Cellulite: A New Treatment Approach Combining Subdermal Nd: YAG Laser Lipolysis and Autologous Fat Transplantation

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Background: Cellulite is an alteration of the topography of the skin that occurs in body areas where fat deposition seems to be under the influence of estrogen: mainly the hips, buttocks, thighs, and abdomen. The presence of cellulite is a significant source of patient dissatisfaction. There is currently no cure or consistently effective treatment for cellulite.

Objective: The authors sought to show that the subdermal application of the neodymium-doped yttrium aluminium garnet (Nd:YAG) laser combined with autologous fat transplantation is a safe and effective treatment for cellulite.

Methods: From January 2003 to December 2006, 52 female patients with Curri grade III to IV cellulite were treated with subdermal 1064-nm Nd:YAG laser lipolysis combined with autologous fat transplantation. Patient assessment was collected for data analysis. After the treatment, tissue samples were obtained in some subjects in order to ascertain the histologic effects of the laser treatment.

Results: This treatment resulted in significant clinical improvement in cellulite. The adverse effects were mild and temporary, and the postoperative period was well tolerated. A majority of patients (84.6%) rated the results of treatment as either good or excellent.

Conclusions: The treatment of severe cases of cellulite (Curri grades III and IV) by a combination of 1064-nm Nd:YAG laser lipolysis and autologous fat transplantation proved to be both safe and effective. In addition, subdermal laser lipolysis has the advantage of inducing neocollagenesis and stimulating postoperative skin tightening. This represents a new treatment option for the ubiquitous cellulite disorder. Although this treatment has shown promising results in this pilot study, further studies are necessary in order to draw final conclusions. (*Aesthetic Surg J 2008;28:656–662.*)

Cellulite, also known as gynoid lipodystrophy and edematous fibrosclerotic panniculopathy, is an alteration in the surface contour of the skin in which areas of lumpy bumpiness seem to alternate with areas of skin dimpling. This uneven skin texture is most prevalent in the abdomen, hips, thighs, and buttocks. It is estimated that 85% of postpubertal women have some degree of cellulite.[1] The etiology is poorly understood; hereditary, vascular, structural, and inflammatory theories have been advanced.[1,2]

The appearance of cellulite is probably caused by conformational changes in fibrous septae within the hypodermis that lead to herniation of subcutaneous fat into the dermis.[3] The anatomic basis of cellulite has been determined through histology[4-7] and, more recently, by magnetic resonance imaging studies[8,9] that further revealed the ultrastructure of the subcutaneous tissue in women and men. In men, the septa are arranged in a criss-cross pattern, dividing the fat cell chambers into small, polygonal units.[4] In women, fat cell chambers, or papillae adiposae, are sequestered by septa of connective tissue, positioned in a radial or diagonal manner, anchoring the dermis to the muscle fascia via the subcutaneous fat. The papillae adiposae of the subcutis bulge up into the dermis

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Table 1. Cellulite classification

Grade I	Patient asymptomatic; no clinical alterations; histopathologic alterations only
Grade II	Grade I + skin pallor; decreased elasticity after skin compression/muscular contraction
Grade III	Grade II + visible orange peel appearance at rest; decreased elasticity
Grade IV	Grade III + more palpable, visible, and painful nodules; dimpled, wavy appearance of the skin surface at rest

Data from Curri.[12]

(sometimes close to the dermoepidermal junction), changing the gross appearance of the skin surface. The three-dimensional architecture of the hypodermal connective tissue is believed to be the reason that the cellulite condition presents as the lumpy, bumpy texture on the skin's surface.[4-7,10] It seems that the criss-crossing connective tissue pattern and the relatively lower circulating estrogen levels protect most men from this condition.[5,8] The pathophysiology of cellulite is a controversial issue, but it seems that obesity is not necessary for its presence. A number of different classification systems have been used to categorize cellulite according to its clinical and histopathologic changes. The one described by Curri[11–12] in 1991 grades the changes on a scale of I to IV (Table 1).

