Aesth Plast Surg (2013) 37:246–253
DOI 10.1007/s00266-012-0027-7

REVIEW AESTHETIC

Laser Lipolysis Using a 924- and 975-nm Laser Diode in the Lower Extremities

Elena Bravo Brañas · Javier Moreno Moraga

Received: 27 April 2012 / Accepted: 9 November 2012 / Published online: 26 January 2013

Abstract
Background Laser technology provides the desired destruction of adipose tissue, hemostasis, and good skin retraction with a minimum of discomfort and a quick return to normal life for the patient. Here we present our experience with the use of laser-assisted liposuction (LAL) with a 924- and 975-nm laser diode and compare it with traditional liposuction alone.
Methods A total of 430 patients were reviewed for this study. Three hundred thirty patients were treated with the 924- and 975-nm laser diode for laser lipolysis and 100 patients were treated with traditional liposuction of the anterior and inner thigh, the knee, the calf, and the trochanter. Patients were assessed by means of ultrasound. Pictures were taken and the degree of satisfaction was assessed. All complications were recorded.
Results A total of 521 laser lipolysis procedures were performed at different areas: anterior thigh (86), inner thigh (122), trochanter (204), knee (67), and calf (42). The mean energy was area-dependent and evaluated in kJ: anterior thigh (15), inner thigh (14), trochanter (22), knee (5), and calf (4.5). The mean reduction of subcutaneous tissue with LAL in the anterior part of the thigh, the inner thigh, the calf, the knees, and the trochanter was 1.45, 1.9, 1.15, 1.2, and 3.6 cm, respectively. One hundred traditional liposuction procedures were performed for different areas: anterior thigh (27), inner thigh (38), trochanter (72), knee (21), and calf (12). The mean reduction of subcutaneous tissue in the anterior part of the thigh, the inner thigh, the calf, the knees, and the trochanter was 1.2, 1.6, 0.9, 0.6, and 3.2 cm, respectively. All patients who underwent LAL had superior satisfaction compared to those who had liposuction alone.
Conclusion Laser lipolysis with 924- and 975-nm diodes is adequate treatment for removal of adipose deposits and to obtain aesthetically good skin results, with a minimum of recovery time and high patient satisfaction.
Level of Evidence IV This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Laser lipolysis · Laser diode · 924 and 975 nm · Adipose tissue · Skin tightening

Traditional liposuction is one of the most demanded aesthetic surgery procedures. Individuals who have localized fat deposits but who are not obese, about two thirds of the world's population, are the targets for this procedure [15]. However, many of these potential patients do not choose this intervention because it is traumatic, has associated risks and a slow recovery time, and the results in some body zones are uncertain [7].

Laser lipolysis, also called laser-assisted liposuction (LAL) or laser lipoplasty, was first described in 1990 [2]. This technique is now widely used throughout Europe and America [17]. Its aim is to obtain more uniform destruction of adipose tissue, greater skin contraction called "skin tightening" and shrinkage of tissue, and improved tissue hemostasis and to avoid damaging adjacent structures. All of these features help the patient have a quicker recovery

E. B. Brañas (✉)
La Paz University Hospital, Madrid, Spain
e-mail: elbrabra@hotmail.com

J. M. Moraga
Laser Medical Institute, Madrid, Spain

and less discomfort with the procedure [6, 16]. Different laser types with various wavelengths (924, 968, 980, 1,064, 1,319, 1,320, 1,344, 1,440 nm) have been described but there is controversy about the effectiveness of different wavelengths on adipose tissue [20].

We report the results obtained in lower-extremity laser lipolysis using wavelengths of 924 and 975 nm and compare laser lipolysis to traditional liposuction. The amount of energy during the procedure per treated area was recorded to compare it with other types of lasers described in the literature.

Materials and Methods

Patients

Between January of 2008 and March of 2011, a prospective study was done on 430 consecutive patients who were treated at our institution (Instituto Médico Láser) for removal of fat deposits in the lower extremities. All patients had a body mass index (BMI) between 18.5 and 30. The criteria for exclusion were a BMI >30 and general contraindications for surgery, including hematological alterations; heart, liver, or kidney failure; pregnancy; or allergy to local anesthesia.

