Ultrasound-assisted Breast Reduction and Mastopexy

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Background: *The development of technology for ultrasound-assisted lipoplasty (UAL) offers the aesthetic surgeon a new tool for breast surgery procedures including breast reduction, breast lift, and the correction of mild- to medium-degree ptosis.*
Objective: *The authors report on a series of 120 patients who underwent breast surgery with the use of UAL from 1995 through 2000.*
Methods: *Preoperative screening, including mammography, was performed to evaluate breast tissue and determine whether patients were good candidates for surgery. Variants of Klein's tumescent solution were infiltrated, depending on the form of anesthesia administered. Stab incisions 2-cm long were made at the axillary line and 2 cm below the inframammary crease to allow entry of a 35-cm solid titanium probe. With use of a 50% power setting, ultrasound energy was applied from 10 to 15 minutes to up to 30 minutes to emulsify the fat. Ultrasound stimulation of the superficial layers of subcutaneous tissue was applied to promote retraction of the breast skin.*
Results: *A mean of 500 mL of fat emulsion from each breast was obtained without major complications. Nipple elevation of up to 5 cm was possible if a large-volume reduction was performed in combination with ultrasound stimulation of the subcutaneous layer.*
Conclusions: *The use of UAL to achieve breast reduction and mastopexy is both safe and effective for selected patients when performed by a surgeon experienced in the technique. (*Aesthetic Surg J *2001;21:493-506.)*

Ultrasound energy has been applied to the adipose component of the breast parenchyma in cases of breast hypertrophy to reduce the volume of the breast mold. As is well known, ultrasound energy was initially used by Zocchi[1-6] to emulsify fat. He created a special instrument comprised of an ultrasound generator, a crystal piezoelectric transducer, and a titanium probe transmitter.

This new technology was first applied to body fat to emulsify only fat cells while sparing the other supporting vascular and connective components of the cutaneous network. More recently, Goes,[7] Zocchi,[1-6] Benelli,[8] and the senior author[9-12] have started to apply this technology to the breast tissue to achieve breast reduction and correction of mild- to medium-degree breast ptosis.

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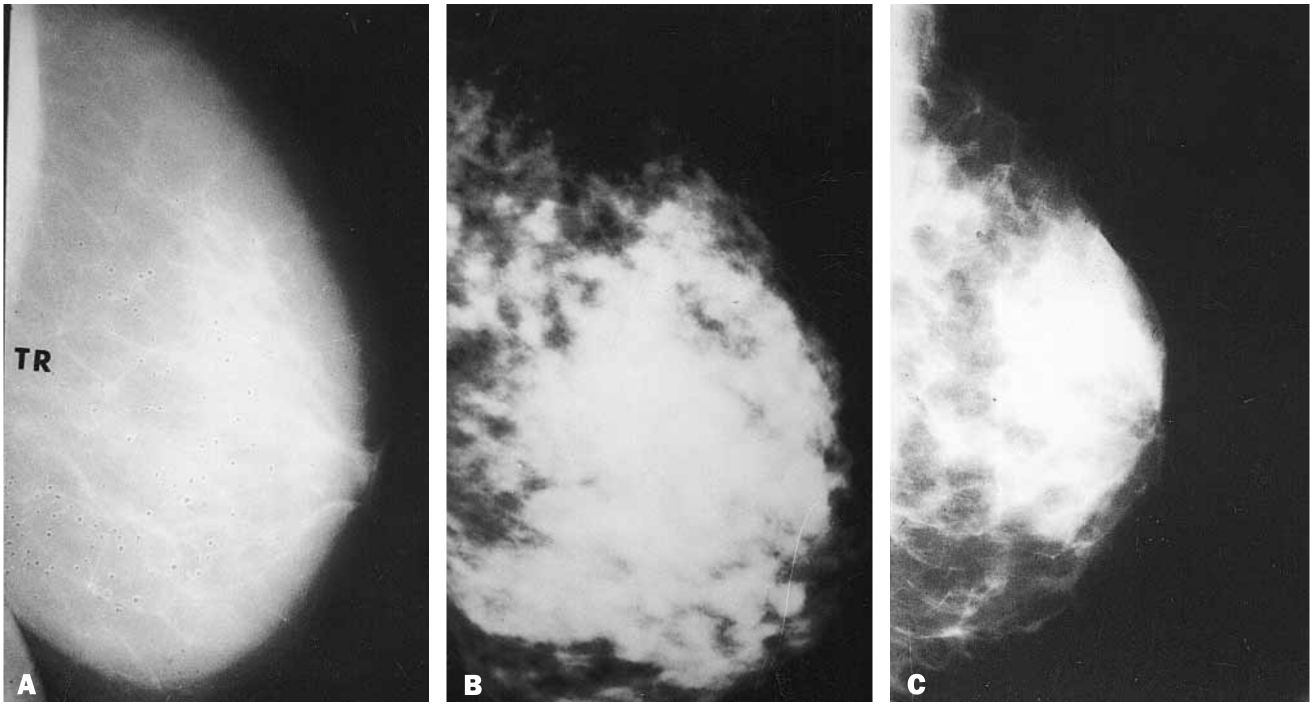


