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Low-Level Laser-Assisted Liposuction: the Neira 4 L Technique

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Liposuction, a procedure that carves out body fat by suction and grafts fat in other places to recreate a harmonic, anatomic, and physiologic corporal shape, is an art. Although this procedure is the most commonly performed cosmetic surgery (384,686 procedures were performed in the United States in 2003) [1], it is not considered altogether benign [2]. In 2000, the mortality rate for patients having liposuction was similar to that for persons dying in motor vehicle accidents in the United States—about 20 in every 100,000 procedures done by physicians certified by the American Board of Plastic Surgery [3].

Liposuction causes severe trauma to the adipose tissue and crushes nerves, vessels, and connective tissue, generating a strong inflammatory response [4]. The patient undergoing liposuction is at risk for multiple problems, such as thrombosis, endothelial edema, fat embolism, immunocompromise, infection, local necrosis, transitory and definitive vascular damage, and lengthy healing processes. Hetter [4] described the surgical trauma in a classic lipoplasty as crush injuries and referred to these wounds as "the internal burn," stressing the loss of serum albumin as well as red cell mass and the release of intracellular products. These events initiate a giant inflammatory cascade that causes a marked fourth-space phenomenon during the first 3 days after surgery.

In an effort to mitigate the trauma of classic liposuction, surgeons have used external laser-assisted liposuction to reduce inflammation and control pain after surgery. This article describes low-level laser-assisted liposuction (LLLL), known as the Neira 4 L technique, a new procedure that our surgical team has developed to moderate the inflammatory response, reduce trauma to tissues, and promote subcutaneous wound healing after lipoplasty-assisted liposuction.

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Mechanisms of action of low-level lasers

Effects of low-level lasers on the adipose cell membrane and mitochondria

Low-level laser irradiation modulates the attachment of cells in vitro by means of cytochrome C oxidase and activates the mitochondrial signaling pathway, which increases the effect of the laser on the cell membrane and the mitochondria [5] and the number of contacts of the endoplasmic reticulum with the mitochondria and plasma membrane [6]. Irradiation with a low-level laser increases ATP levels in cells cultivated in vitro, increasing the survival of the cell by increasing cell energy that could be necessary to repair and heal tissues after surgical trauma [7]. The increase in cellular ATP levels produced by monochromatic red light depends on the growth phase of the culture. ATP levels are insignificant in the lag phase of cultured cells, increase in the log phase, and reach a maximum (about 190%) in cells at the late logarithmic and early plateau phases [8,9]. Iaffaldano and coworkers [10] found increased ATP levels, electric potential across inner membranes, and action potential in the mitochondrial matrix, as well as small changes in the matrix configuration. Although increasing intracellular cAMP concentrations in vascular smooth muscle increases blood flow and promotes edema, increasing cAMP concentrations in the endothelium may suppress edema by enhancing the permeability barrier [11].

Radiation of cells with a low-level laser causes morphologic changes in the mitochondrial lymphocyte [12]. Because hemoglobin does not absorb in the red and near-infrared spectral region, light can penetrate deep into the living tissue.

At least three signaling pathways relate cell attachment, the respiratory chain, and the Na^+, K^+-ATPase, and N^+/H^+ exchanger activities [13]. Cu(A) and Cu(B) chromophores of cytochrome C oxidase may be involved as photoacceptors, and various signaling pathways between cytochrome C oxidase and cell attachment regulation are at work.

Effect of laser light on the body

Used in the treatment of a broad range of conditions, including acute and chronic pain and injured tissues, low-level laser therapy (LLLT) has improved wound healing, reduced edema, and relieved pain of various origins.

Inflammation

Low-level lasers have been used for many years to reduce inflammation. LLLT reversibly suppresses the action potentials elicited by bradykinin and blocks the conduction of nociceptive signals in primary afferent nerves [14]. At 4 J/cm^2, the anti-inflammatory effect is superior to that with 8 J/cm^2 [15]. LLLT is used to stabilize vascular endothelia to prevent tissue hypoperfusion through endothelial edema [16].

Pain

LLLT for pain involves suppression of late discharges in caudal neurons evoked by excitatory inputs from C-fiber afferents but not of early discharges evoked by impulses from A-fiber delta afferents [17]. These results suggest that low-level laser energy blocks the depolarization of C-fiber afferents and suppresses impulse conduction of unmyelinated A-fiber delta afferents in the peripheral sensory nerve, which causes pain. Kasai and coworkers [18] showed that LLLT acts as a reversible direct suppressor of neuronal activity.

