13 Laser Lipolysis

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INTRODUCTION

Liposuction is one of the most common cosmetic surgical procedures performed in North America with over 400 000 operations performed in 2006. As technology improves, physicians continue to investigate ways to optimize the final results and minimize trauma, risks, and down-time for their patients.

There are several drawbacks associated with traditional liposuction, particularly when performed under general anesthesia. These drawbacks include increased blood loss, ecchymoses, and long recovery times with increased post-operative discomfort, skin laxity as well as pulmonary emboli, seromas, and visceral perforations. Perhaps the greatest drawback is the fact that it is a surgical procedure which most individuals would prefer to avoid if at all possible.

A 1064-nm neodymium:yttrium-aluminum-garnet (Nd:YAG) laser was approved by the United States Food and Drug Administration (FDA) in October of 2006 for the surgical incision, excision, vaporization, ablation, and coagulation of all soft tissues. The 1064-nm pulsed Nd:YAG laser system (SmartLipo, manufactured by Deka [Florence, Italy], distributed by Cynosure [Westford, MA, USA]) is indicated for laser-assisted lipolysis as well as improvement of areas of flaccidity. The objective of this new device is to addresses the drawbacks mentioned in the previous paragraph: increased blood loss, ecchymoses, long recovery times, and skin laxity. It achieves these improvements by creating lipolysis, coagulating small blood vessels, and inducing new collagen formation, the end result being reduced adiposity and skin retraction and decreased flaccidity.

HISTORICAL OVERVIEW

Apfelberg published the first description of the direct action of laser in the fatty tissue—laser lipolysis—in 1992. In 1994, Apfelberg et al conducted the first multicenter trial studying laser-assisted liposuction. The laser used was an Nd:YAG laser at 40 W for 0.2-second pulse duration with a 600-micron fiber inserted in a 4- or 6-mm cannula requiring cold saline cooling. This fiber was encased within a cannula and was not in direct contact with the fatty tissue. The study suggested a trend toward decreased ecchymoses, pain, edema, and less strain for the physician. However, no significant benefit of the laser lipolysis was demonstrated, it was not FDA approved, and the sponsoring company (Haraeus Lasersonics, Milpitas, CA, USA) abandoned the technology.

Between 2000 and 2003, Blugerman, Schavelzon et al, and Goldman et al introduced the concept of the pulsed 1064-nm Nd:YAG laser in laser-assisted liposuction. Their work serves as the foundation of the current principles and techniques behind laser lipolysis by being the first to demonstrate the effect of the laser energy on fat as well as the surrounding dermis, vasculature, and apocrine and eccrine glands.

In 2003, Badin supported these findings in a study titled 'Laser Lipolysis: Flaccidity Under Control'. The author demonstrated the histological changes after thermal damage by the laser. The adipocyte membranes were disrupted, blood vessels were coagulated, and new collagen was reorganized. These histological changes translated to the clinical observation of decreased areas of local adiposities, decreased ecchymoses, and blood loss and improved skin tightening. Badin concluded that laser-assisted lipolysis was less traumatic due to smaller cannula size as well as the unique tissue reaction of the Nd:YAG system, which improved skin retraction.

A subsequent study by Goldman treated 1734 patients, 313 men and 1421 women, with an age range between 15 and 78 years. This group also documented less blood loss and ecchymoses, improved patient comfort postoperatively, and better efficacy for reducing fat in more dense areas such as gynecomastia.

Further support for the original works by Goldman and colleagues were published in 2005 by Ichikawa and colleagues. Ichikawa et al evaluated freshly excised human skin and subcutaneous fat and then irradiated the tissue with the pulsed Nd:YAG laser. A control group was cannulated with only the hand piece and no irradiation. Hematoxylin-eosin staining as well as scanning electron micrograph images was obtained following treatments. The changes included 300-μm tunnels that corresponded to the laser fiber diameter, disintegrated cell membranes, small vessel coagulation, and dispersed lipids. Scanning electron microscopy after irradiation showed greater destruction of the adipocytes than in the control group. Degenerated cell membrane, vaporization, liquefaction, carbonization, and heat-coagulated collagen fibers were observed. The study concluded that laser lipolysis appeared to be histologically effective for destruction of human fat tissue.