Figure 1. *Mammographic evaluation of candidates for breast reduction with the use of ultrasound-assisted lipoplasty (UAL).* **A,** *A typical fatty breast. This patient is an ideal candidate for UAL.* **B,** *Fibrotic glandular tissue is a contraindication for UAL.* **C,** *Fibrotic mixed tissue. This patient is a candidate for UAL of the posterior upper and lower cone.*

Methods

Patients

Since 1995, 120 patients have been treated with ultrasound energy to decrease the fatty component of the breast tissue, and simultaneously perform a breast lift (mastopexy). This series included 92 cases of breast reduction and 28 cases of breast lift. Patient ages ranged from 17 to 53 years.

Patient selection

The ideal candidates for a breast reduction with ultrasound-assisted lipoplasty (UAL) are those patients with juvenile breasts, which are usually characterized by fatty parenchyma, or those with postmenopausal involution parenchyma, with good skin tone and elasticity present. Between 60% and 70% of women with large breasts are candidates for reduction with UAL alone or combined with surgical resection.

Initial screening of the potential candidates for a breast reduction with UAL included a mammographic study, breast clinical history, evaluation of breast ptosis, and evaluation of the consistency of breast parenchyma.

Preoperative mammography

Preoperative mammograms (anteroposterior and lateral views) were taken to evaluate the nature and consistency of the breast tissue (fibrotic, mixed, or fatty parenchyma) (Figure 1); the distribution of the fat; and the presence of calcifications, areas of dysplasia, or nodularity that might necessitate eventual further ecotomographic studies or agobiopsy. The presence of fibroadenomas, calcifications, and other suspected or doubtful radiologic findings was double-checked with a senologist and a radiologist experienced in breast-tissue resonance.

Contraindications

Patients with a history of breast cancer or mastodynia and those fearful of potential sequelae from this new technique were not considered for this study. Furthermore, because the amount of fat in the breast is variable as is its distribution (Figure 2), not all women are candidates for breast volume reduction with UAL. If fat tissue and glandular tissue are mixed, penetration of the tissue may be impossible, as noted by Lejour.[13,14] If the breast tissue is primarily glandular, the technique is not indicated.

