Subsurface Laser and Radiofrequency for Face and Body Rejuvenation

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KEYWORDS

• Side firing • Cellulite • 1440 nm • Lasers through fibers • Neck rejuvenation • Skin tightening • Platysma muscle

KEY POINTS

- Laser and radiofrequency energy can be delivered below the skin.
- Small (1 mm) incisions are used to enter the subdermal space.
- Temperature levels play a key role in minimally invasive energy procedures.
- Significant skin and muscle tightening effects are possible.
- Healing time is minimized because external skin is not affected.

INTRODUCTION

Before 2006, energy delivery, in particular laser energy, was delivered through the skin. If higher energies and subsequently higher temperatures were required for deeper penetration, the available parameters were larger spot sizes, longer wavelengths, and surface cooling to protect the skin surface from overheating and complications. There was no other method of deeper delivery or higher energies until the advent of the delivery of laser energy through a subdermal fiber in 2006. This original device, marketed under the name of Smartlipo (Cynosure, Westford, MA), was originally low power (6 W) and delivered through a small fiber diameter of 300 μm. This device was improved over 6 generations until the current device, which is 46 W, has 1000-μm fibers, and 2 other uses to be detailed later (**Fig. 1**). Three initial studies were performed by this author to substantiate the physics and safety profiles,[1] the skin tightening phenomenon,[2] and the blinded comparison of skin tightening and change in elasticity compared with suction lipolysis alone.[3] Findings for skin tightening were significant at a temperature of 47°C, as measured 5 mm deep by a thermistor, with 62% on the laser side compared with 5% on the laser control side.

Subsequent developments of the same platform were produced in 2010 and 2011. The next challenge had been insurmountable for years; namely a significant improvement of cellulite with a single treatment, with long-lasting results (>3 years) and US Food and Drug Administration (FDA) approval. Women were affected only because of the subsurface architecture; cellulite was poorly understood in its anatomy and specific defects. With no clear understanding of the problem, a clear path to treatment was elusive as well. Final conclusions as to the anatomy were based on 3 specific defects (**Fig. 2**). It was determined that the raised areas were caused by excessive areas of

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Clin Plastic Surg ■ (2016) ■–■
http://dx.doi.org/10.1016/j.cps.2016.03.009
0094-1298/16/$ – see front matter

Fig. 1. Minimally invasive laser device. (Cynosure, Westford, MA.)

subdermal adipose, the depressed areas by fibrotic vertical septae pulling down, and the surface orange-peel appearance from fat globules herniating into the thin dermis, as seen in all patients with cellulite (**Fig. 3**). A side-firing laser was developed using a 1440-nm wavelength to achieve results (Cellulaze, Cynsoure, Westford, MA). This unique wavelength forms microbubbles at the tip of the fiber, thus creating a glass-air interface, thereby allowing the laser light to bend. This phenomenon is unique to this wavelength. A step-by-step summary of the procedure is provided later. The initial details are in the preliminary report by this author,[4] followed by the multicenter confirmatory trial used by the FDA for clearance, and longer-term data from the multiple centers.[5]

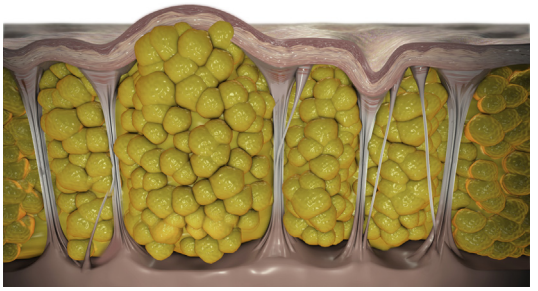

Fig. 2. The anatomy of cellulite.

Once side firing was a proven entity showing results otherwise achieved by forward firing laser fibers, the fiber was then reduced in size to 800 μm. This device, which was a software/hardware upgrade to the original device, was known as Precision Tx (Cynosure, Westford, MA). The smaller diameter allowed treatment of fat and skin defects in areas such as the neck[6] and knees, treatment of hyperhidrosis, and specialty uses such as treatment of moderate to deep acne scarring.[7]

More recently, subdermal treatment has extended to minimally invasive radiofrequency (RF) treatments.[8] Still using a small probe in the 1-mm range, energy is delivered at different levels to achieve effects in skin and fat, and nerve effects on muscle. This device is marketed under the brand ThermiRF (Thermi, Irving, TX). Unique to this system is accurate temperature monitoring both below the skin with a thermistor and above the skin with a thermal camera.[9] Skin tightening is achieved at a subdermal temperature range of 55°C to 65°C, whereas fat disruption occurs at 70°C. The process called Thermirase maps out specific nerves with a nerve stimulator before applying a temperature of 85°C for 1 minute. There is a learning curve to these procedures and proper training is imperative.