Finally, a 2006 study by Kim and Geronemus used magnetic resonance imaging (MRI) to evaluate the volume of fat reduction after laser lipolysis. In addition to the 17% fat volume reduction documented by MRI, patients noted a 37% improvement in only 3 months, quick recovery times, and good skin retraction.

EQUIPMENT AND LASER SPECIFICATIONS

The laser devices thus far used in laser lipolysis have been pulsed 1064-nm Nd:YAG and pulsed 1320-nm lasers. The pulse width of the SmartLipo device is 150 ms and the repetition rate is 40 Hz. The power output works up to 10 W. The key features of this device include the short pulse duration that creates a high peak power and the high repetition rate (Fig. 13.1).

Other pulsed Nd:YAG lasers are also being developed for laser lipolysis.

A 1320-nm device was approved by the FDA in January 2008. It is referred to as CoolLipo and is manufactured by Cooltouch (Roseville, CA, USA). As with the 1064-nm predecessor it is designed to liquefy fat and tighten skin. The specifications of this device are as follows: power up to 15 W, repetition rate 20–50 Hz, pulse width 100 µs, and 200, 350 or 500 µm fibers are available.

Another device under development by Drs Dressel, Zelickson and Sowyrda incorporates a laser fiber inside a protective suction cannula that facilitates lipolysis and suction synchronously. Preliminary studies reveal that laser energy optimized for fat absorption with this device

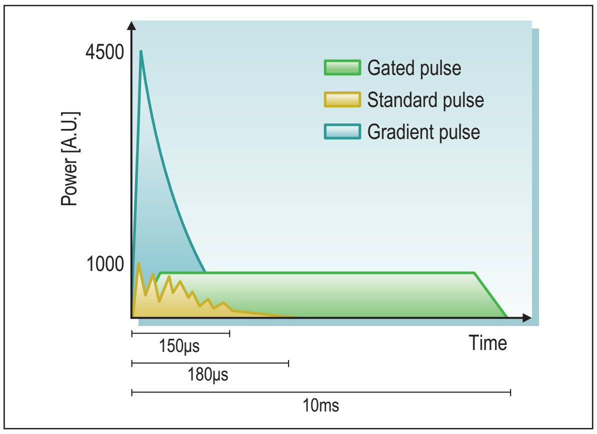

Fig. 13.1 Comparison of the gradient pulse used in the laser lipolysis system versus the gated pulse and standard pulse used with other laser technologies

resulted in an increase in aspiration rate at 7.5 W vs. 50 W for the Nd:YAG (personal communication with Dressel—at the time of this publication further specifications of this device were not available).

Laser lipolysis uses a gradient pulse delivering high peak power. This feature contrasts with other laser systems, which use a gated or standard pulse delivery system that delivers energy over a longer period of time leading to potential collateral tissue damage. The peak power of laser lipolysis leads to adipocyte rupture without charring of adjacent tissue.

In the SmartLipo procedure, energy is transmitted to the subcutaneous tissue through a 300-µ fiber. The fiber is carried in and supported by a 1-mm-diameter stainless steel microcannula of variable length, working up to 10 W. The distal portion of the fiber optic is extended 2 mm beyond the end of the cannula. In order to visualize the subcutaneous laser fiber while operating, a helium:neon (He:Ne) laser source is combined into the beam path. This combination provides a red guiding beam that the surgeon uses to precisely follow the laser tip. A 1-mm incision is enough to introduce the cannula, which is then moved in the fat at various depths, including the subdermal layer.