The first 100 patients of this study were treated with a traditional liposuction technique and served as a control group. The following 330 patients were treated with laser lipolysis and liposuction. All patients included in this study are consecutive patients and only patients who met the exclusion criteria were excluded from this review.

Laser

A laser diode with the SlimLipo™ Aspire™ platform (Palomar, Burlington, MA) and equipped with two wavelengths (924 and 975 nm) was used. The former wavelength has an absorption coefficient two times greater than that of water for the lipid membrane interface and obtains a temperature effective for the disruption of adipocytes and the subsequent release of triglycerides. The latter wavelength has the maximum absorption coefficient for water, causing collagen coagulation and, hence, skin retraction of the dermis. The energy is emitted using a continuous emission mode, which is safer than pulse emission for it avoids the thermal peaks that may cause burns [18]. Thermal coagulation of local vessels may modify angiogenesis and avoid recurrence of fat deposits [5, 10]. The laser's power can be adjusted from 8 to 40 W. The laser has a touch screen by which the user selects the quantity of energy to be emitted per unit of volume at 924 and 975 nm, depending on the characteristics of the area to be treated.

The optic fiber has a diameter of 1.5 mm, is flexible, and has a conical design that diminishes the mechanical damage of the surrounding tissues (Fig. 1). Its tip illuminates through a guide laser (red beam) when the energy is freed to control its position.

Technique

The zone to be treated was marked with the patient standing. All surgeries were performed on an ambulatory basis under aseptic conditions and a single dose of intravenous antibiotic. A single dose of oral midazolam 7.5 mg was given 30 min before the procedure. Local anesthesia was used (lidocaine 0.5 %) for 5 mm incisions, and Klein-type tumescent infiltration was performed with a maximum dose of 40 mg/kg [14].

Laser-Assisted Lipoplasty Procedure

The sterile zone was prepared and the optic fiber was introduced into the subcutaneous tissue and moved in a fan-like fashion in different planes (deep and medium depth). During this part of the procedure, 65 % of the total energy to be used was distributed in a homogeneous way to break up the adipocyte membrane. In a second step, the 3 mm liposuction cannula was introduced to aspirate the liquefied fat, and then the optic fiber was again introduced into the subcutaneous (superficial) plane to deliver the final 35 % of the total energy to increase the coagulation effect on the collagen and to remove all the adipose accumulations that could create irregularities.

The total amount of energy to be used was calculated according to the expected volume of fat to be removed; the rate was 3.5 kJ/100 ml. During treatment, the physician uses the hand that is manipulating the cannula to evaluate how the tissue resistance diminishes while energy is being emitted. With the other hand, the physician must evaluate

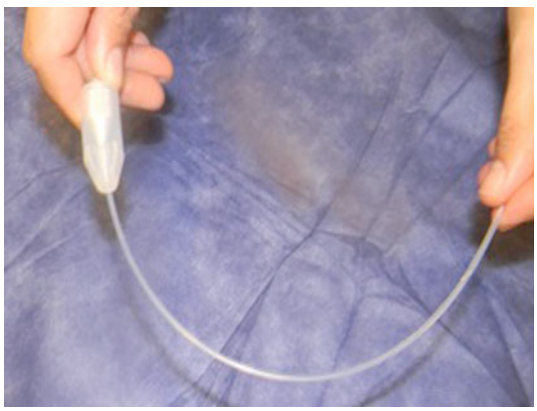

Fig. 1 Optical fiber used for laser-assisted lipoplasty. The flexible design avoids perforations

both the temperature and how the cutaneous pinch becomes progressively thinner.

Traditional Liposuction

This technique was performed as described for the LAL procedure but with 3- and 4-mm liposuction cannulae and without the use of the laser (corresponds to step 2).

At the end of either procedure the patient is placed in an elastic compression garment that must be worn for 2–4 weeks, depending on the tumefaction in the treated zone. Nonsteroidal anti-inflammatory drugs are prescribed initially along with oral antibiotics and gastric protection during the first week.