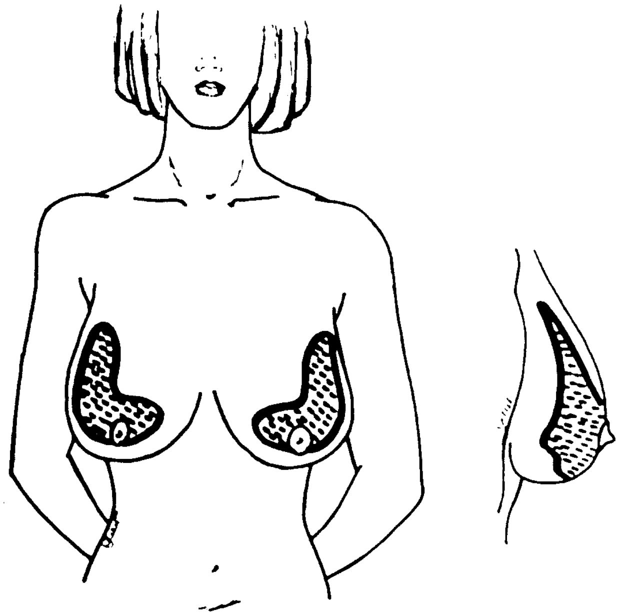


Figure 2. *Distribution of glandular tissue in the breast cone.*

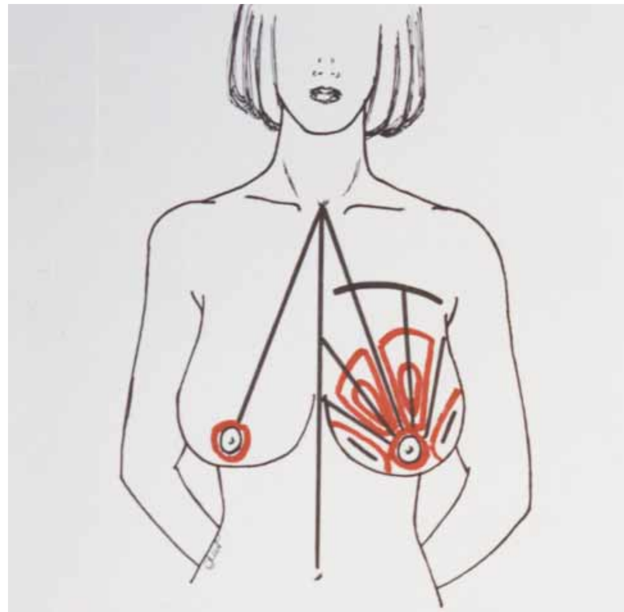


Figure 3. *Preoperative markings. Straight lines indicate the lines of subcutaneous skin stimulation. Enclosed areas indicate areas of thicker breast tissue. A 5-cm circle drawn around the areola indicates the limits of the operative area.*

Infiltration

When surgery was performed under general anesthesia or intravenous sedation, a wetting solution was used that is a variation of the universally known Klein tumescent solution. The tumescent solution was used to distend the breast area and induce severe vasoconstriction. Tumescent infiltration was also necessary to allow transmission of ultrasound energy to emulsify the fat cells.

The solution was composed of 1000 mL Ringer's lactate and 1 mL (or 1 ampule) of pure adrenaline. No bicarbonate or lidocaine was used. The anesthesiologist chose either intravenous or oral analgesics to assure postoperative analgesia. (It is also possible to use a standard Klein tumescent anesthesia, using 200 mg lidocaine or more for postoperative analgesia. In this case, the solution is made with 1 L Ringer's lactate, 1 mL pure adrenaline, and 200 mg lidocaine.) If surgery was performed under local anesthesia, a modified Klein solution was prepared (1000 mL Ringer's lactate, 12.5 mEq bicarbonate, 500 to 750 mg lidocaine, and 1 mL pure adrenaline). To achieve good tumescence, 500 to 1000 mL of solution per side, depending on the breast size, was necessary.

Technique

After preoperative marking (Figure 3), the fatty breast was emulsified in the lateral and medial compartments, upper quadrants, and inferior aspect of the periareolar area. All the periareolar area where most of the glandular tissue is localized (5-cm circumference around the nipple-areolar complex) was preserved.

The deep portion, mostly fat, was also emulsified, allowing natural rotation of the breast mold to regain a natural shape and increase the elevation from the initial position, taken from the midclavicular notch (Figure 4). Up to 4 cm of breast elevation was obtained, after proper reduction and stimulation, to allow skin retraction and correction of the ptosis.

Incisions

Two 1.5- to 2-cm stab incisions, one at the axillary line and one 2 cm below the inframammary crease, were made to allow entrance of the titanium probe (Figure 5). A periareolar incision was made in a few patients with very lax skin for further subcutaneous stimulation. Through these incisions the surgeon can reach all the breast tissues, working in a crisscross manner. The skin is protected from friction injuries with a specially-made skin protector. (Recently, we have abandoned use of the skin protector because the ultrasound device software has been upgraded to provide the same degree of cavitation

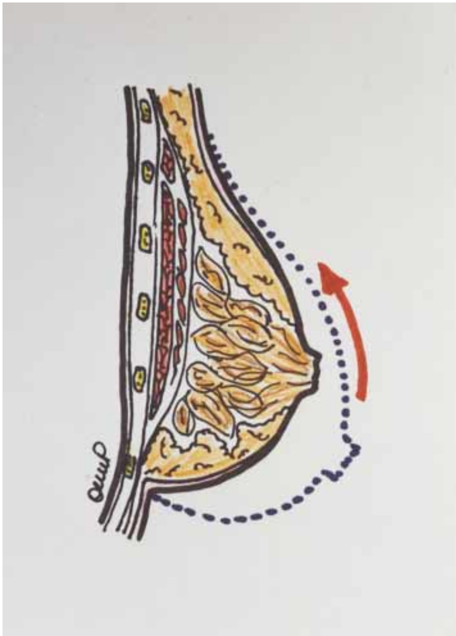


Figure 4. *By thinning the lower pole, the breast cone naturally rotates upward.*