In a study of the effect of low-power laser irradiation on pain using substance P in rat spinal dorsal root ganglion, Ohno [19] found a statistically significant difference in substance P–like immunoreactivity between the control group and stimulated group. These results suggest that laser irradiation suppresses excitation of the unmyelinated C-fibers in the afferent sensory pathway.

LLLT on local points in rats with arthritis relieved arthralgia, reduced swelling in the ankles, and produced instant analgesia [20].

Peripheral nerves

Irradiation with a low-level laser can prevent posttraumatic degeneration of peripheral nerves and postpone degeneration of the central nervous system [21]. Low-level laser energy inactivates the potential of the cell membrane, preventing the transmission of pain through afferent nerves after surgery, and acts on the demyelinated nerve to speed recovery. In one study [22], transcutaneous low-power irradiation with low-level lasers significantly increased the rate of regeneration of rat facial nerve after a crush injury when compared with that of the control group ($P < .01$).

In their classic study, Rochkind and coworkers [23] found that LLLT improved the recovery of injured peripheral nerves and the central nervous system, as well as the healing of cutaneous wounds and burns. LLLT applied to crushed injured nerves significantly increased the compound action potential in unirradiated tissue and irradiated tissue on the left side. Laser irradiation done on only the right side in bilaterally inflicted cutaneous wounds enhanced recovery on both sides ($P < .01$). In the nonirradiated control group, all rats sustained advanced necrosis of the feet and bilateral gangrene. These systemic effects have implications for the clinical application of LLLT and for basic research into the possible mechanisms involved.

Wound healing

Use of low-level lasers accelerates and improves wound healing and minimizes scarring. The mechanism of this phenomenon is unclear and still under investigation [24]. It is well known that cell-cell and cell-matrix adhesion is altered during wound repair [25]. The cell membrane may develop cellular adhesiveness, joining normal cells to each other when the membranes are exposed to the laser beam [26].

Biophysical effects of laser light on adipose cells

When our team studied the biophysical effect of low-level lasers on adipose cells, we found a transitory pore in the adipocyte membrane [27] and fat leaking from the inside of the cell into the interstitial space outside [28]. Moreover, laser light did not destroy the adipocyte when it mobilized the fat from the inside to the outside of the membrane [**Figs. 1–3**]. It kept the cell alive and in good condition, as confirmed with trypan blue staining and XTT [29].

Neira and colleagues, based on the work of Kolárová and coworkers [30], studied adipose-irradiated tissue samples for 2, 4, and 6 minutes with and without a tumescent solution. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) showed that, without laser exposure, normal adipose tissue appeared as a grape-shaped node [**Fig. 3**]. After 4 minutes of laser exposure, 80% of the fat was released from the adipose cells [**Fig. 4**]. At 6 minutes of laser exposure, almost all of the fat was released from the adipocyte [**Fig. 5**] [31]. The released fat collected in the interstitial space [32].

TEM images of adipose tissue taken at a magnification of 60,000× revealed a transitory pore

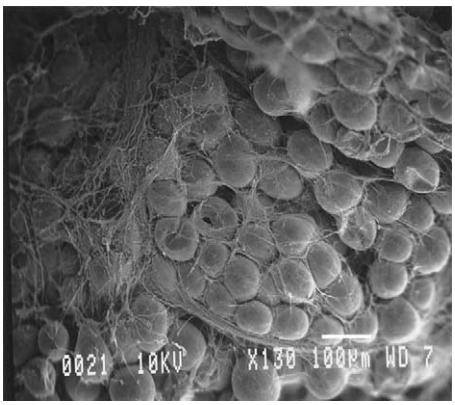

Fig. 1. Scanning electron microscope (SEM) image of normal adipose membrane of adipocyte. Some connective tissue is evident surrounding the adipose cells.

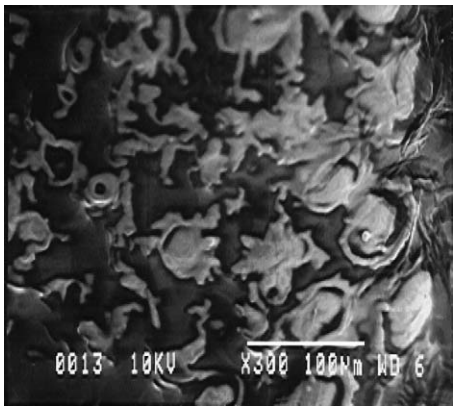

Fig. 2. Adipocytes after 4 minutes laser exposure. Some are deformed and have a crenate shape.