The main treatment modalities[1] that have been described to attenuate or treat cellulite are topical agents, systemic pharmacologic agents, iontophoresis, ultrasound, radiofrequency energy, infrared light, mechanical tissue manipulation,[13,14] and low-energy diode laser, contact cooling, suction, and massage.[15] Lasers and light-based treatments have also been used as an alternative in patients who suffer from cellulite.[16,17]

The objective of this study is to present the use of the 1064-nm Nd:YAG laser—in a superficial subdermal plane—in combination with autologous fat transplantation as a new option in the treatment of patients with Curri grades III and IV cellulite.

METHODS

From January 2003 to December 2006, 52 female patients with Curri grades III and IV cellulite were treated using a superficial subdermal application of a pulsed 1064-nm Nd:YAG laser (Smartlipo [DEKA, Calenzano, Italy] and Cynosure [Westford, MA]) and autologous fat injections at Clinica Goldman de Cirurgia Plastica (Porto Alegre, Brazil) and Cosmetique Dermatology, Laser & Plastic Surgery, LLP (New York, NY). The pulsed Nd:YAG laser used in this study emitted energy at 6 watts, 40 Hz, and 150 mJ/pulse. Subjects who had undergone previous surgical treatments, such as lipoplasty or subcision, in the same areas under consideration for this treatment were excluded from the study, as were pregnant or lactating patients or patients with unrealistic expectations regarding the treatment limitations and results.

All patients underwent a preoperative assessment, including laboratory tests, to determine their general medical condition and the characteristics, distribution, and severity of their cellulite.

Informed consent was obtained for each patient. Under the same lighting conditions and using the same photographic equipment at each facility, color photographic documentation was taken of all patients before the procedure and at both 3 and 6 months postprocedure.

All procedures were performed on an ambulatory basis under aseptic conditions and with the use of local tumescent anesthesia; intravenous sedation or general anesthesia were used according to patient and surgeon choice during the preoperative consultation. Preoperative sedation, such as midazolam and fentanyl, was used according to anesthesiologist choice. The procedure is usually well tolerated, however, and results in little discomfort. No prophylactic antimicrobial therapy was used.

Important patient characteristics that must be evaluated before the procedure are the skin laxity, thickness, and turgor; previous treatments; scars; and other areas of lipodystrophy. Accurate preoperative marking represents the most important step in the procedure; once the procedure began, precise treatment was based on these markings. The areas to be treated were determined and marked with the patient in the standing position. The elevated and depressed areas commonly present in severe cases of cellulite were carefully demarcated using markers of different colors. Other areas of localized accumulation of excess fat could be treated at the same time; these regions often served as the donor site for fat transplantation.

The treatment was performed with a subcutaneous infiltration of Klein tumescent solution. Lidocaine (500 mg), epinephrine (1 mg [1 cc of 1:1000 dilution]), and 12.5 mL of 8.4% sodium bicarbonate are added to each liter of normal saline. This yields a buffered solution containing 0.05% lidocaine, 1:1,000,000 epinephrine. The total volume injected per patient ranged from 170 to 2000 mL. The tumescent solution was delivered using syringes or infusion pumps, and the procedure was initiated following a 20-minute delay; this allowed diffusion of the solution and appropriate vasoconstriction.

In the procedure, the laser energy was conducted to the subcutaneous tissue through a 300-µm diameter optical fiber delivered through a 1-mm diameter cannula. One or more 1-mm incisions were made in the treated areas. After assuring adequate eye protection for the patient and the entire operating team, the cannula containing the optical fiber was inserted through the incisions and laser energy was delivered to the elevated areas of adiposity that were marked and discussed with the patient preoperatively. The transillumination effect of the HeNe aiming beam facilitated this step of the procedure, because the surgeon could visualize the precise location of the tip of the optical fiber and, therefore, the precise location of the laserlipolysis. Throughout this portion of the procedure, the laser fiber was maintained

in the superficial subdermal plane. The action of the laser energy in this layer induced neocollagenesis and subsequent skin tightening. The final step using the laser was performed in a deeper subcutaneous plane, throughout the entire area affected with cellulite, for overall adipose volume reduction. The total accumulated energy ranged from 2000 to 12,000 J, depending on skin phenotype, cellulite severity, and overall dimension of the treated area.