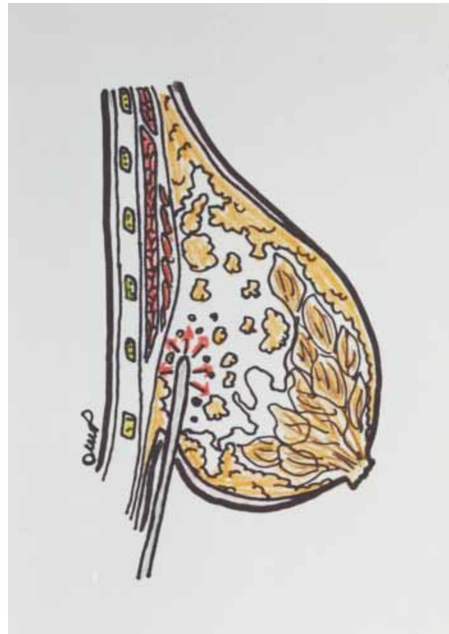


Figure 6. *Emulsification of fat at the lower breast pole with the titanium probe.*

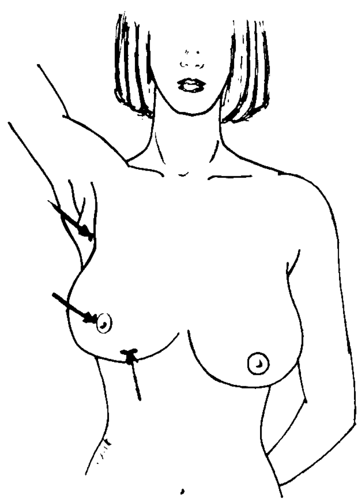


Figure 5. *Axillary, submammary, and periareolar incision lines.*

Figure 7. *Emulsification of the subdermal layer with the titanium probe to stimulate skin retraction.*

with less power, which reduces the risk of friction injury and burn at the entrance site.)

Probe

Routinely, the standard 35-cm-long titanium probe was used. This probe has a diameter that tapers from 5.5 mm in the proximal portion to 4 mm in the distal portion. With the existing technology, a solid probe has been found to be more efficacious than a hollow probe because none of the hollow probes existing today is strong enough; they can easily break in the tissues as a result of the vibrations produced when ultrasound energy is applied. Moreover, the level of ultrasound energy conveyed by a hollow probe is limited, and consequently the level of the cavitation obtained in the tissues is diminished.

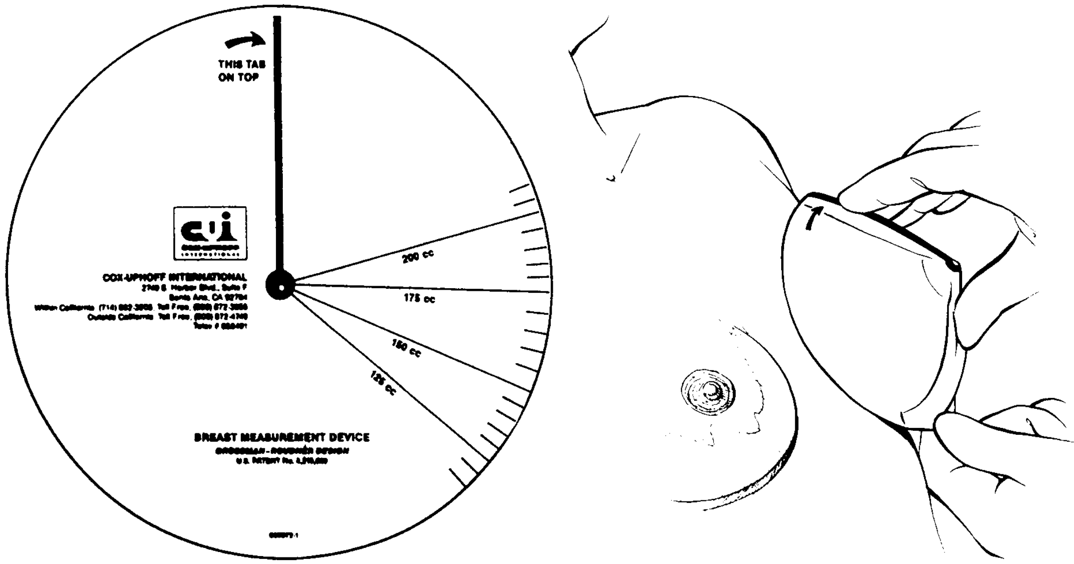


Figure 8. *A breast-measurement device (CUI, Santa Ana, CA) was used to assess preoperative and postoperative breast size.*

Table 1. Evaluation of breast procedures with ultrasound-assisted lipoplasty

Procedure (No. of patients)	No. of patients (%)	Reduction (mL)*	Total emulsified fat aspirated (mL)†
Breast reduction (92)	4 (4.4)	600	1200
	10 (9.2)	200	300
	28 (30)	400	800
	50 (54)	300	500
Breast lift (28)	9 (30)		500
	19 (70)		300

*Evaluated with breast sizers.