[**Fig. 6**]. Low-level laser energy opened this pore in the cell membrane, permitting fat to go from the inside to the outside of the adipose cell [**Fig. 4**]. The interstice and capillaries of the cell remained intact. By 4 minutes of exposure, partial disruption of the adipose cell was observed, but several cells maintained their properties and structure [32]. Adipose cells with and without laser exposure are shown in the same sample in **Fig. 7**.

When adipose cells were cultured until maturity and then irradiated with a low-level laser (637 nm) with an equivalent dose of 3.6 J/cm^2, the cells were semi-destroyed [31]. Five days after being recultured, the adipose cells were alive and had recovered their normal anatomy [29,31]. Although the initial results of further studies with light microscopy were not conclusive because of initial sample testing procedures, the case study was continued because the preliminary clinical evidence clearly warranted further investigation.

Both SEM and TEM were done on superficial and deep fat samples to establish whether cellular effects correlated with the penetration depth of the laser beam after application of the tumescent technique [33]. The analysis of fat samples indicated that tumescent infiltration facilitated laser beam penetration and movement of fat from inside to outside the cell. A detailed study of the adipose cell membrane with TEM confirmed the existence of the suspected pore [**Figs. 2,8**] [34].

When superficial and deep fat samples of laser-treated tissue taken from the infraumbilical area were studied [29], no major observable differences were found in the samples of adipose tissue exposed to laser radiation for 2 and 4 minutes without tumescence [31]. Laser penetration through the adipose tissue decreased when tumescent solution was not used, suggesting that the application of the tumescent solution is an important enhancement factor [35].

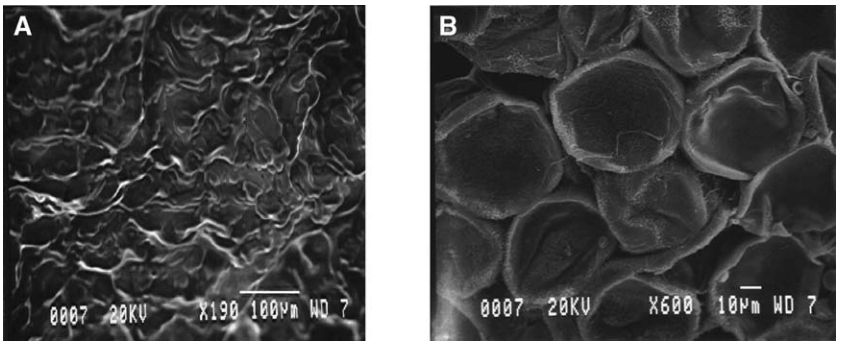

Fig. 3. (*A*) Adipose tissue after 6 minutes of laser exposure. Fat is outside the cell, and only membranes are seen. (*B*) The adipocytes have lost their fat and look deflate.

Without laser exposure, the adipose tissue remains intact; adipocytes maintain their round grapelike shape [see Fig. 3]. After 4 minutes of laser exposure, the membrane of the adipocyte is partially disrupted [Fig. 4], and 80% of the fat is outside the cell. Fat particles build up in the shape of a helmet on the cell. The membranes of adipocytes are partially disrupted, exposing fat bodies outside the cell [Fig. 4]. At 6 minutes of laser of exposure, SEM shows almost total disruption of the adipose cell membrane and evacuation of fat [Fig. 5]. The back fat sample shown in Fig. 1 has increased connective and reticular tissue, explaining why is more difficult to take out.

Low-level laser-assisted liposuction

The procedure

The Neira 4 L procedure has been described previously [36]. In preparation for LLLL, the completely naked patient is washed with Isodine while standing up. The Isodine is sprayed on the body, including the hands and feet. Two blankets of sterilized rubber are placed on the operating table, one on top of the other, and covered with sterilized fields. The patient is then instructed to lie down on the operating table and given local sedation with propofol (fentanyl and or midazolam) intravenously.

An ultrawet infiltration is performed on the target areas [37]. The greater the hydration of the tissue, the deeper the transmission of the laser beam. When the tissue is not well hydrated, the beam will not reach the desired depth, and the results are not as good.

The surgeon makes 2 mm incisions with a No. 11 scalpel blade and introduces cannulas for infiltration. Almost simultaneously, the assistant begins to apply the laser continuously at 14 mW at a focal distance of 26 cm irradiating with two lines of light until a dose of 3.6 J/cm^2 is reached.