The product of the 1064-nm Nd:YAG laser action was an oily lysate that contained fragments of cells, oil, and tumescent solution; it was removed from the region by gentle aspiration using a 2-mm external diameter cannula and a negative pressure of ≤ 0.5 atm (50 kPa or 350 to 380 mm Hg).

Finally, the most depressed areas previously demarcated before the surgery received autologous fat injections with an overcorrection of about 10% to 15%. The fat was aspirated from another area of the body and not from the area treated with the laser. The fat was harvested and transplanted according to Coleman's technique[18-20] of structural fat grafting, using a 10-cc syringe attached to a 2-hole harvesting cannula. After centrifugation and refinement, a blunt infiltration cannula was used to place the fat in the subcutaneous layer through 2-mm incisions. The average fat transplantation volume per patient was 240 cc.

The procedure was finalized with a delicate massage of the treated area. The intent was to evenly distribute the fat and to render uniformity to the treated surface. A smooth, elasticized garment was used during the first 2 weeks postprocedure. On the second day following surgery, the subjects began physiotherapeutic postoperative treatments with a combination of external diode lasers, a cooling system, and a gentle rhythmic massage (Triactive [DEKA, Calenzano, Italy] and Cynosure [Westford, MA]). Skin biopsies and histology were performed in some subjects after the treatment.

The patients were asked to fill out a questionnaire 1 year postoperatively. The patients' global assessment classified the outcome in 4 categories: poor (no improvement), fair (limited improvement), good (significant improvement), and excellent (marked improvement). This classification was based on patient estimation of the percentage of cellulite reduction: poor (improvement from 0% to 25%), fair (from 26% to 50%), good (from 51% to 75%), and excellent (>75%). The follow-up period was 12 to 30 months.

RESULTS

Patient characteristics can be seen in Table 2. The main areas treated were the hips, buttocks, and thighs. The adverse effects were mild and temporary and were represented mainly by ecchymosis and edema. The ecchymosis lasted for 1 to 2 weeks and the edema persisted for up to 6 months postoperatively. No patient sustained any cutaneous burn or infection. Hemosiderosis, which persisted for 8 months, was observed in one patient.

Table 2. Characteristics of patients with cellulite treated with Nd:YAG laser and fat injections

No. of subjects	52
Average age (yrs)	24.2 (range, 18–47)
Average time of disease (yrs)	4.1 (range, 1–21)
Follow-up	12–30 mos
Cellulite grade	III (42–80.8%); IV (10–19.2%)
Treated patients according to each region*	Hips (47–90.4%); buttocks (38–73%); thighs (22–42.3%); abdomen (12–23%); flanks (2–3.8%)

*Some patients had more than one region treated.

Table 3. Adverse effects

Adverse effect	n (%)
Ecchymosis	8 (15.3%)
Edema	39 (75%)
Burn	0
Infection	0
Hemosiderosis	1 (1.9%)
Decrease in sensibility	37 (71.1%)

Decrease in sensibility, a common finding after lipoplasty or any kind of superficial surgery or trauma, was transient and lasted for several weeks (Table 3). The return of normal sensibility was gradual and spontaneous. The postoperative period was well tolerated in all patients, without significant pain, discomfort, or complications.

The major outcome of the procedures was a reduction and improvement in cellulite. Improvement of the skin texture with consequent global amelioration in the appearance of the treated areas was achieved in the majority of patients (Figures 1 to 3). The patients' assessment was excellent in 16 patients (30.8%), good in 28 patients (53.8%), fair in six patients (11.6%), and poor in two patients (3.8%); this resulted in an 84.6% good or excellent outcome (Table 4). Despite the well known progressive nature of cellulite with the aging process, some patients were followed for more than 2 years after the procedure and demonstrated persistent and lasting improvement.