†Emulsified analyses revealed that approximately 75% of aspirate was composed of fat, 5% was blood, and 20% was wetting solution.

Fat emulsification

In breast reduction with UAL, the duration of the procedure varies depending on the volume of reduction, the type of breast tissue encountered, and the amount of skin stimulation required. A breast with purely fatty tissue is easier to treat than one with mixed glandular tissue, in which fat cells are smaller, stronger, and denser.

Energy was applied with a Smei-sculpture-ultrasound device (SMEI, Casale Renferrato, Italy) set at 50% power for at least 10 to 30 minutes, depending on the patient. The application of 10 to 15 minutes of ultrasound energy in fat tissue usually produces from 250 to 300 mL of emulsion (Figure 6).[15] The surgical planes, with good crisscross tunneling and adequate undermining, were routinely followed, as planned in the preoperative drawings. If intense stimulation was required for skin retraction, the superficial layers were treated initially. Then the deeper planes were reached, and more time was spent in thicker areas. In more standard cases, it was possible to start with the deeper planes. Surgeons inexperienced in the procedure should be especially cautious when performing the technique, particularly on the subdermal planes.

Subcutaneous UAL stimulation

Together with UAL application to the fat layers, starting from the deeper layers and progressing to the more superficial ones, it is advisable to stimulate the superficial layers of the subcutaneous tissue of the upper and lower quad-

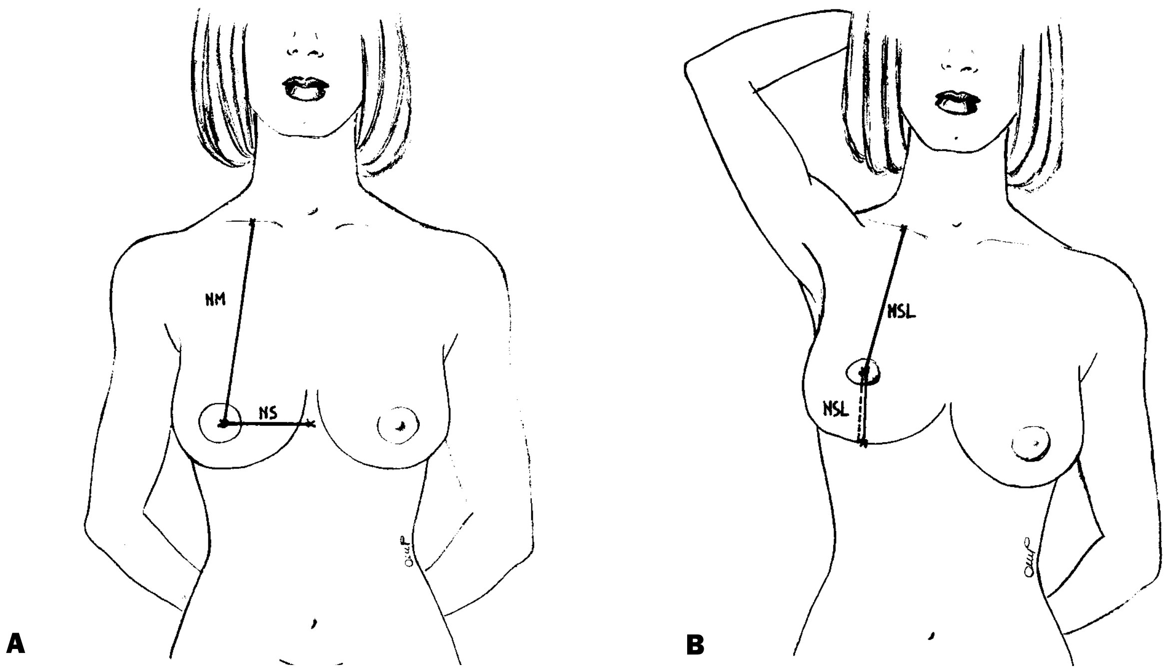


Figure 9. *Breast measurements were assessed by checking the preoperative and postoperative distances from the midclavicular notch to the nipple (NM), from the nipple to the sternum (NS), from the midclavicular notch to the submammary line (MSL), and from the nipple to the submammary line (NSL).*