The assistant then applies laser radiation to the appropriate areas to extract fat, beginning with the left or right hemi-abdomen, for about 12 minutes. The infiltration may last 30 to 40 minutes, during which time the assistant simultaneously applies the laser to all of the tissues being infiltrated. This application saves time because the surgeon begins infiltration at the same time that the assistant begins to apply the laser. After completion of the

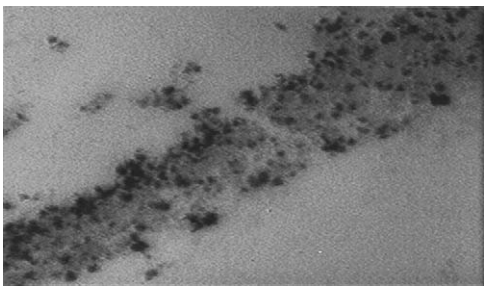

Fig. 4. Transmission electron microscopy (TEM ×60000) of the membrane after 6 minutes laser exposure. (Channel formation)

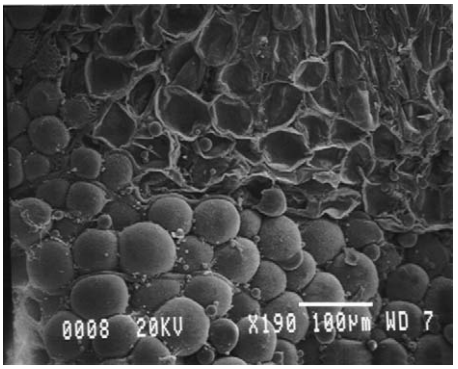

Fig. 5. Upper half of the image depicts "deflated" adipocytes. Lower half of the image demonstrates normal adipocytes.

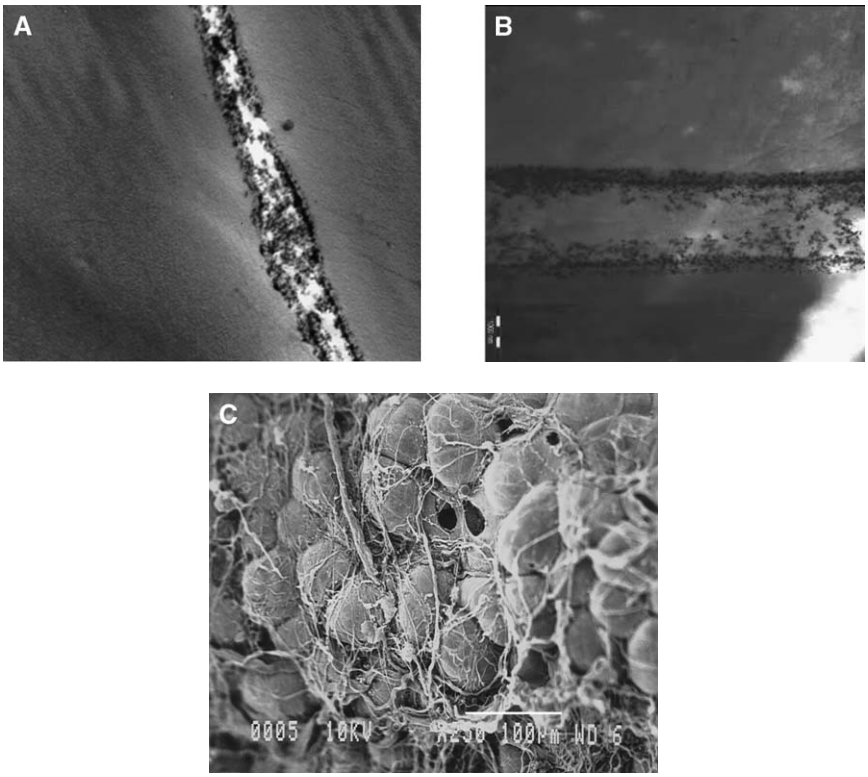

Fig. 6. Normal adipose membrane. (*A*) Transmission electron microscope (TEM) image without irradiation, original magnification ×400,000. (*B*) TEM image without irradiation, original magnification ×50,000. (*C*) Fat tissue from the back has more conjunctive and reticular tissue, explaining why it is harder to remove.

infiltration, about 10 to 12 minutes longer are needed to finish applying the laser to the tissue in target areas. Ultrawet infiltration is maximized in all tissues to ensure success of the procedure. Laser penetration and effectiveness are poorer in patients in whom tumescence is suboptimal [32,35].