Monitoring

Follow-up visits were scheduled postoperatively at 1 week, 1 month, 3 months, 6 months, and yearly thereafter. At each follow-up visit the following occurred: (1) ultrasound measurements of subcutaneous tissue thickness were used as an objective assessment of fat tissue reduction. The distance between the deep fascia and the dermis was measured in centimeters. The same technician and ultrasound machine were used. In the inner thigh, the measurement was done in the upper third, in the zone that has the greatest adipose accumulation. In the anterior part of the thigh, the measurement was done where the upper and middle third areas meet; in the trochanter, it was done around the subgluteal fold; in the knee, in the superior region of the patella; and in the calf, in the area where the leg's upper and middle third areas meet. (2) The grade of satisfaction of the patients was self-assessed on a scale from 1 to 5 (1, excellent; 2, good; 3, fair; 4, poor; 5, very poor). (3) Photographs of front, back, oblique, and lateral views were taken at each follow-up visit.

Statistical Analysis

The normal distribution of patients treated per different areas was analyzed using the χ^2 test. Descriptive statistical analyses were performed to show the evolution of the analyzed parameters (including depth of fat reduction) over time and are shown in figures. Patient satisfaction was analyzed using the χ^2 test.

Results

The treated areas of the LAL and traditional liposuction patients were compared and no statistical differences were found ($p = 0.75$). The most frequently treated zones were the trochanter and the inner thighs in both procedure groups (Table 1).

All treated patients were women with a mean age of 38.5 years (range = 18–63). In the LAL group, the mean age was 41.3 years (range = 20–63), and in the SAL group, it was 35.6 years (range = 18–56). There were no differences in BMI between the LAL group and the SAL group (27.7 vs. 26.5, respectively). In more than half of the patients (58 %) two areas were treated during the same session. The most frequent combination of treated areas was the trochanter with inner thigh followed by the trochanter with anterior thigh and the knee with inner thigh (Figs. 2, 3, 4, 5).

The amount of tumescent infiltration ranged between 350 and 3,800 ml, with a mean of 2,200 ml depending on the area and volume of the area (all volumes are for bilateral areas). The volume of infiltration was similar for both procedures. The mean total amount of fat removed and energy delivered per zone in LAL and SAL is summarized in Tables 2 and 3.

Subcutaneous tissue thickness from treated areas assessed by ultrasound at 1 week, 1 month, 3 months, and 6 months is shown for both procedures in Fig. 6. The mean reduction of subcutaneous tissue with LAL in the anterior part of the thigh, the inner thigh, the calf, the knees, and the trochanter was 1.45, 1.9, 1.15, 1.2, and 3.6 cm, respectively. The values for traditional liposuction were 1.2, 1.6, 0.9, 0.6, and 3.2 cm, respectively. The mean satisfaction rating was superior for the LAL procedure ($p = 0.00001$) (Fig. 7).

In the LAL group, 15 % of the cases had erythema in the treated areas that disappeared within 24 h. All patients returned to their usual daily activities within 2 days. There were no cases of burns, infection, or impaired healing. In 85 % of the cases, ecchymosis was minimal and resolved within 10 days; and it was not observed in any patient after 4 weeks. Eighty-nine patients reported transient paresthesia that disappeared with conservative treatment by the 3 month follow-up. All patients were prescribed and used the same kind of pressure garment at the end of the procedure. Two hundred sixty patients (79 %) used it for 2 weeks and the remainder for

Table 1 Number of patients treated by each procedure per area

Treated area	Traditional liposuction	Laser-assisted lipoplasty
Anterior thigh	27	86
Inner thigh	38	122
Knees	21	67
Calf	12	42
Trochanter	72	204

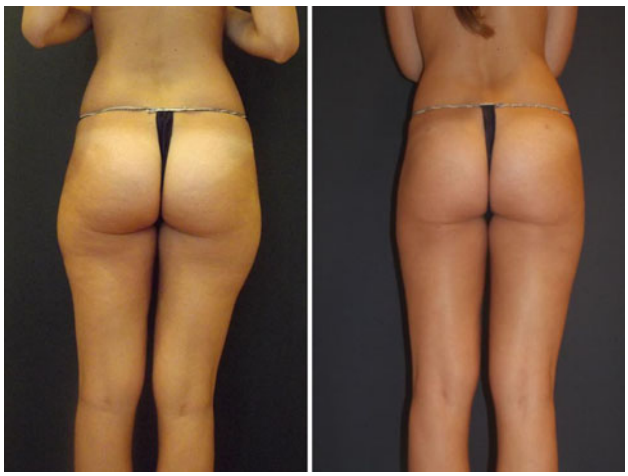

Fig. 2 A 34-year-old patient with asymmetry due to scoliosis. A trochanter lipolysis was performed and the preoperative and 3-month follow-up photos are shown. Power (924–975) nm, (20–20) W; delivered energy, 18 kJ per area