The pulsed 1064-nm Nd:YAG SmartLipo laser offers two modes of action that might be of relevance in lipodistrophy treatment: photothermal heating and photomechanical effects. The properties of the laser result in heating and disruption of fat cells, remodeling of collagen resulting in tissue tightening, and hemostasis of blood vessels leading to less bleeding and ecchymoses.

FACILITY CONSIDERATIONS

The surgical suite and set-up for laser lipolysis remains largely unaltered when compared with that of traditional tumescent liposuction. The suite should accommodate an electric table that can be raised or lowered so that the physician and support staff may access the patient comfortably. It should be large enough to house many pieces of equipment including intravenous poles, Mayo stands, infusion pumps, aspiration pumps, and the laser. Sterile facilities and technique should be employed with the use of sterile instrument trays, gowns, and towels.

TREATMENT TECHNIQUES

• Indications and patient selection

Generally, the indications for laser lipolysis are similar to those for traditional liposuction—that is, the procedure is designed for liposculpture and body contouring in relatively healthy individuals. Lawrence and Leonhardt state that most physicians believe cosmetic procedures, including liposuction, should be limited to patients who fall into the American Surgical Association class I or II, or rarely III. Class I patients are normal, healthy patients. Class II patients have mild systemic disease which results in some functional limitation. Class III patients have moderate to severe disease which results in some functional limitation. Class IV patients demonstrate systemic diseases that pose constant threats to life and are functionally incapacitating. Class V patients are moribund and are not expected to survive 24 hours with or without surgery.

The fact that liposuction is designed for liposculpture and body contouring rather than weight reduction is an important point to emphasize and assists with managing patient expectations. Many liposuction candidates will inquire about the utility of liposuction for weight reduction. Despite efforts during the consultation to minimize expectations for weight reduction, patients occasionally continue to expect dramatic weight loss after the procedure. They should be told explicitly that weight loss is not a goal of the procedure.

Patients should also be encouraged to eat a healthy, balanced diet and exercise regularly. Clinicians should be aware that patients who diet frequently show significantly more weight regain than those who diet less often. Patients should be able to demonstrate a consistent weight for several months prior to the procedure, rather than drastic weight fluctuations. If they have the procedure at a weight that is lower than their normal weight, the subsequent weight regain can have a negative impact on the result of the procedure.

Localized subcutaneous fat deposits that are disproportionately large and are unresponsive to exercise and diet are areas to consider for laser lipolysis. Locations amenable to treatment with laser lipolysis include the submental area, upper arms, abdomen, hips, flanks, inner thighs, outer thighs, knees, and ankles. In addition, sites that tend to have more laxity after removal of adipose tissue such as the neck/jowls, upper arms, abdomen, inner thighs, and knees are particularly ideal locations to consider laser lipolysis due to the skin tightening effect of the Nd:YAG laser.

In summary, with regard to indications for laser lipolysis and patient selection, the main indication of the technique is the treatment of lipodistrophy and irregularities of the fatty tissue. The ideal patient is a healthy individual with small to moderately sized local areas of adiposity that may also be at an increased risk of skin laxity.

• Preoperative evaluation

As in traditional liposuction with the tumescent technique, the preoperative evaluation involves obtaining adequate history, physical examination, and laboratory data to ensure the suitability of the liposuction candidate.

A thorough medical history should be obtained at the consultation. In patients with pre-existing cardiovascular or respiratory conditions, it may be prudent to request medical clearance by their primary care physicians, cardiologist, or pulmonologist. It is natural for patients to downplay the severity of their health conditions, especially for an elective cosmetic procedure. The physician should be particularly aware of those patients with impaired liver function, hepatitis C, chronic active hepatitis B, and alcoholic liver disease, because lidocaine is metabolized by the cytochrome P450 enzymes of the liver. Patients with liver disease are at an increased risk of developing lidocaine toxic effects.