Skin biopsies obtained after the treatment showed disruption of adipocytes (focal lipolyisis), collagen coagulation of the fibrous septal connective tissue, small blood vessel coagulation, and degenerative alterations of the septal connective tissue layer (Figures 4 and 5).

DISCUSSION

The search for products and techniques that promise to improve cellulite seems never-ending, but few of them are effective.

Some of the physical and/or mechanical methods available to treat cellulite are iontophoresis, thermother-

Figure 1. **A**, Pretreatment view of a 29-year-old woman with Curri grade IV cellulite. **B**, Posttreatment views 13 months after a single treatment combining deep and subdermal Nd:YAG laser lipolysis and autologous fat transplantation.

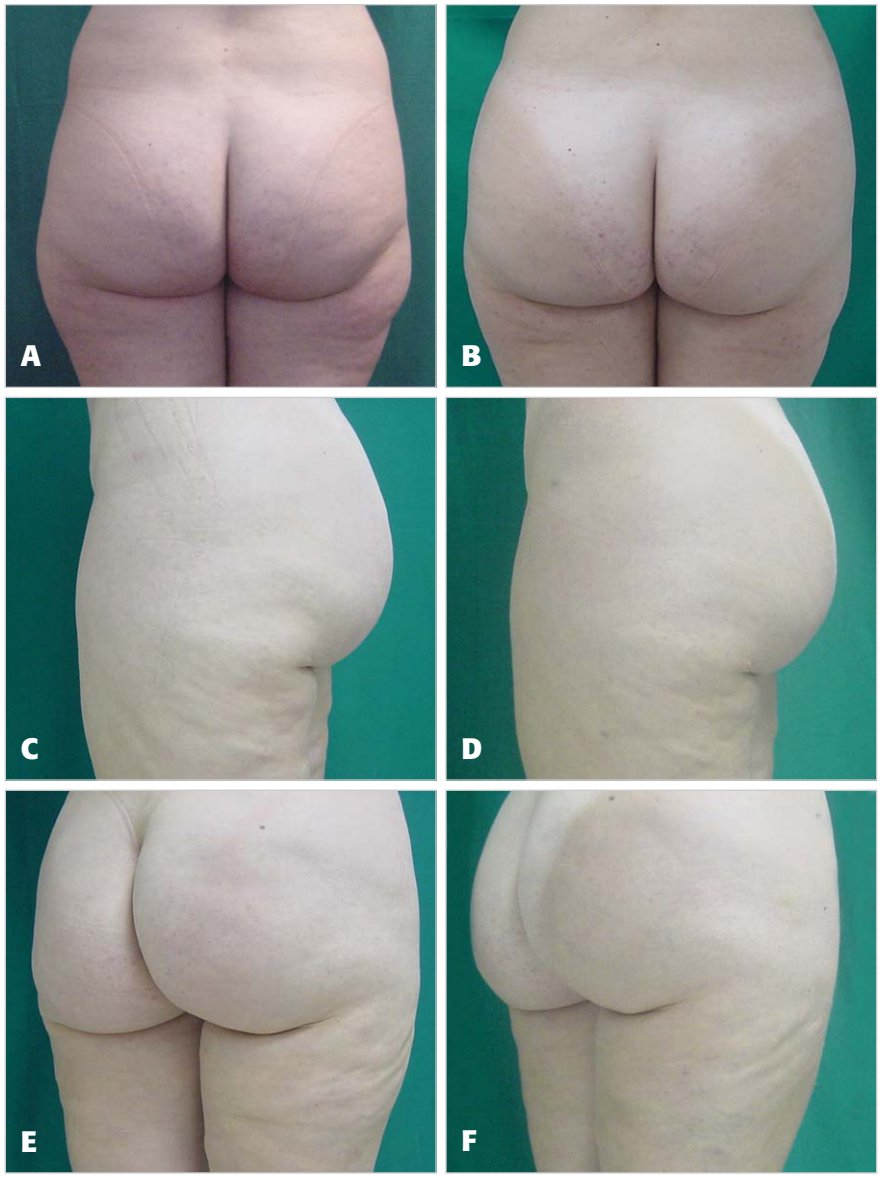

Figure 2. **A**, **C**, **E**, Pretreatment views of a 35-year-old woman with Curri grade IV cellulite. **B**, **D**, **F**, Posttreatment views 2 years after a single treatment combining deep and subdermal Nd:YAG laser lipolysis and autologous fat transplantation.