Fig. 4 A 33-year-old patient in whom an anterior and inner-thigh lipolysis was performed. Preoperative and 3-month postoperative photos are shown. Power (924–975) nm, (20–20) W; delivered energy, 31 kJ per area

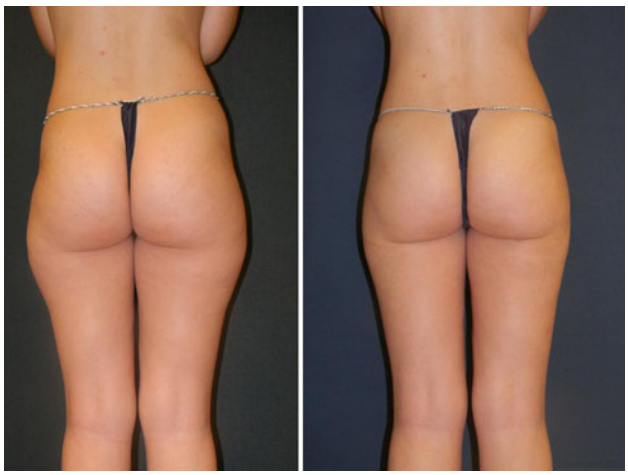

Fig. 3 A 27-year-old patient with pelvis imbalance due to limb length discrepancy. A trochanter lipolysis was performed and the preoperative and 3-month follow-up photos are shown. Power (924–975) nm, (20–20) W; delivered energy, 20 kJ per area

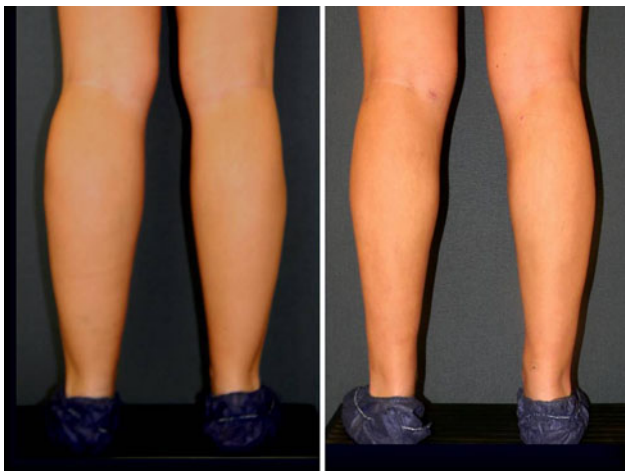

Fig. 5 A 42-year-old patient in whom lipolysis was performed in the knee, calf, and ankle. Preoperative and 3-month follow-up photos are shown. Power (924–975) nm, (15–15) W; delivered energy, 9 kJ per area

3–4 weeks. No patient used it longer than 4 weeks. Four patients who had the trochanteric area treated underwent a touch-up procedure because of irregularities or asymmetries in the area (1.2 %). No adverse systemic effects were reported.

In the traditional liposuction group all patients had ecchymosis and it was more severe and lasted longer than that in the LAL group. Eighty percent of the patients showed ecchymosis at 2 weeks and 26 % showed ecchymosis at the 1 month follow-up. Patients returned to their daily activities 7 days after the procedure. All patients used the elastic compression garment for a minimum of 4 weeks. Three patients required a touch-up procedure for asymmetry (3 %).

Discussion

Currently, laser lipolysis is an accepted treatment for local fat deposits that has been used since 2006 when the US FDA approved it. However, there are surgeons who believe that this treatment only increases the operative time and the risk of adverse effects, and there has been a lack of evidence showing improved results compared to traditional liposuction.