Table 2. Preoperative and postoperative breast measurements

Unit	Preoperative	Postoperative
NM	19 - 28	18 - 24
NS	10 - 14	9 - 11
MSL	25 - 35	24 - 31
NSL	6 - 3	6 - 7

NM, Midclavicular notch to nipple; *NS,* nipple to sternum; *MSL,* midclavicular notch to submammary line; *NSL,* nipple to submammary line.

rants by using a different-angles pattern, as in a standard lipoplasty.[16,17] This superficial stimulation with low-frequency ultrasound energy helps to enhance the retraction of the breast skin, and to redrape the breast skin to the newly shaped and reduced mammary cone (Figure 7). The fibrosis that follows the thermic insult caused by the passage of the ultrasound solid probe is probably responsible for the great skin retraction which normally follows and which contributes to the correction of breast ptosis.

Postoperative care

Suction drainage was routinely applied in the breast for at least 24 to 48 hours. A custom-made elastic compression support (Topiform, Lysonics, Inc., Santa Barbara, CA) was applied for 7 to 10 days, and a brassiere completed the dressing. These items together with skin redraping helped support the breast in the immediate postoperative period.

Evaluation

Postoperative mammograms were obtained at 1 and 3 years after the operation. The evaluation of the clinical and radiologic results was supervised by a senologist, with particular attention to the evaluation of calcification and the long-term evolution of postoperative fibrosis in the breast. The minimum follow-up for patients was 4 years.

The range of breast tissue reduction was measured on the basis of emulsified breast fat, including tumescent solution infiltrated at the beginning of the procedure. Breast measurements to assess preoperative and postoperative breast size, and the position of the nipple in relation to the clavicle and sternum, were assessed as follows.