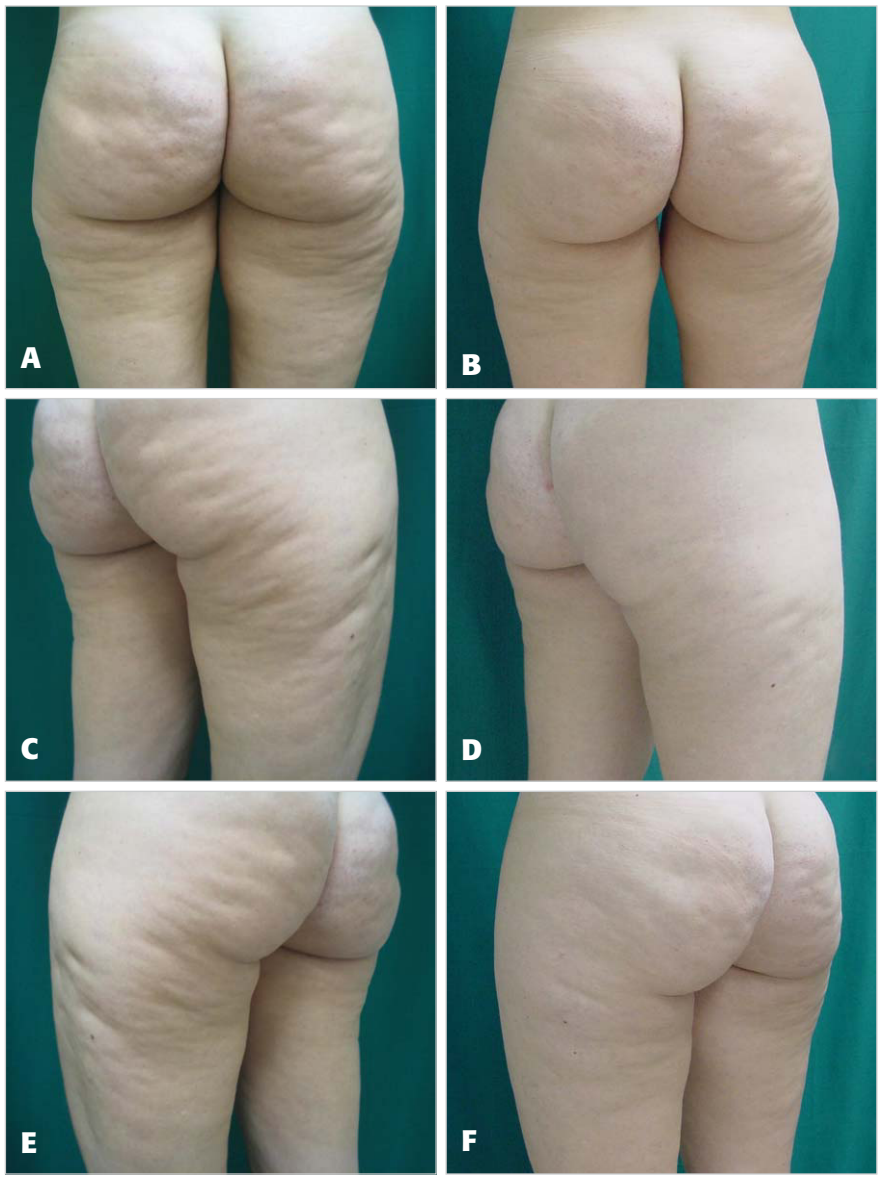

Figure 3. **A**, **C**, **E**, Pretreatment views of a 24-year-old woman with Curri grade IV cellulite. **B**, **D**, **F**, Posttreatment views 13 months after a single treatment combining deep and subdermal Nd:YAG laser lipolysis and autologous fat transplantation.