Laser lipolysis is not a substitute for a good liposuction technique but rather a tool that may improve outcome. In our technique, we introduce the laser optical fiber and then the liposuction cannula to remove the liquefied fat. This first maneuver facilitates the destruction of the adipocyte

Table 2 Amount of fat removed per area and energy released in each area with the LAL procedure

Treated area	Amount of fat (ml)[a]	Energy per unilateral area (kJ)[b]
Anterior thigh	400 (280–650)	15 ± 2.2 (11–22)
Inner thigh	350 (200–500)	14 ± 1.9 (10–20)
Knees	100 (65–150)	5 ± 0.6 (4–7)
Calf	140 (95–220)	4.5 ± 0.4 (4–6)
Trochanter	570 (300–950)	22 ± 4 (14–38)

All areas are bilateral and the amount of fat and energy used are shown only as the unilateral area

[a] Values are mean (range)

[b] Values are mean ± SD (range)

Table 3 Amount of fat removed per area in each area in traditional liposuction

Treated area	Amount of fat (ml)
Anterior thigh	350 (220–435)
Inner thigh	260 (150–330)
Knees	80 (50–120)
Calf	145 (80–175)
Trochanter	585 (280–800)

Values are mean (range)

membrane, making its removal easier and more homogeneous by decreasing the viscosity of triglycerides due to the thermal effects, while it coagulates small blood and lymphatic vessels, induces the formation of collagen, and promotes skin tightening. Goldman [8] has observed all these changes in the histological study of biopsies obtained from areas treated with laser lipolysis. These laser effects allow rapid recovery of the patient (normal daily activities within 2 days) and less pain, ecchymosis, and postoperative edema. Skin appearance is improved due to skin tightening compared to that from traditional liposuction techniques (Fig. 4) [9, 20, 22]. Because of all these advantages, laser-assisted lipoplasties can be done in areas with a thin dermis or uncertain skin retraction [3, 11], and large volumes of fat can be removed, minimizing the risk of hemodynamic repercussion [4, 24]. Slightly increased volumes of removed fat were observed in the LAL group compared with that from traditional liposuction in areas with a thin dermis such as the knee or the inner thigh (Tables 2, 3).

Volume reduction over time shows a similar distribution for both techniques, indicating that similar volume reductions can be achieved with both procedures, if properly performed. After 1 month postoperatively only minor changes can be expected.

The mean energy ratio of 3.5 kJ/100 ml has shown to be safe and effective for every area but it can be modified for different areas. Areas with more sagging skin and fewer fat tissue deposits may need an increased amount of energy for greater skin tightening. As is shown in Fig. 6c, the amount of energy is increased in the knee to improve skin retraction and improve the early results.

In our study, patient satisfaction has improved with the LAL procedure; this may be due to the laser mechanism of action and the small number of complications.

The mechanisms of action of laser lipolysis are theoretically photoacoustic, photomechanical, and photothermal effects. However, the main mechanism of action of the laser is thermal [9, 12]. Laser energy is transmitted through heat into the adipocyte, which absorbs it, expands its volume, and breaks. Initially, the heat generated by the laser alters the balance of sodium and potassium in the cell membrane, leading to the passage of extracellular fluid to intracellular space with an increased volume of adipocytes [4, 8, 17–19]. Photothermolytic warming is the most appropriate mechanism to control the release of heat in the tissue, and by using an optic fiber to release the heat, its penetration is optimized and heating peaks are avoided. The continuous emission and selectivity for lipids decrease peak heating in the dermis [1, 23]; this would explain the absence of dermal–epidermal burns in our cases.

The adipocyte membrane is ruptured by energy and the liberated lipases produce the liquefaction of the tissue which facilitates the subsequent aspiration process [18]. Two parameters must be considered to obtain lysis of the adipocyte without additional thermal damage: the laser's wavelength and the minimum amount of energy that can cause the rupture the adipocyte, the coagulation of the blood and lymphatic vessels, and the formation of neocollagen without damaging adjacent structures. The dose–response relationship should be taken into account.