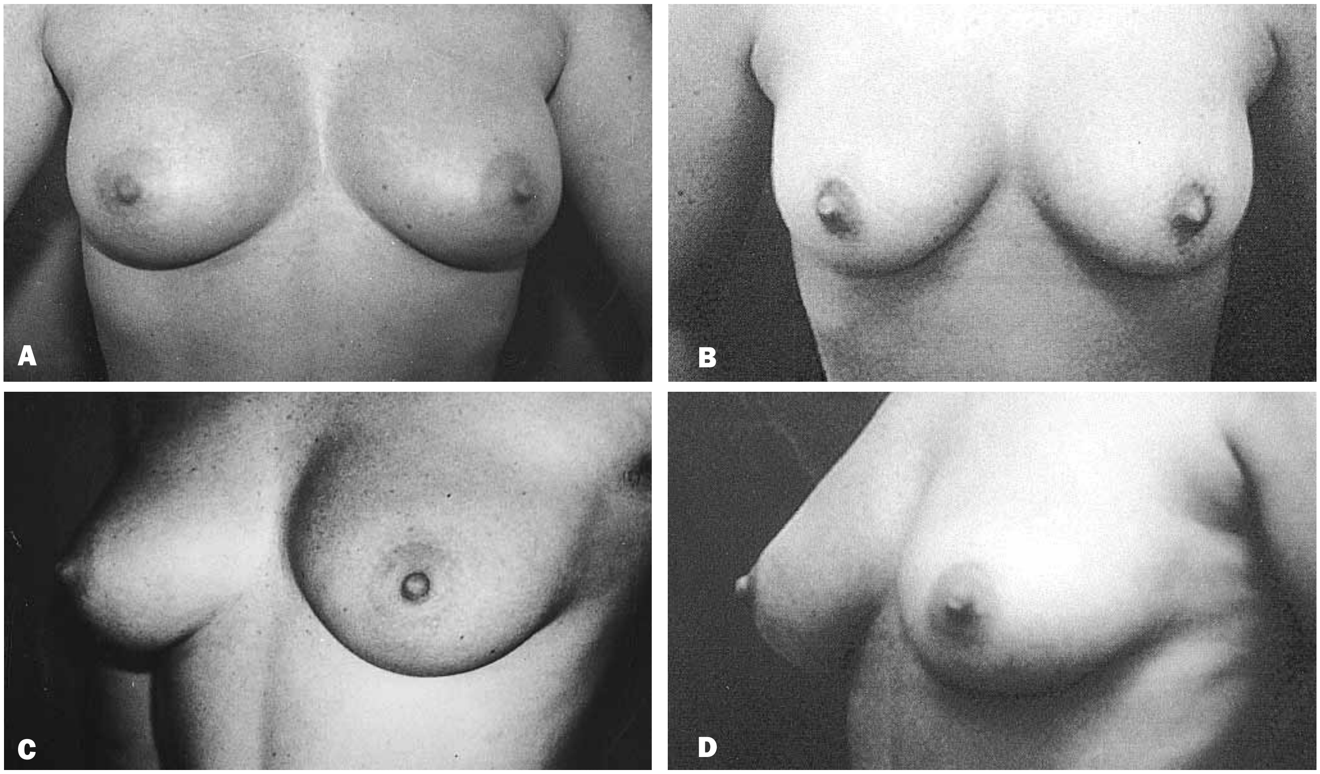


Figure 10. **A**, **C**, *Preoperative photographs of a 29-year-old woman with moderate breast hypertrophy.* **B, D,** *Postoperative views 6 months after ultrasound-assisted lipoplasty through a submammary fold incision and emulsification of 500 mL of fat per site.*

Breast sizers (CUI Corporation, Santa Ana, CA) were used to evaluate preoperative and postoperative breast measurements (Figure 8). Breast measurements were assessed as in a classic breast drawing, checking preoperative and postoperative distances of the nipple from the midclavicular notch of the nipple (NM), from the nipple to the submammary line (NSL), from the midclavicular notch to the submammary line (MSL), and from the nipple to the sternum (NS) (Figure 9).

Results

Results were visible immediately after surgery; the skin envelope redraped nicely and contoured the new breast shape and mold (Figures 10 to 14). The skin and treated breast tissue appeared soft and pliable. The elevation of the nipple-areolar complex resulting from skin contraction and the rotation of the breast mold was immediately visible. Major postoperative nipple-areolar complex elevation was 5 cm.

Emulsification of fatty breast tissue ranged from a minimum of 300 mL per breast in mild reductions and breast lifts to a maximum of 1200 mL of aspirate for each breast in large breasts.

Preoperative and postoperative breast measurements are given in Tables 1 and 2. In my experience, we often easily obtained a mean of 500 mL of fat emulsion from each breast, after infiltration of 700 mL of Klein modified solution for tumescence, followed by energetic skin stimulation of the subcutaneous tissue, to allow skin redraping. Elevation of the nipple-areolar complex up to 5 cm was obtained in large-volume reductions in combination with stimulation of the subcutaneous layer.

No evidence of suspect calcifications resulting from surgery was found at the 5-year postoperative follow-up. Essentially, an increase in breast-tissue fibrosis was noticeable in the postoperative mammograms, which was responsible for the new consistency, texture, and tone of the breasts; the increase was also responsible for the lifting of the breasts, according to clinical results.