PATIENT SELECTION

Patient selection varies according to the minimally invasive procedure described. Starting with laser-assisted liposuction, these patients often present as standard liposuction patients. The subgroup most indicated for this procedure has mild to moderate fat excess and has some degree of mild to moderate skin laxity as well. Patients are often in the age range of 35 to 60 years old, although some are younger or older. If skin excess is too severe, then a surgical excision of the skin is more warranted. Typical areas are abdomen, medial thighs, and arms.

All forms of cellulite are able to be treated with Cellulaze, including dimples, horizontal streaks, as well as orange-peel appearance. Formally, these are in the range of all grade II and grade III mild and moderate as per the modified Nurnberger-Muller Scale. Patients with grade III severe need a combination of liposuction and fat grafting before the cellulite procedure.

Necks can be treated with laser subdermally with a mild to moderate presentation of fat excess

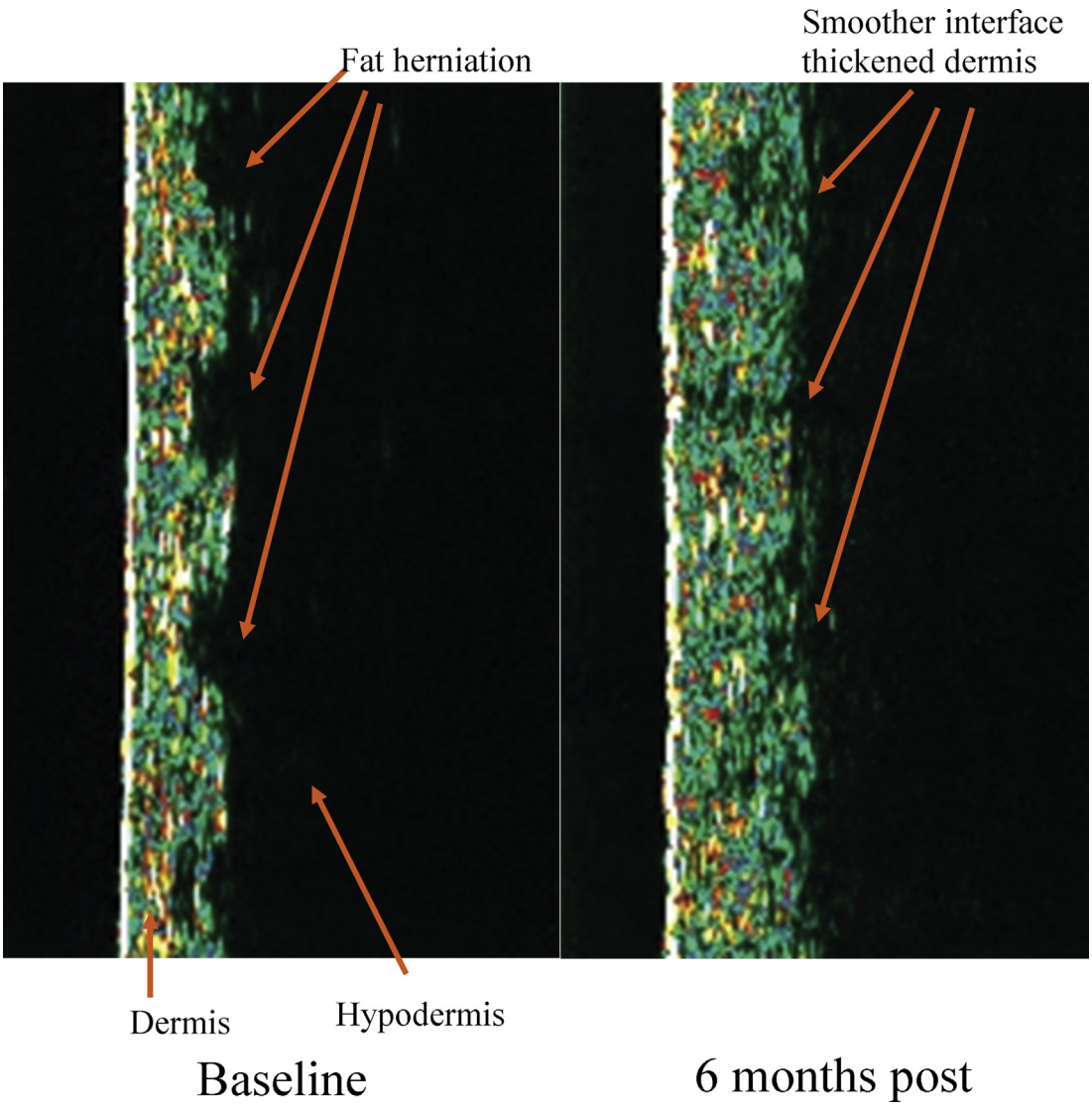

Fig. 3. High-resolution ultrasonography of the dermis before and after (post) cellulite treatment.