The easier penetration of the laser fiber allows less forced and more regular movements. This, along with the flexibility of the tip, facilitates the possibility of reaching all the areas with the help of the outside hand. This maneuver does not increase the risk of the procedure because it is performed with a flexible cannula that bends and does not perforate. The use of a flexible cannula with a conical design and rounded edges and the way the heat is released by means of conduction, obtaining homogeneous heat with lower temperatures near the tip and less carbonization, allow us to work with increased safety and less risk of burns. By using this laser diode, we combine two safe wavelengths: 924 nm, which has the maximum coefficient of fat absorption [18], and 975 nm, which produces proper skin retraction [1, 6, 13, 17, 19, 21–23].

The appearance of the erythema mentioned in the discussion of our results with the LAL procedure is a

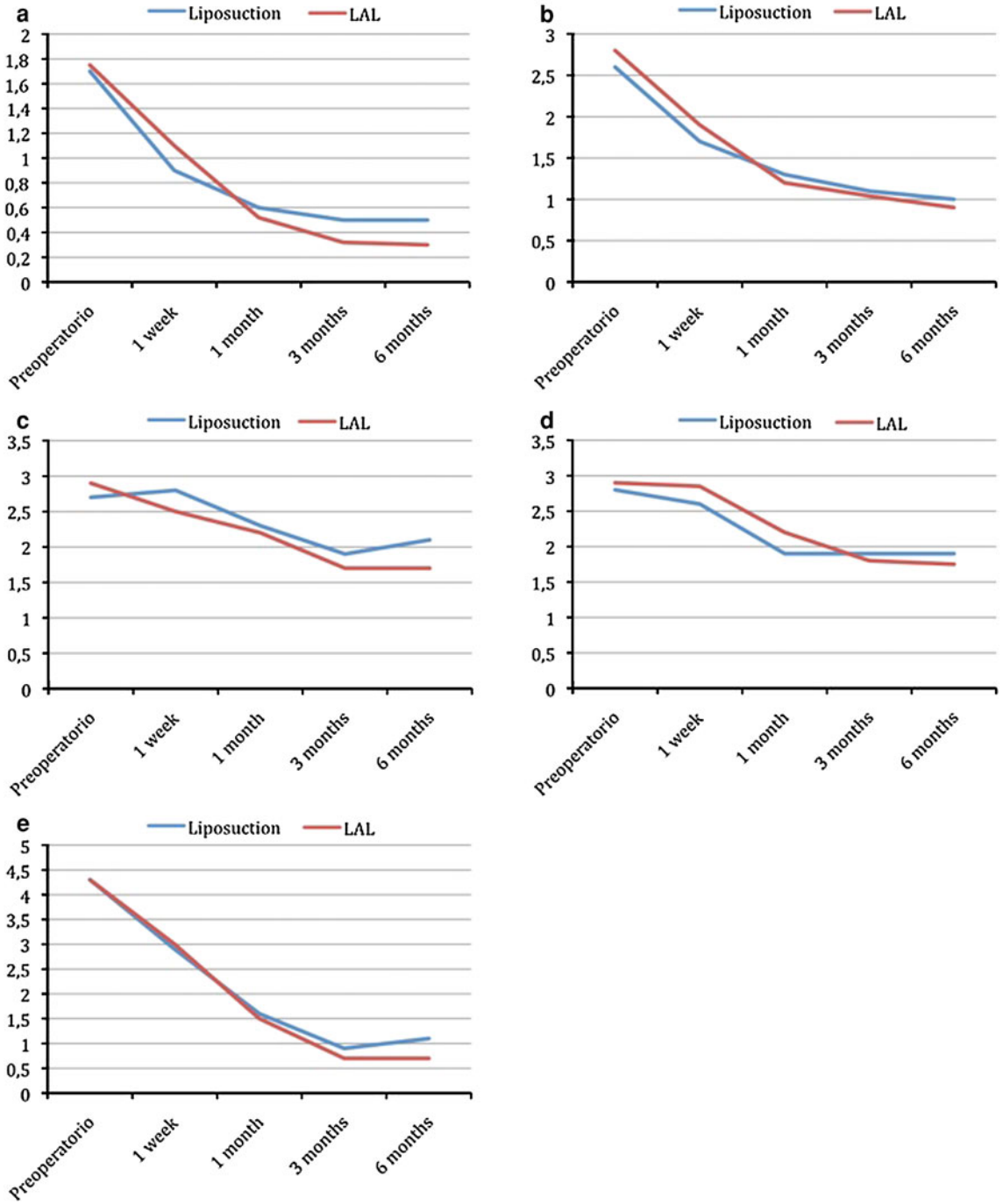

Fig. 6 **a** Reduction of fat tissue in the inner thigh (in cm) for both procedures at successive time points. **b** Reduction of fat tissue in the anterior thigh (in cm) for both procedures at successive time points. **c** Reduction of fat tissue in the knees (in cm) for both procedures at successive time points. **d** Reduction of fat tissue in the calf (in cm) for both procedures at successive time points. **e** Reduction of fat tissue in the trochanter (in cm) for both procedures at successive time points

