1064 nm Nd: YAG laser, 4 skin burns occurred.[7]

Although most reports on LAL indicate decreased bruising as a distinct advantage over traditional liposuction, 1 author has disputed this advantage with a case series and a retrospective review.[26,27] Three of 44 patients in 1 series experienced severe ecchymoses, with tenderness lasting beyond the resolution of bruising after LAL with a Nd: YAG system.[27] Lack[26] also found a higher degree of edema, ecchymosis, skin sensitivity, and pain in LAL patients compared to those undergoing traditional liposuction, although no statistical analysis was performed.

Blistering of the skin is a direct result of superficial thermal damage. Superficial treatment more readily leads to epidermal injury.[16] Epidermal injury is typical when the skin surface temperature reaches 47°C, with blistering at temperatures of 58°C or greater.[16] However, in clinical practice, we have witnessed epidermal blistering when surface temperatures are far below 58°C. Therefore, continuous thermal monitoring is necessary and the temperature endpoint should not exceed 40°C.

The presence of tumescent fluid may provide some epidermal protection. According to Mordon et al,[22] cooled tumescent fluid infiltration decreases skin surface temperature greatly. The large volume of tumescent fluid used for anesthesia serves as a large reservoir for heat transfer. Just as cooled tumescent fluid lowers the skin surface temperature, tumescent fluid heated by laser light from bioheat transfer could cause epidermal heating, with increasing temperatures occurring beyond the treatment time. Therefore, we advocate close monitoring of skin surface temperatures with an infrared temperature sensor or similar technology. We often discontinue laser lipolysis in an area once a temperature of 38°C-40°C has been reached, knowing that the maximum temperature may reach 41°C several minutes later. If this does occur, we quench the area quickly with an ice bath.

A theoretic concern of laser lipolysis is its effects on serum lipid levels. Laser-induced adipocyte rupture causes the release of intracellular lipid contents, and how this is metabolized by the body is unclear. Studies on lipid levels after laser lipolysis indicate no change in serum lipid levels after the procedure.[22,28] Mordon et al[22] followed serial lipid panels in 4 patients for 30 days after LAL and found no deviation from baseline levels. Goldman et al[28] conducted LAL with a 1064 nm and observed no increase in cholesterol or triglyceride levels after the procedure. Woodhall et al[17] also found no change in triglycerides in 39 patients undergoing LAL with the 1064, 1320 nm, or multiplex (1064 + 1320 nm) device. Given the lack of serum lipid level elevation after LAL, there seems to be no lipid-related renal or hepatotoxicity risk. Lipid metabolism after LAL has not been studied although mechanisms of action have been postulated. Lipid metabolism may occur slowly, avoiding changes in serum lipid levels or alternatively, lipids may be cleared through a phagocytic route via macrophage digestion.[22]

Noninvasive Laser Lipolysis Technology

Several technologies have appeared recently in the medical literature as possible noninvasive laser alternatives for adipocyte destruction. The advantage of such technology, if effective, would be the nonsurgical delivery of therapy. However, the relative paucity of available studies as well as the lack of reproducibility from one of the studies casts doubts on the true effects and efficacy of these light sources.

The first noninvasive laser light source reported to produce fat liquefaction was a 635 nm, low level energy laser source.[29] Low-level laser therapy requires that the delivery of laser energy does not result in a temperature increase in the treated tissue. A similar light source has been used in a variety of applications in the fields of physical therapy and anti-inflammatory research[30] and is FDA-approved for pain alleviation and for use with lipoplasty.[31] Other applications include promotion of wound healing and edema reduction.[29] The clinical effects may be partially explained by the multitude of effects on the skin from the action spectra produced within the wavelengths of 630-640 nm. These include fibroblast and keratinocyte proliferation, microcirculatory stimulation, and scar dimunition.[29]

In an effort to exploit the biomodulatory effects of low-level 635-nm laser light (Erchonia Laser PL3000, Majes-Tec Innovations, Inc, Mesa, AZ), Neira et al[29] subjected 12 human postlipectomy adipose tissue samples to treatment for increasing time periods. The device consists of a single diode, variable Hertz, and red light source. Neira et al[29] reported 80% adipocyte membrane disruption after 4 minutes of exposure to laser light, and 99% disruption after 6 minutes. Electron microscopic examination revealed transitory pores within cell membranes, deflation of adipocytes, and emptying of cellular contents.

The favorable results reported by Neira et al[29] in 2002 failed to be reproduced by an independent study in 2004 by Brown et al.[31] Using both porcine and human models, no cellular changes were observed after low-level 635-nm laser treatment. Despite lengthy exposure times of up to 60 minutes, no change in adipocyte structure or morphology was indicated, disputing prior research that this diode laser source produces adipocyte liquefaction.[31]

A second noninvasive laser light source has been used to target adipocytes. A 1210 nm, continuous wave semiconductor diode laser was used by Wanner et al[32] to treat 24 patients. A 3-second exposure with precooling was used at increasing fluences to treat the abdominal area. The treatment was painful, necessitating the use of local anesthesia. Erythema persisted after treatment, in some cases several days. Histologic evidence of fat necrosis was noted, but dermal damage was also present with increasing energy. The authors concluded that this laser light source may preferentially target adipocytes, but within a narrow therapeutic window. Further refinement in pain management, epidermal cooling, and energy delivery is necessary before this laser light source is a safe and reliable device for targeting fat.

Future Applications

Appropriate uses for LAL will continue to develop as this technology matures. It has been suggested that LAL may be a suitable treatment for axillary hyperhidrosis,[6] or for revising flaps.[5]

There is a particular interest in using LAL for the treatment of cellulite, a condition that affects approximately 85% of postpubertal females.[33] Cellulite continues to be a frustrating esthetic problem for many women without treatment modalities that offer dramatic improvement. In fact, traditional liposuction affords only minimal improvement of cellulite, and may even worsen its appearance.[18]

Combination treatment of LAL with autologous fat transfer was used in a small case series of 52 female patients.[18] A 1064 nm Nd: YAG system (SmartLipo) was combined with subsequent fat transfer to treat Curri grade III to IV cellulite of the hips, buttocks, thighs, and abdomen. Patients were very pleased with the clinical outcome, with 84.6% of patients rating their results as good to excellent, but the effect of the laser alone was unknown.[18]

We conducted our own study to answer this question. Nine patients and 11 sites were treated in a comparative study of LAL (CoolLipo) to mechanical disruption with a liposuction microcannula (Palm MP, Goldman MP, presented at the ASDS national meeting, October 4, 2009, Phoenix, AZ). There was no difference between treatment groups with regards to cellulite grading after treatment, with both LAL and mechanical disruption improving 1 point on a 4-point cellulite scale. Patient-scored improvement did not differ between treatment sides, but physician-scoring indicated increased improvement on the LAL-treated side. Future, large-scale studies are necessary to determine if LAL is a suitable treatment option for cellulite.

Conclusions

LAL development has occurred rapidly over the last decade with the advancement of device platforms, usable wavelengths, surgical techniques, and new indications. LAL is a safe technique in experienced hands and with proper monitoring. It has distinct advantages to traditional liposuction that complement its use. Future studies may better characterize treatment parameters and the optimal technology for use in LAL.

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