It is also important to obtain a surgical history. Patients with prior abdominal surgeries or liposuction may have increased scarring, making passage of the cannula difficult. Surgeries complicated by hernia, infection, or dehiscence may disrupt the normal anatomy of the underlying musculature and peritoneum. In these scenarios, prior cases can be discussed with the patient's surgeon or it may be possible to obtain radiographic studies. The age of scars is also important information to obtain from the patient. Older scars tend to be softer and may be suctioned through while newer scars should be suctioned around.

Physical examination is an essential part of the consultation. The patient should be in a gown and examined in the standing position. First, listen to what the patient would like to have addressed. Then evaluate the overall body habitus. Then palpate areas under consideration, squeezing gently between the thumb and first two digits to assess the degree of subcutaneous adiposity. Pay particular attention to small areas with local adiposities and the potential for skin laxity after the procedure. These areas are best suited for laser lipolysis. Asymmetries should be pointed out to the patient before the procedure. Irregularities such as cellulite and scars should be addressed. There is some early evidence that cellulite may be diminished with the Nd:YAG laser employed in laser lipolysis.

In terms of preoperative laboratory evaluation, the same work-up as with traditional liposuction using the tumescent technique should be employed. Laboratory evaluation should include a hepatitis panel, complete blood cell count with differential, serum chemistries, partial thromboplastin and prothrombin times, international normalized ratio, human immunodeficiency virus test, pregnancy test, and cholesterol panel.

• Surgery preparation: patient photographs, marking, perioperative medications

Once the suitable candidate has been identified, the patient is prepared for surgery. First, a description of the procedure is performed and the patient is informed of the risks, benefits, and adverse effects. Once the consent form is signed, the patient is weighed. This weight is used to determine the optimum, safe maximum volume and concentration of tumescent anesthesia. The recommended maximum dose of lidocaine for tumescent anesthesia is 55 mg/kg according to the American Academy of Dermatology. A conservative dosage guideline for a maximum lidocaine dose in tumescent anesthesia is 35–45 mg/kg, and lidocaine concentrations in the range of 0.05–0.75% can be employed. Higher concentrations up to 0.1% may be employed for very sensitive areas such as the umbilicus.

The patient is photographed using standard positioning and lighting. It is important to standardize images as much as possible to ensure a correct comparison of before and after images. Excellent clinical images cannot be overemphasized. Many patients forget their preoperative shape and are impressed by the change when provided the opportunity to compare before and after images. Patients are informed that the images are confidential and sign a patient release form if the photographs are used for research or publication purposes. The images are also vital for medical–legal purposes.

Once the patients are photographed, they are subsequently marked with a surgical marker. Meticulous marking is paramount, because once the anesthesia is administered, anatomical landmarks can easily be lost. When marking it is helpful to closely follow the contours of the adipose areas to facilitate smooth transitions between anatomic units.

Guidelines of care for liposuction patients advise for obtaining baseline vital signs including blood pressure and heart rate measurements. These baseline measurements allow the clinician to monitor changes throughout the procedure and afterwards. If marked variations occur throughout or after the procedure, appropriate supportive management can begin. Cardiac monitoring with pulse oximetry and supplemental oxygen should be available, and a plan for medical emergencies should be established.

Perioperative medications vary among clinician preference and patient requirements. Some clinicians provide an anxiolytic such as lorazepam or midazolam prior to the procedure. Clonidine, an α-2 adrenergic receptor antihypertensive medication, may be employed for its effect to increase the threshold for possible lidocaine toxic effects. Intramuscular narcotics such as meperidine may be employed to dampen the discomfort associated with the infusion of tumescent anesthesia. Finally, an antihistamine such as hydroxyzine is often employed for additional sedation and to offset any nausea produced by the medications mentioned herein.

• Tumescent technique

After the perioperative medications have been administered, the patient is cleansed with a surgical antimicrobial cleanser and local tumescent anesthesia can be administered. A full review of the tumescent technique is beyond the scope of this chapter. Its benefits, safety profile, composition in normal saline (various concentrations of lidocaine, epinephrine, and bicarbonate depending on surgical site), and risks have been elaborated in previous texts and journals. What should be emphasized in this chapter is that virtually all cases of laser lipolysis can be performed with tumescent anesthesia. This is an incredible advantage because multiple studies have documented the superior safety record of tumescent liposuction and the greater risks of liposuction under general anesthesia or intravenous sedation. In addition, data shows that tumescent liposuction performed in the outpatient setting is safer than any liposuction performed in the hospital inpatient setting.