As soon as infiltration and laser irradiation are completed, tunnels are started in the superficial layers of fat without suction. Fat is extracted later with a 3- or 4-mm cannula, a syringe, or regular wall vacuum without special machines. Deep fat is extracted carefully with the tip of the cannula just touching, or kissing, the deep fascia at all times so that no damage is done. Observations indicate that a smoother and more uniform surface is obtained this way [38–40].

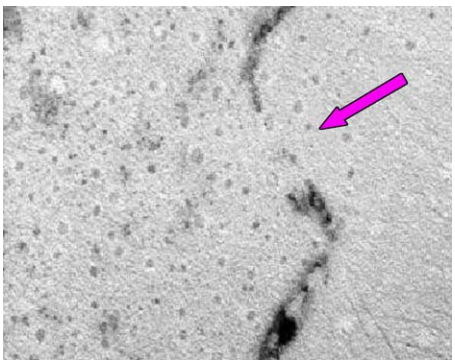

Fig. 7. 6 minutes laser exposure demonstrating interruption of the adipose cell membrane.

Fat is extracted from the superficial layer first. The surgeon then works downward toward the deep layer, where fat can be extracted with 2 and 3 mm cannulas without touching the skin. Fat is extracted with 3, 4, 5, and 6 mm Becker or Mercedes type cannulas. We always begin with 3 mm cannulas to remove superficial fat, and then use 4 and 5 mm cannulas to extract the fat more easily, especially in the dorsal area. Dorsal fat, in particular, is extremely reticular, dense, and hard, making it difficult to extract. The assistant can help keep the skin stretched to avoid damage. Because the fat is more liquefied, no nodules or condensed fat remains in the tissues undergoing fat extraction. Wounds are covered with Micropore rather than sutured, and the patient is completely wrapped in adult diapers, which are kept in place with a garment.

Three days after surgery, the laser can be applied for 3 minutes at 5 mW for each area to reduce the duration of inflammation. Massage can be initiated

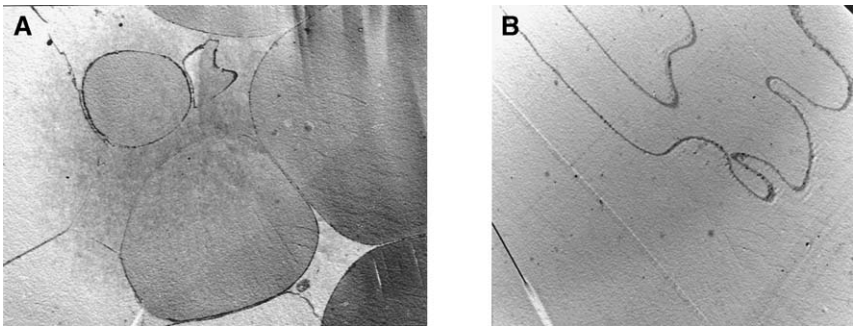

Fig. 8. (*A*) Transmission electron microscopy (TEM) showing adipocyte cell with well defined borders, no laser exposure. (*B*) TEM adipocyte after 6 minutes laser exposure, flexed membrane.

4 or 5 days after surgery. Improved skin retraction occurs within 3 months. Most patients express their satisfaction with the results obtained with this procedure [36].

Treatment of complications

Fluid in the lowest area of the abdomen during the first 3 days can be drained with a syringe and local anesthesia, or the flap can be squeezed and the liquid removed through the original surgical incision or with a needle and syringe. In general, fluid should be drained through the same incision or by syringe with local anesthesia. We have not seen real seromas in our patients.

Almost 20% of patients have pain, which can be controlled with nonsteroidal anti-inflammatory medication and codeine. Irregularities in the skin, which occur in 4% of patients, can be difficult to manage, but massage and the use of an external beam laser for a couple weeks may help. Itchiness can be treated with antihistamines and topical olive oil. Flap problems are treated with subcutaneous oxygen and 3 minutes of laser treatment over the area every day for 3 to 5 days. Edema of the hands and feet occurring 3 or 4 days after surgery is treated with furosemide 20 mg/day, PO for 2 to 3 days.

Infection, which occurs in 1% of patients, is more frequent in the sacral area. If infection is suspected, a hemogram, urinalysis, and hemodynamic evaluation should be done. If the results of these tests indicate infection, the wound may have to be drained. Antibiotics and culture are recommended if the infection is caused by *Staphylococcus*. Dicloxacillin 500 mg QID should be started. If the infection does not respond and the culture indicates no bacterial infection, which is rare, the patient should be monitored carefully within 8 hours, and vancomycin 1 g Q12H, ciprofloxacin 500 mg BID intravenously, should be started immediately. If *Escherichia coli* is found, oral ciprofloxacin (500 mg) should be started twice a day for 8 days.