apy (application of heat), subcision,[21] and pressotherapy (pneumatic lymphatic drainage)[11]—all used as adjunctive therapies. There are also systemic or topical pharmacologic agents that are purported to have a lipolytic effect on adipose tissue.[7,22] The combination of topical photoactive phosphatidylcholine cream and light-emitting diode light was recently described as another treatment for cellulite improvement.[23] Subcutaneous carbon dioxide injection,[24] Endermologie,[25] noninvasive ultrasound and lymphatic drainage massage,[11,26] and newer noninvasive treatment combinations, such as radiofrequency, infrared light, and mechanical tissue manipulation[13,14] or contact cooling, laser diodes, and tissue massage[15] all represent various options to attenuate cellulite. In severe cases of cellulite (Curri grades III and IV), each alteration must be thoroughly evaluated. The skin texture, extent of cellulite, associated alterations, elevated and depressed areas, irregularities, previous treatment, presence of scars or fibrous tissues, and changes in skin pigmentation represent important points to be evaluated before treatment. A dynamic assessment of the patient's cellulite is also relevant and must be

Table 4. Improvement of cellulite aspect according to patient's assessment

Improvement	n (%)
Poor (no improvement)	2 (3.8%)
Fair (limited improvement)	6 (11.6%)
Good (significant improvement)	28 (53.8%)
Excellent (marked improvement)	16 (30.8%)
Total	52 (100%)

Classification based on the percentage of cellulite reduction: poor (improvement from 0% to 25%), fair (26% to 50%), good (51% to 75%), and excellent (>75%).

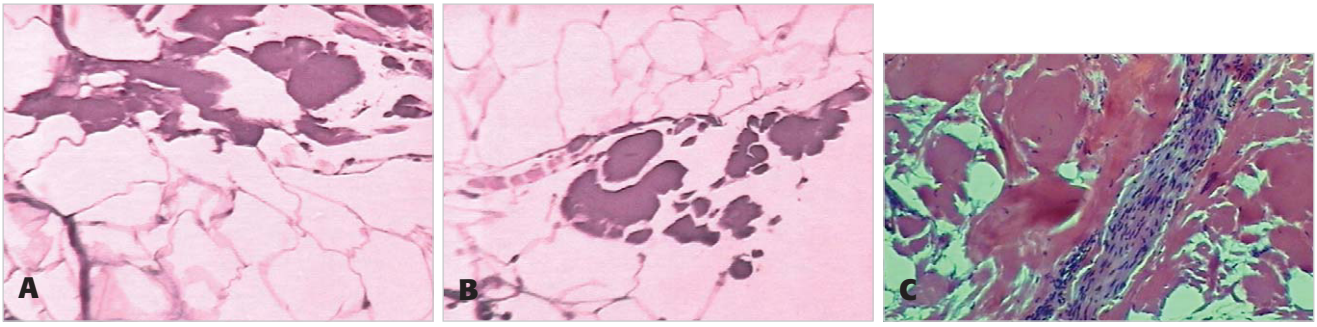

Figure 4. A-C, Adipose tissue showing lipolysis and septal connective tissue coagulation.

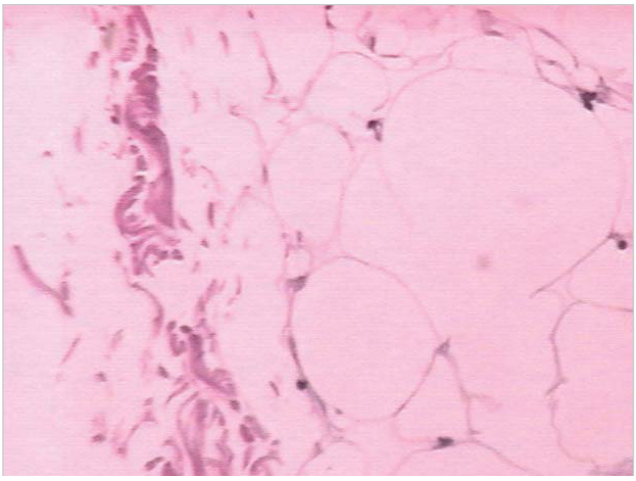

Figure 5. Focal lipolysis in fatty tissue and degenerative alterations in the septal connective tissue.