Earlier, the maximum lidocaine dose in tumescent anesthesia was alluded to. Once this has been calculated, the anesthesia can be infused through 1-mm incision sites or via 18-gauge needle puncture sites. The insertion sites should be anesthetized with buffered 1% lidocaine with epinephrine, usually at a dilution of 1 : 100 000. Placements of the incision sites for the anesthesia are made where they can be camouflaged by clothing or undergarments, while simultaneously providing appropriate access to local adiposities. For example, when treating the abdomen, incision sites may be placed at the superior and inferior borders of the umbilicus or in the pubic area. Incisions should be placed asymmetrically so that they are less noticeable and do not appear as markers of previous liposuction. After approximately 20–30 minutes to allow an adequate diffusion of the tumescent solution and to provide effective vasoconstriction, tiny incisions are made with a 1.5-mm punch or No. 11 blade. The laser fiber travels through these strategically placed incisions. Depending on access, the same incisions made previously may be used for the infusion.

• Surgical technique, endpoints, and energy

Patients and medical staff are equipped with protective goggles. An encased 300-μm fiber emitting 1064-nm (Nd : YAG laser system) (Fig. 13.2) is inserted through the incisions and slowly manipulated forward and backward in a criss-cross pattern. As a rough guideline, ten passes per section are made; however, it is important to recognize surgical endpoints when using laser lipolysis. These endpoints are determined by tactile appreciation of the reduction in the volume of the subcutaneous layer. The tissue is continually palpated during cannulation until it feels less dense, soft, and more pliable, contrasting with the preoperative firm, larger, indurated areas. Temperature of the treated area is another endpoint to use. Specialized infrared thermometers are being developed to assist in accurately quantifying the surface temperature. Finally, additional endpoints such as the accumulated energy and change in resistance of fiber passage can be employed.

The total energy used should be documented. Because the technology is continually developing, in order to reach the desired endpoint, the surgeon may find that total energies used exceed the manufacturer's recommendations. Continued experience and documentation of previous cases will provide the surgeon with appropriate benchmarks when performing subsequent cases.

Once the procedure is complete, the patient is cleaned and bandaged, and their compression garments are placed. The garments are worn 24 hours a day for 1 week, then 12 hours per day for the second week. For treatment of the submental region, the garment is worn 24 hours a day for 3 days. Some surgeons have patients return the second day after the procedure, at which time ultrasound, lymphatic drainage, diode laser, or defocused Nd : YAG external laser treatment are employed. These treatments, one of the current authors (AG) believes, hasten healing time.