and skin laxity. Fat and skin can be treated with the laser or RF, whereas any platysma muscle laxity traditionally requires surgical intervention. With the advent of the RF treatment of the cervical branch of the facial nerve, muscle relaxation and improvement can be seen with minimally invasive techniques. Again, caution is needed if the muscle laxity is too severe and surgical judgement is required to ascertain whether more invasive neck tightening surgical procedures are more appropriate.

For acne scarring, the subdermal laser is more indicated in moderate to severe cases of acne scarring, whereas mild to moderate conditions may be more appropriate for external devices.

OVERVIEW OF TREATMENT STRATEGY

Laser and Radiofrequency Safety

Laser safety is critical to both practitioners and patients. There are excellent published guidelines on laser safety. The most critical safety issue with minimally invasive techniques is eye safety and proper protection must be used for practitioners and patients. Even though the laser is under the skin, inadvertent removal can affect the eyes of the staff and/or patient.

Temperature end points are critical in both laser and RF procedures. Proper training for staff and physicians is paramount, whereas temperature monitoring is critical to results and skin safety. All

of these devices have sophisticated internal monitoring systems. The laser has an internal thermistor at the tip of the fiber, which prevents the laser from firing in 0.2 seconds from the time the temperature is reached (Thermaguide). The laser also has motion detectors (SmartSense), which sense lack of motion if the firing pedal is still depressed and again stops the laser from firing in 0.2 seconds.

RF also uses high temperature in fat, skin, and muscle. This temperature is also regulated by on-screen deep thermistor measurements as well as surface thermal camera readings for skin surface safety.

Indications

The indications for these minimally invasive procedures are partly covered earlier.

Laser liposuction: mild to moderate fat; mild to moderate skin laxity.

Cellulaze: any grade II and grade III mild to moderate cellulite.

Laser fiber neck: mild to moderate fat and skin laxity; no muscle banding.

Laser fiber acne scarring: moderate to severe scarring in cheek and temporal area.

RF neck: mild to moderate skin excess and fat; mild to moderate platysmal banding or wrinkles in areas consistent with botulinum toxin injection.

MINIMALLY INVASIVE LASER AND RADIOFREQUENCY TECHNIQUE

Treatment Protocols

Laser-assisted liposuction

Unique markings are placed on the patient representing 5 × 5 cm squares over the treatment area, and these are used to regulate energy distribution. The patient is then prepped and draped as for a liposuction procedure. Tumescent fluid of choice is instilled but only at a maximum of 100 mL per sector. The fat is disrupted with the forward-firing laser energy. Two wavelengths of energy are used: 1064 nm for coagulation of small blood vessels and 1440 nm for disruption of fat and tightening of vertical fibers using the water content thereof. A second laser step is performed with the laser immediately under the dermis with monitoring of temperature and end point in the 45°C to 47°C range. The laser is set to stop firing between 45°C and 47°C, depending on skin color. Once laser treatments are completed, suction is performed to remove the appropriate amount of unwanted fat. The deep end point for laser is loss of resistance, and superficially is the temperature goal. Postoperative technique is similar to any other liposuction technique.

Laser cellulite treatment

The target area is divided into 5 cm × 5 cm sectors and each sector is treated individually. Incision areas are given topical lidocaine (if necessary) and cleaned with povidone-iodine antiseptic (Betadine, Purdue Pharma) before infusion of tumescent lidocaine solution. From 2 to 4 1-mm incisions are made with a trocar or blade under standard-of-care conditions for introducing the laser cannula. Between 50 and 80 mL of the tumescent anesthesia mixture (50 mL of 1% lidocaine [without epinephrine], 1 mg of epinephrine per liter of warm normal saline, and 12 mL of 8.4% sodium bicarbonate) are infused into each sector to a maximum total volume of 1 L. The laser cannula is then inserted through one of the incisions close to the target area. A red aiming beam from a He:Ne laser source permits the physician to visualize the tip of the fiber during treatment. The cannula is gently positioned below the skin surface. At this stage the procedure is divided into 3 steps with the fiber: (1) in the down position, (2) in the horizontal position, and (3) in the up position. The fiber is placed in the down position (1–2 cm beneath the skin) to melt the excess hypodermal fat to minimize its expansion into the dermis and to reduce the irregularity of the dermal-hypodermal interface (**Fig. 4**). Once in place, the cannula-fiber unit is moved back and forth in a fanlike pattern until the delivered energy totals 100 to 600 J, depending on the dimensions of the raised areas in the sector undergoing treatment. When all selected raised sectors are treated, the fiber position is changed to horizontal to direct the side-firing energy parallel (rather than perpendicular) to the skin surface (**Fig. 5**). In this step, energy is delivered only to areas premarked as dimples when the patient was standing. Each