carefully evaluated before treatment. Standardized photographic documentation before, during, and after the completion of treatment is essential.

The possibility or necessity of multiple treatments or even the use of different therapeutic modalities can also improve the long-term results. Cellulite is a chronic condition; the patient must understand this fact and the necessity of repetitive treatments and changes in the appearance of the problem over time and with the aging process.

All treatments already described to treat this condition have some limitations. Traditional lipoplasty, with or without autologous fat transplantation, has generally been disappointing in the treatment of cellulite; it can even worsen the condition. This is likely because of the larger cannulaes used, the higher vacuum pressures associated with traditional lipoplasty, and the lack of any significant tissue tightening seen in laser lipolysis.

The combination of pulsed subdermal Nd:YAG laser energy and autologous fat transplantation is able to treat many alterations usually present in cellulite. Autologous fat has long been used as a material for soft tissue augmentation[27] and its transplantation has many advantages.[28] In using the patient's own fat, adverse effects such as allergic reaction, migration, and foreign body reactions can be avoided. In cases of hypercorrection, it is possible to aspirate some volume using a small cannula or even induce a new lipolysis using the laser. In cases of hypocorrection, it is always possible to inject a bit more fat and fill out the depressed areas. As an extra advantage, the removal of this donor fat from another body region can represent another positive effect in terms of overall body sculpting.

The treatment of the elevated areas by the disruption of fat cells using the pulsed 1064-nm Nd:YAG laser represents a useful tool in the treatment of cellulite. There are many positive characteristics of this laser–tissue interaction. The use of such a small cannula (1 mm) does not leave a "footprint" at the dermal–fat junction and does not cause any further cutaneous irregularities. It represents a less traumatic procedure than traditional lipoplasty. The photoacoustic, photomechanical, and photothermal effects of the laser energy in the fibrous septal connective tissue layer induce cell lysis and stimulate neocollagenesis; the consequent contraction and tightening effect in the dermis is a further beneficial effect of the subdermal use of the Nd:YAG laser.[29-39] This effect of the laser has been described in many publications[29-39] and has also been shown in this study. The histologic findings shown demonstrate both collagen coagulation and degenerative alterations of the fibrous septal connective tissue layer.

The use of a 1-mm cannula, along with the reddish transillumination of the HeNe beam, offers the surgeon precise knowledge of where and at what level the Nd:YAG beam is acting, and thereby decreases the possibility of cutaneous burns and perforations. A more intense red HeNe beam means that the laser is operating more superficially; the less intense the color, the deeper the laser is penetrating. The main benefit of treatment with the pulsed 1064-nm Nd:YAG laser is the opportunity to treat all affected layers in severe cases of cellulite: the dermis, fibrous septal connective tissue, and fat.

In the photographic pre- and postoperative comparisons, the improvement in skin texture and skin quality (the "orange peel," or dimpling and undulations of cellulite) are evident.

CONCLUSIONS

Cellulite has a multifactorial or an elusive, obscure etiology. The search for causation and for new and effective treatments is ongoing. Many of the treatments described to date have little or no scientific basis. The combination of the pulsed 1064-nm Nd:YAG laser and autologous fat transplantation represents a viable option for the treat-

ment and improvement of severe cases of cellulite. Although the combination of laser and fat injections has shown promising improvement in severe cases of cellulite in this study, additional studies are necessary to further refine the technique, to demonstrate reproducibility, and to draw final conclusions. ◗

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DISCLOSURES

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