reflection of the heat absorbed by the skin. In the first cases it created uncertainty about the evolution of that stored energy, but monitoring has shown that there are no burns or pigmentation changes afterward.

The duration of the ecchymosis, the time to get back to daily activities, and the duration of elastic compression therapy without an increase of side effects may account for the improved patient satisfaction with the procedure.

The amount of average energy released in each area is difficult to compare with that from other publications because they use different wavelengths and the volume is calculated differently [13]. As more studies emerge, tables

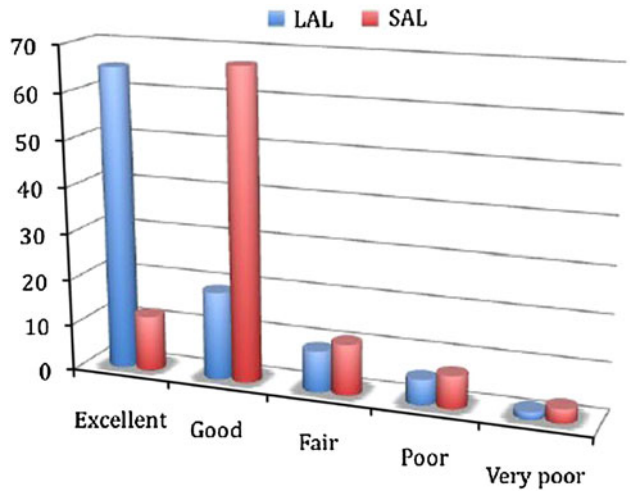

Fig. 7 Patient satisfaction rates comparing laser-assisted lipoplasty (LAL) versus suction-assisted lipoplasty (SAL) show improved results for laser-assisted lipoplasty patients

could be created to specify the amount of laser energy per volume of fat tissue that did not have risk of side effects or undertreatment. The main cause of the lack of difference in outcomes between classic liposuction and laser lipolysis in the early cases was an inadequate implementation of energy or an insufficient accumulation of heat that could be explained by the learning curve.

The limitations of the study are the lack of randomization in patient allocation to treatment. The exact amount of fat removed is difficult to evaluate and use of ultrasound to measure the subcutaneous thickness is used as an objective measure. However, ultrasound has been shown to be technician-dependent which could be a source of potential bias, but the technique to measure the fat width is a very simple procedure and was performed by the same technician and same equipment. The strengths of the study include its prospective nature, the use of an adequate number of patients with the same operative protocol, and an adequate follow-up.

Conclusion

Laser lipolysis in lower extremities using wavelengths of 924 and 975 nm is an efficient tool to model the body contour and has a low rate of complications and is associated with a quick recovery. It can be safely applied to different body areas, including areas of thin dermis, or to allow removal of large amounts of fat per procedure. Traditional liposuction achieves similar results with a longer postoperative course and less patient satisfaction. Further studies that account for the amount of liberated energy per volume of removed fat with objective results are needed to evaluate the efficiency of the different lasers available today.

Disclosure None of the authors has any financial interest in any of the products, devices, or drugs mentioned in this article.