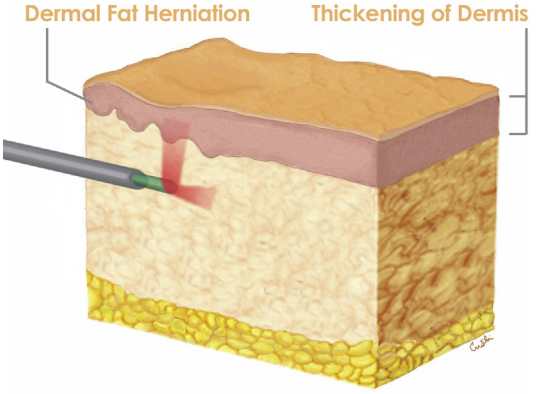

Fig. 4. The laser fiber in the down position to melt the excess hypodermal fat. (*Courtesy of* Cristi A. DiBernardo, BA, Montclair, NJ.)

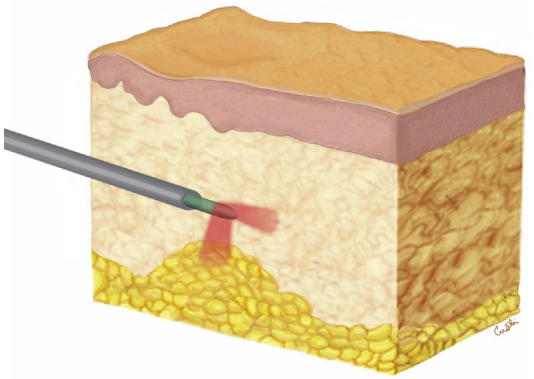

Fig. 5. The laser fiber in the horizontal position to thermally subcize the septal connective tissue strands connecting the dermal and muscle layers. (*Courtesy of* Cristi A. DiBernardo, BA, Montclair, NJ.)

sector containing dimples or cellulitic dimpling is retreated with the horizontal fiber moving in same fanlike pattern and in the same plane. This step is designed to thermally subcize the septal connective tissue strands connecting the dermal and muscle layers. The end point in this second step is the loss of resistance as the cannula passes through the tissue, indicating that the septa no longer connect the dermal and muscle layers. The fiber is then set to the up position and placed 2 to 3 mm below the skin surface and just under the dermal-hypodermal interface (**Fig. 6**). All sectors are then uniformly treated to make the dermal-hypodermal layer smoother by heating (and melting) the fat in the dermal invaginations, increase the skin elasticity, and stimulate fibroblasts for collagen remodeling to increase dermal layer thickness during the months after treatment. Total

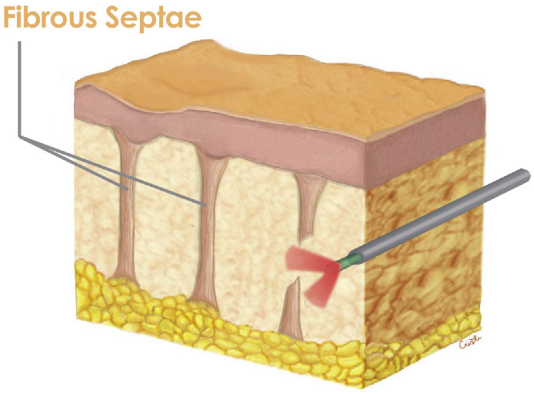

Fig. 6. The laser fiber in the up position to make the dermal-hypodermal layer smoother, increase skin elasticity, and stimulate collagen remodeling to increase dermal layer thickness. (*Courtesy of* Cristi A. DiBernardo, BA, Montclair, NJ.)

time (including pretreatment and posttreatment care) is approximately 2 minutes per sector, depending on the area treated.