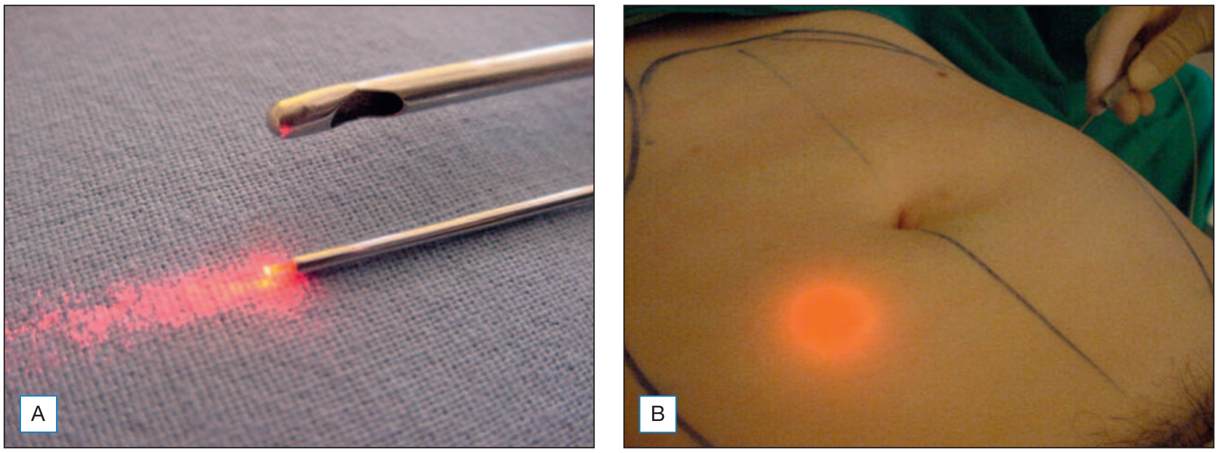

Fig. 13.2 **(A)** Laser fiber with guiding light compared with traditional 4-mm cannula. **(B)** Laser fiber with guiding light beneath the skin

• Suction/aspiration: Yes or no? When?

The product of the cellular lysis is usually removed using negative pressure of around 350–450 mmHg in conjunction with a 2.5- or 3-mm suction cannula. The current authors recommend using syringes, pumps, or aspirators. In cases of small areas (usually less than 50 mL of estimated fat) or in patients with skin laxity, it is not necessary to aspirate the treated tissue. It is not necessary to use sutures for the small incisions, thereby allowing for a natural drainage of the infiltrated solution, blood, and the oily solution produced by the laser action.

• Major determinants and troubleshooting

When mastering any new technical procedure, a learning curve is often experienced. New practitioners may cite the additional time required to administer the laser treatments as a negative feature. When starting, new physicians should choose smaller localized areas such as the submental area before tackling larger, more complex locations such as the outer or inner thighs. In addition, special care is needed to avoid puncturing through the skin with the fine, thermal laser cannula during criss-cross manipulations. Epidermal burns are also possible if the laser is fired prior to insertion through the incision points.

In the current authors' experience, when first using the SmartLipo system, operators may underutilize the laser, administering far too low total energy. It is important to remember the endpoints and use the recommended 10 passes per area as a guideline to supplement those endpoints.

• Histology

Laser lipolysis coagulates small blood vessels in fatty tissue (Fig. 13.3). In addition to coagulated vessels, the laser also reorganizes dermal collagen (Fig. 13.4).