Serosanguinous liquid that collects in the sacral area is usually extracted 1 week after surgery one or two times. Innovative adjuvant techniques for liposculpture have been used and have shown good postoperative results [36].

Discussion

The Neira 4 L technique offers a new less traumatic method of liposuction. The main goals of this technique are as follows:

- To protect the cells, especially the adipocytes, and the tissues around them
- To improve the defense mechanisms of receptor tissue
- To modulate the inflammatory response
- To improve the healing process
- To avoid creating a neuroaxonal lesion, preventing the development of neuralgias after surgery, decreasing postoperative pain, shortening recovery time, and decreasing the risk of side effects of surgical trauma

It is essential to reduce the surgical trauma to the patient or, at least, to improve their tolerance to the surgery and reduce pain. The Neira 4 L technique provides these benefits. Each new method or procedure comes with attendant expectations about its potential benefits. This article documents the scientific evidence that the Neira 4 L technique will make a valuable contribution to plastic surgery by decreasing the surgical risk, preventing side effects, and improving the quality of life for patients.

Summary

The Neira 4 L technique is less harmful to cells than ultrasound, the VASER, the power cannula, or lipoplasty-assisted liposuction, minimizing their destruction and death. Low-level lasers focus liposuction, protecting the patient's tissues, increasing

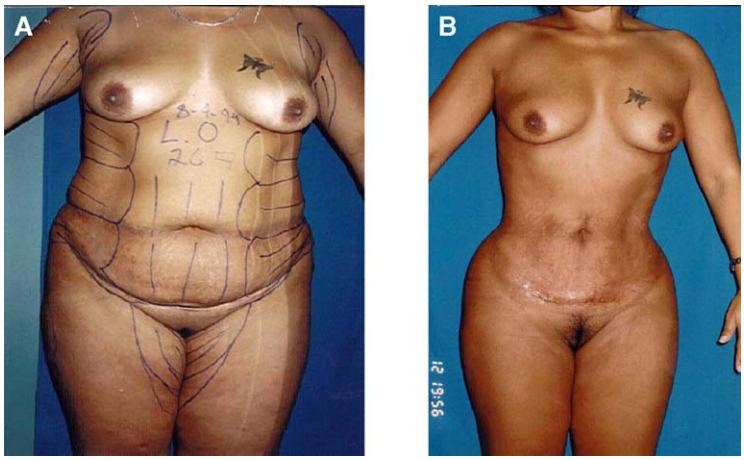

Fig. 9. Low-Level Laser Lipoplasty (LLLL) (Neira 4 L Technique). (*A*) Before and (*B*) after photos of a 26 year-old woman that had 9 liters of fat removed in one procedure.

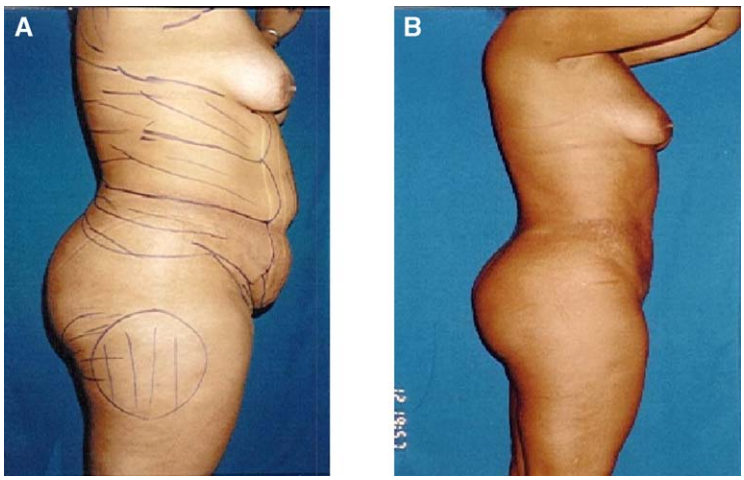

Fig. 10. Low-Level Laser Lipoplasty (LLLL) (Neira 4 L Technique). (*A*) Before and (*B*) after lateral views of a 26 year-old woman.