Laser neck treatment

A sequence similar to the laser fiber techniques is followed. The cannula in this case is miniaturized at 800 μm and side firing. The area to be treated is marked, and fat and areas of tightening are indicated. Tumescent anesthesia is given but at a maximum in the neck of 100 to 150 mL. The laser is then introduced through 3 small incisions at the submental area as well as the posterior neck bilaterally. The laser is aimed down at the areas of fat and fired to a maximum temperature of 40°C to 41°C. The laser is then aimed upward to the skin with a temperature goal of 45°C to 47°C. The laser is set to shut off at 47°C. All areas of laxity are threated in this manner. Once disrupted, fat is removed with a 2.4-mm cannula and suction. Incisions are closed and the area is taped with 25-mm (1-inch) paper tape and foam compression for 5 to 7 days.

Radiofrequency tightening procedure

Regardless of the area of the body, similar preparations are made. Areas of skin laxity are marked. Local anesthesia is given at the incision points. The appropriate-length RF probe (10 or 15 cm) is selected and the tumescent fluid of choice is

Fig. 7. Thermal camera for use with RF procedure.

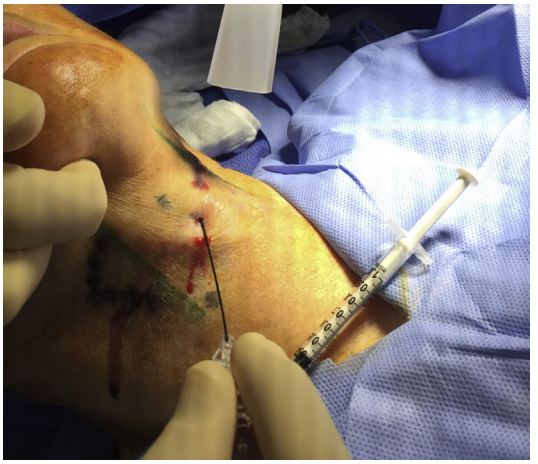

Fig. 8. RF probe with distal port.

given. If skin tightening only, a modest amount of fluid is required. The thermal camera is set into position (Fig. 7) and the treatment area is confirmed to be in view. The RF energy limit is selected: 55°C to 65°C for skin, lower for thinner areas, higher for thicker dermal areas, and 70°C for fat. This setting is the set temperature. The device ceases energy output when this temperature is reached. The probe is inserted, the device turned on, and, when the set temperature is reached, the probe is slowly retracted, allowing each subsequent area to achieve the temperature goal. The thermal camera temperatures are safely monitored in the range of 42°C to 45°C and the evenness of heat application is seen on the screen. Before any neck procedure, mapping of the marginal mandibular nerve is performed to avoid excessive heat leading to neuropraxia.

At completion, wounds are optionally closed and a compression dressing placed for up to a week.

Radiofrequency nerve treatment of muscles

Similar to botulinum toxin, nerves can be temporarily disabled to enhance the appearance either of the upper face or the neck. After careful mapping of the nerves to be treated, the RF probe is inserted and, in the stimulation mode, the nerve is triggered 1 more time to verify the exact position. Carefully, and without moving the probe, 4% lidocaine is instilled through a port of the distal probe (Fig. 8) and given at least 1 to 2 minutes to take effect. The area is then chilled with ice or a cold air chiller for 30 seconds before applying RF energy to 85°C for 1 minute. This treatment creates a lesion on the nerve. One or several areas of the nerve can be treated, with more longevity of the procedure coming with several areas being treated. The effect on the muscle is seen immediately (Fig. 9).

Fig. 9. Before and after RF treatment of the nerves to the platysma muscle.

COMPLICATIONS AND TREATMENT

Other than complications similar to liposuction, which are beyond the scope of this article,[10] most complications are related to heat and temperature. These complications are rare with the sophisticated temperature monitoring in the newer devices, but, if they do occur, place ice immediately and treat as per the appropriate level of burn that is clinically evident.

Increased temperature can also lead to pigmentation abnormalities, which can be treated topically with hydroquinone or with lasers appropriate for pigment reduction. Darker skins usually require lower temperatures for this reason.

Treatments immediately under the skin, such as cellulite, can stimulate localized small blood vessels during the healing process. These vessels usually subside with time (6–12 months) but, if still persistent, can be treated with an intense pulsed light with vascular filters in place.

Again, proper training of doctors and staff in these sophisticated devices cannot be overemphasized.

SUMMARY

Minimally invasive procedures are growing in scope and popularity with patients' desires for smaller incisions and less surgery. Significant progress has been made in this category in recent years, with fat, skin, and nerve targets now receiving attention. The importance of this category is not only a less invasive way to treat existing aesthetic problems but also new treatments of targets that have been otherwise untreatable in the past.

ACKNOWLEDGMENTS

The authors thank Cristi DiBernardo for the original artwork.

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