References

1. Anderson RR, Farinelli W, Laubach H, Manstein D, Yaroslavsky AN, Gubeli J, Jordan K, Neil GR, Shinn M, Chandler W, Willians GP, Benson SV, Douglas DR, Dylla HF (2006) Selective photothermolysis of lipid-rich tissue. Lasers Surg Med 38: 913–919
2. Apfelber DB, Rosenthal S, Hynstad JP, Achauer B, Fodor PB (1994) Progress report on multicenter study of laser-assisted liposuction. Aesthetic Plast Surg 18:259–264
3. Badin AZ, Moraes LM, Gondek L, Chiaratti MG, Canta L (2002) Laser lipolysis: flaccidity under control. Aesthetic Plast Surg 26:335–339
4. Bazin AZ, Gondek LBE, García MJ, Valle LC, Flizikowski FB, de Noronha L (2005) Analysis of laser lipolysis effects on human tissue samples obtained from liposuction. Aesthetic Plast Surg 29:281–286
5. Christiaens V, Lijnen HR (2010) Angiogenesis and development of adipose tissue. Mol Cell Endocrinol 318:2–9
6. DiBernardo BE, Reyes J, Chen B (2009) Evaluation of tissue thermal effects from 1064/1320-nm laser-assisted lipolysis and its clinical implications. J Cosmet Laser Ther 11:62–69
7. Dudelzak J, Hussain M, Goldberg DJ (2009) Laser lipolysis of the arm, with and without suction aspiration: clinical and histologic changes. J Cosmet Laser Ther 11:70–73
8. Goldman A (2006) Submental Nd:Yag laser assisted liposuction. Lasers Surg Med 38:181–184
9. Goldman A, Gotkin RH (2009) Laser-assisted liposuction. Clin Plast Surg 36:241–253
10. Goldman A, Wollina U, Mundstock EC (2011) Evaluation of tissue tightening by the subdermal Nd:YAG laser assisted liposuction versus liposuction alone. J Cutan Aesthet Surg 4:122–128
11. Gordon H, Tevez A (2009) Laser-assisted liposuction for facial and body contouring and tissue tightening: A 2-year experience with 75 consecutive patients. Semin Cutan Med Surg 2:226–235
12. Khoury JG, Saluja R, Keel D, Detwiler S, Goldman MP (2008) Histologic evaluation of interstitial lipolysis comparing a 1064, 1320, and 2100 nm laser in an ex vivo model. Lasers Surg Med 40:402–406
13. Kim KH, Geronemus RG (2006) Laser lipolysis using a novel 1,064 nm Nd:YAG laser. Dermatol Surg 32:241–248
14. Klein JA (1987) The tumescent technique for liposuction surgery. Am J Cosmet Surg 4:263–267
15. Lin CY, Chen PC, Kuo HK, Lin LY, Lin JW, Hwang JJ (2010) Effects of obesity, physical activity, and cardiorespiratory fitness on blood pressure, inflammation, and insulin resistance in the National Health and Nutrition Survey 1999–2002. Nutr Metab Cardiovasc Dis 20:713–719
16. McBean JC, Katz BE (2011) Laser lipolysis: an update. J Clin Aesthet Dermatol 4:25–34
17. Mordon S, Eymard-Maurin AF, Wassmer B, Ringot J (2007) Histologic evaluation of laser lipolysis: pulsed 1064-nm Nd:YAG laser versus cw 980-nm diode laser. Aesthet Surg J 27:263–268
18. Mordon SR, Wassmer B, Reynaud JP, Zemmouri J (2008) Mathematical modeling of laser lipolysis. Biomed Eng Online 7:10

19. Moreno Moraga J, Royo J, Bravo E (2011) Laser lipolysis. In: Aesthetic medicine: therapeutic approach. Editorial Medica Panamericana, Santiago, pp 355–362
20. Palm MD, Goldman MP (2009) Laser lipolysis: current practices. Semin Cutan Med Surg 28:212–219
21. Parlette EC, Kaminer ME (2008) Laser-assisted liposuction: here's the skinny. Semin Cutan Med Surg 27:259–263
22. Reynaud JP, Skibinski M, Wassmer B, Rochon P, Mordon S (2009) Lipolysis using a 980-nm diode laser: a retrospective analysis of 534 procedures. Aesthetic Plast Surg 33:28–36
23. Seckel BR, Doherty ST, Childs JJ, Smirnov MZ, Cohen RH, Altshuler GB (2009) The role of laser tunnels in laser-assisted lipolysis. Lasers Surg Med 41:728–737
24. Stebbins WG, Hanke CW, Petersen J (2011) Novel methods of minimally invasive removal of large lipoma after lipolysis with 980-nm diode laser. Dermatol Ther 24:125–130