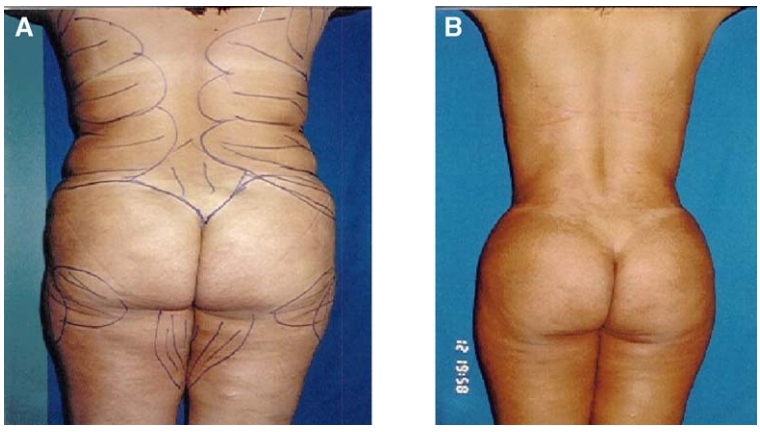

Fig. 11. Low-Level Laser Lipoplasty (LLLL) (Neira 4 L Technique). (*A*) Before and (*B*) after photos.

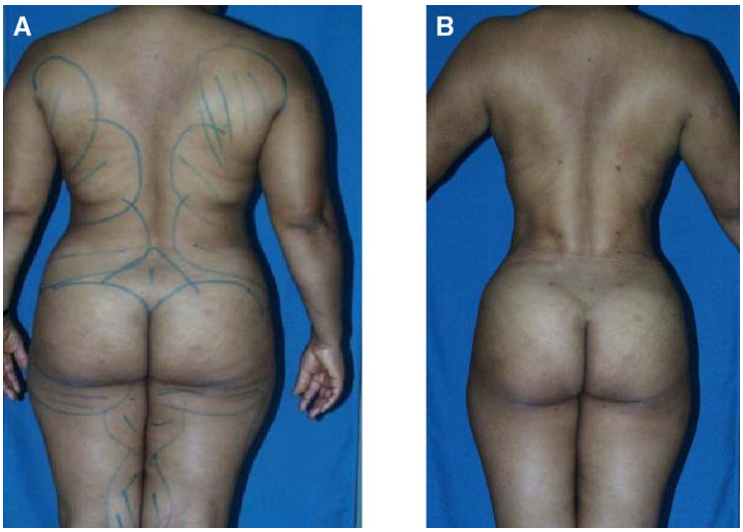

Fig. 12. (*A*) Before surgery and (*B*) after Neira 4 L Technique.

and activating cell mechanisms, and modulating the inflammatory response against surgical trauma. The main benefits of this procedure are improved tissue healing, decreased pain, minimal destruction of cells, improved cicatrization, improved nerve and vessel healing, and decreased risk of neuropathies.

The laser facilitates the formation of a transitory pore exclusively at the level of the adipocyte membrane and the release of fat by disrupting fat panicles and allowing the fat to leak from the cell into the interstitial space outside the cell. With use of ultrawet infiltration as an adjuvant, the remaining interstices are preserved.

This technique may be the precursor of other less aggressive plastic surgery procedures. Follow-up demonstrates adequate medium- and long-term body contouring. Clinical cases before and after LLLL are shown in Figs. 9–16. The patient is not exposed to

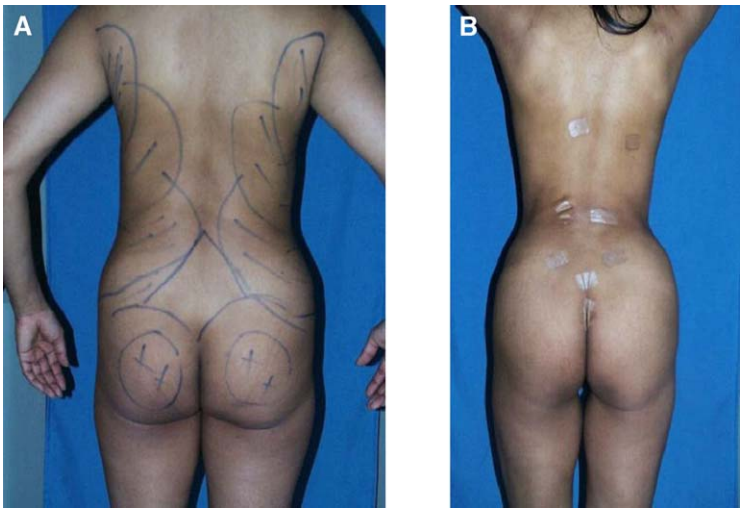

Fig. 13. Corporal liposculpture and gluteal Fat injection (*A*) before and (*B*) after surgery.