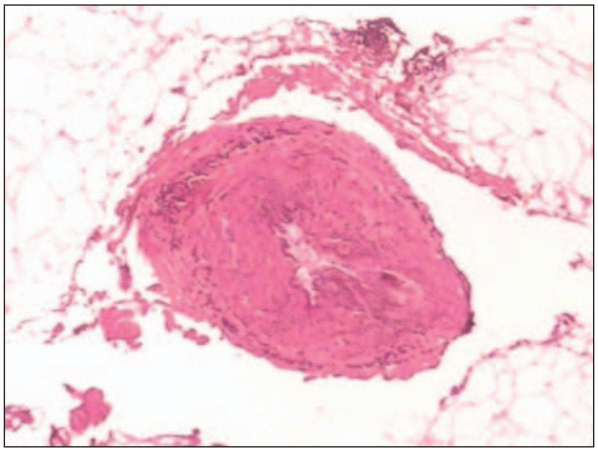

Fig. 13.3 Obliterated small artery in the subcutaneous layer

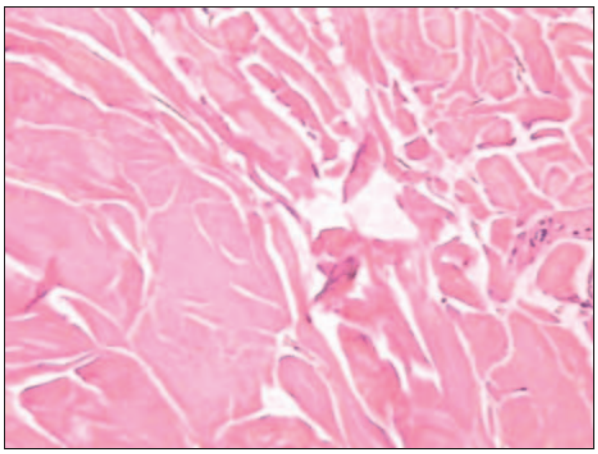

Fig. 13.4 Reorganized collagen after laser lipolysis

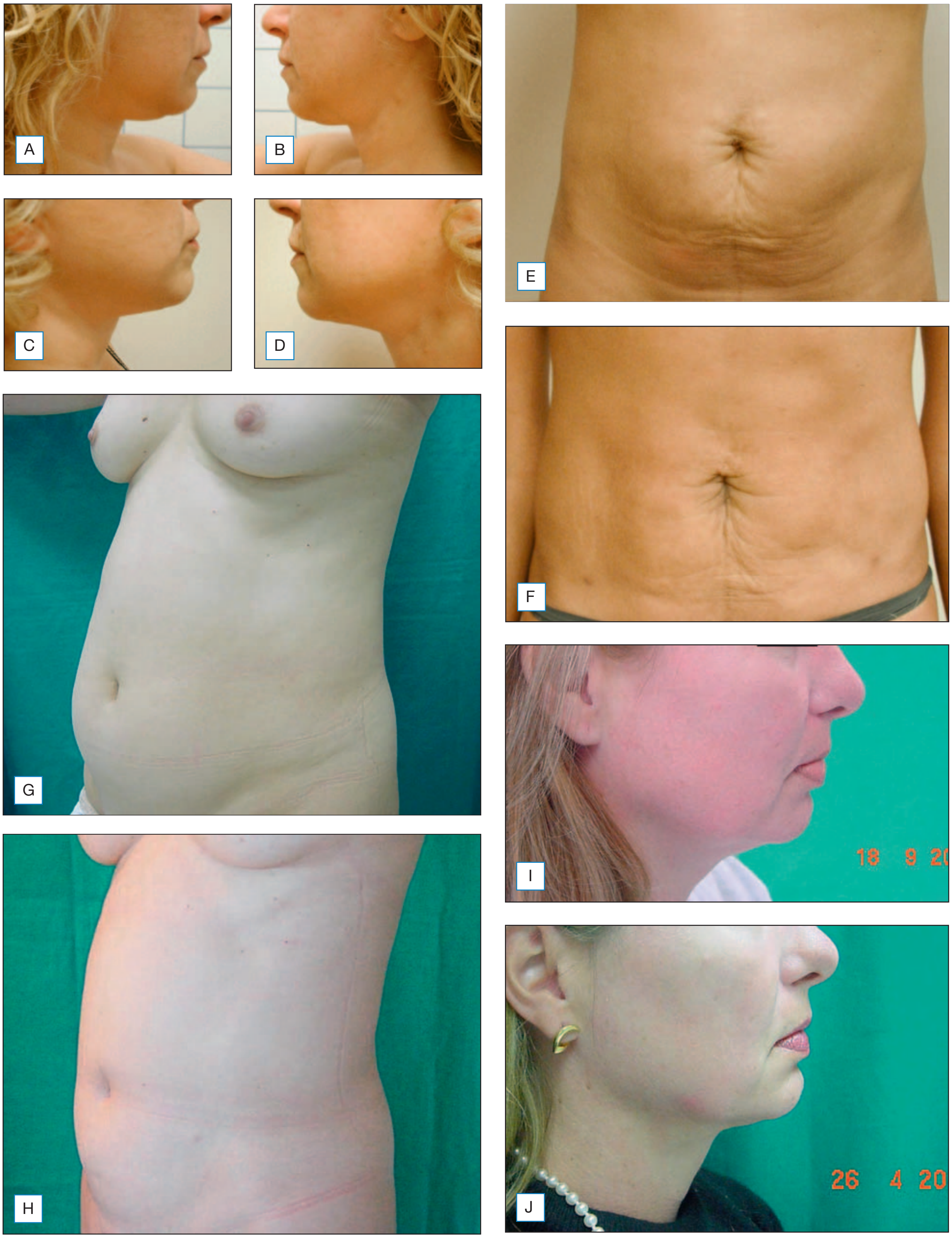

Fig. 13.5 (A), (B), (E), (G), (I) Before laser-assisted lipolysis of the abdomen and submental area. **(C), (D), (F), (H), (J).** After laser-assisted lipolysis

Histologically, disintegration and liquefication of adipocyte membranes after laser lipolysis has been documented.

• Positive clinical attributes of laser lipolysis

There are several positive attributes of laser-assisted lipolysis. First, tumescent anesthesia can be used in virtually all cases. Therefore, patients easily tolerate the procedure; they are awake and when proper sedation and pain control is achieved, they often sleep through the procedure. The patients may communicate during the operation, and they are able to stand, thereby optimizing physician postoperative evaluation and correction. Figure 13.5 shows before and after photos of a variety of body regions improved through laser-assisted lipolysis.

Second, the lipolysis effect improves the removal of adipose tissue. By liquefying the adipose tissue, larger volumes can be removed more easily. The third advantage of laser-assisted lipolysis is less trauma. Because of the small cannula size and lipolysis effect, less mechanical destruction by the cannula is required. The result is faster recovery times and diminished ecchymoses.

A fourth positive attribute is coagulation of small blood vessels. In addition to the reduced trauma associated with the small cannula size, the Nd:YAG laser coagulates microvessels. This has been demonstrated in several previous studies.

The fifth positive attribute is skin retraction or skin tightening. Disruption and coagulation of collagen may lead to the creation of a new, thicker and more organized reticular dermis, the end clinical result being tightened skin and reduced laxity. This feature makes laser lipolysis a useful tool for areas of localized adiposity as well as localized laxity following liposuction.