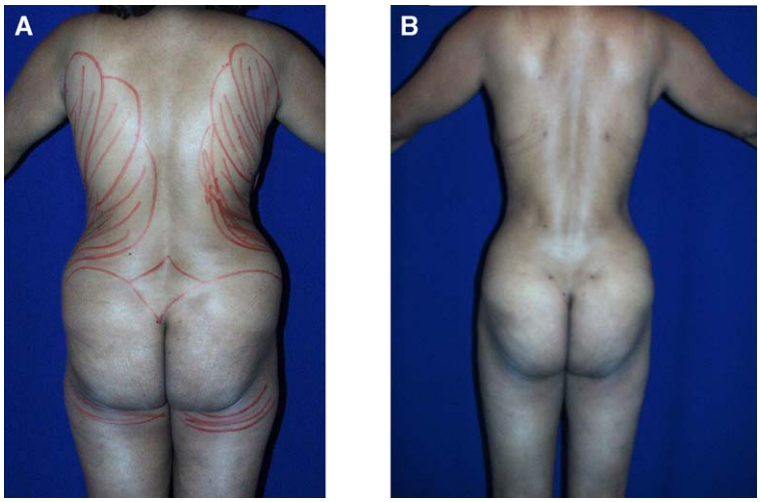

Fig. 14. (*A*) Before and (*B*) after gluteal sculpture, Low Level Laser Lipoplasty.

skin burns, cells are not killed, and adipose tissue is not damaged, which permits the use of irradiated tissue for fat grafts in other parts of the body. The time needed to extract fat seems to be reduced. Surgical trauma, postoperative edema and pain, and medical leave from work are diminished, as are ecchymosis, hematomas, and postoperative fibrosis. The resulting skin surface is even. The results are highly satisfactory for the patient and the surgeon. The technique is simple, easy to apply, and low cost, serving as an excellent adjuvant tool for the surgeon practicing liposculpture. Using LLLL, one may be able to carve the human body based on inspiration, imprinting the surgeon's love in pa-

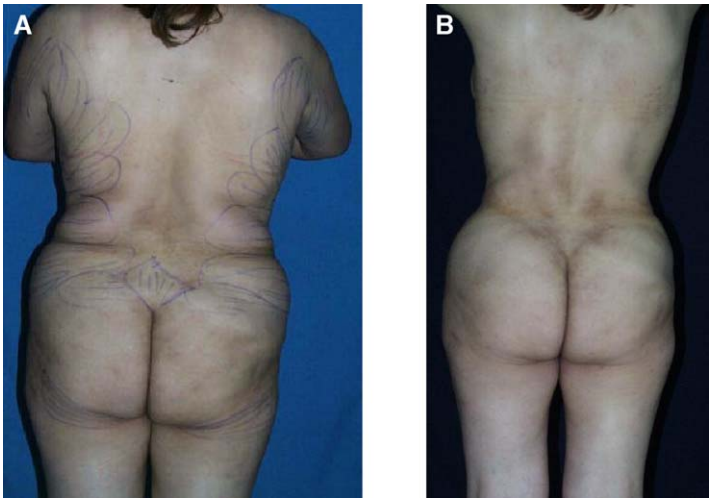

Fig. 15. (*A*) Before surgery and (*B*) after Neira 4 L Technique.

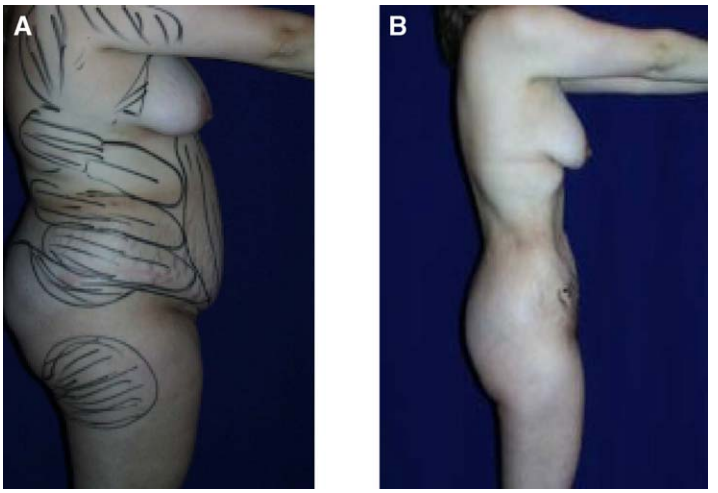

Fig. 16. (*A*) Before surgery and (*B*) after Neira 4L technique. 13 liters of fat were removed.

tients and creating a wonderful human art in plastic surgery.

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