All of these benefits are achieved through tiny incisions that do not require sutures, allow drainage, prevent infection, and heal within weeks of the procedure. Despite these benefits, adverse effects are still possible. Patients will still have edema and mild ecchymoses similar to traditional tumescent liposuction. However, the severity and duration of these adverse effects tend to be less using the laser lipolysis technology.

RESULTS

• Complications and adverse effects

Potential complications associated with laser lipolysis include all those that may occur after traditional liposuction using the tumescent technique. Most of these sequelae are minor and usually resolve on their own. Bruising, swelling, soreness, seromas, inflamed incision sites, and fatigue are among the common findings. In over 400 cases performed at author BEK's facility, one local infection and three minor burns with no residual scarring have occurred. Additional possible adverse effects include overcorrection and asymmetries.

ADDITIONAL UTILITIES OF LASER LIPOLYSIS: AXILLARY HYPERHIDROSIS

Another possible use for the SmartLipo system includes treatment of axillary hyperhidrosis. The safety and efficacy of liposuction treatment of axillary hyperhydrosis has been reported. Using SmartLipo it is possible to destroy sweat glands, thereby reducing perspiration. Bromhidrosis represents another indication for this type of laser. The subdermal laser-assisted axillary hyperhydrosis treatment using a 1064-nm Nd:YAG laser induces impairment of the eccrine/apocrine glands and resulted in significant clinical improvement.

CONCLUSION

Laser lipolysis is an exciting new procedure that provides improved patient tolerability, shorter recovery times, and optimal skin tightening. These improvements are safe, require virtually no down-time, and provide an excellent option for patients reluctant to undergo more invasive procedures. Despite these features, laser lipolysis is still surgery, and managing patient expectations is important. Patients should be completely informed about the procedure preoperatively and be provided with frequent post-operative visits. Patients should also be informed that optimal skin tightening results might take up to 6–8 months to become evident given continued collagen remodeling after the procedure.

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