Complications

No major complications occurred in our series. It should

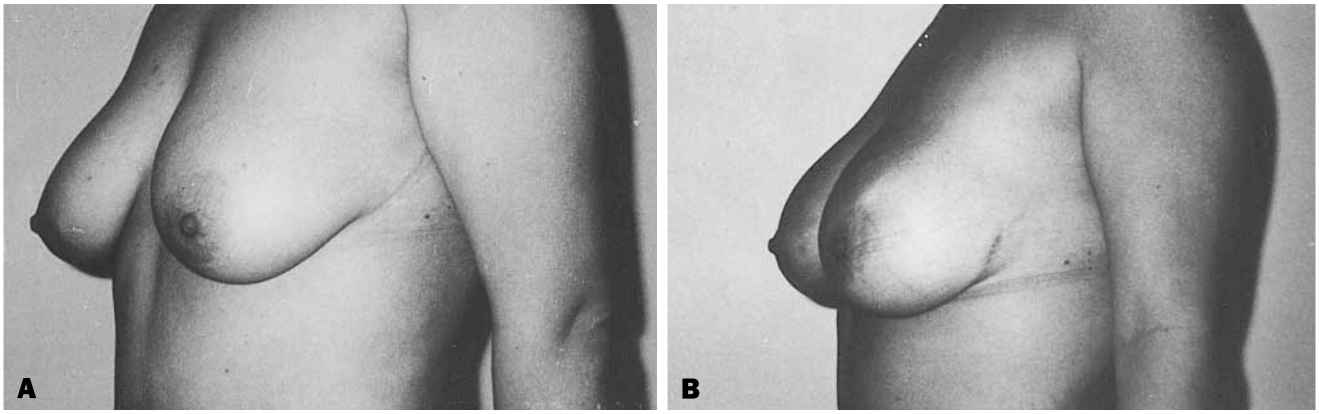
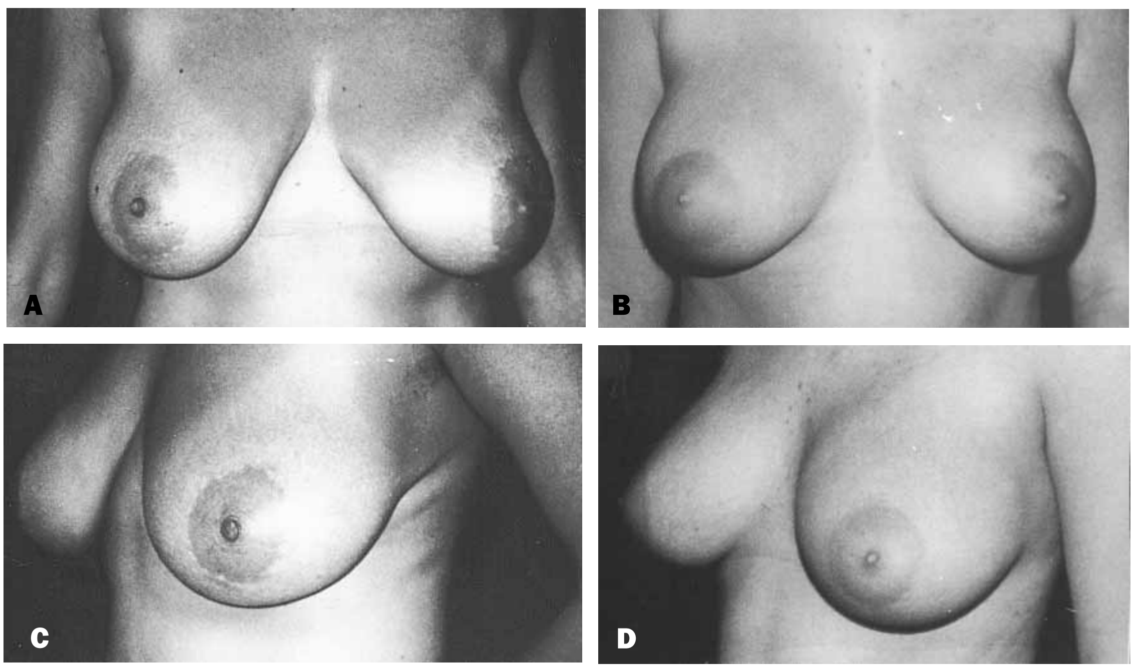


Figure 11. A, *Preoperative view of a 30-year-old woman with moderate breast ptosis.* **B**, *Postoperative view 3 weeks after ultrasound-assisted lipoplasty subdermal stimulation to allow skin retraction and breast lift.*



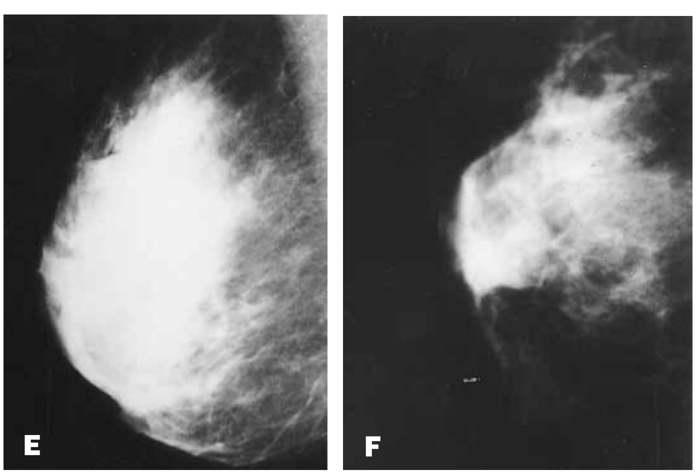


Figure 12. A, C, *Preoperative views of a 40-year-old woman before breast reduction and mastopexy.* **B, D,** *Postoperative views 1 year after emulsification of 800 mL of aspirate per side.* **E,** *Preoperative mammogram.* **F,** *Postoperative mammogram 6 months after breast reduction and mastopexy.*

be emphasized that such good results require extensive experience with UAL. As stated by a task force on UAL established by the American Society for Aesthetic Plastic Surgery (ASAPS), the Plastic Surgery Educational Foundation (PSEF), the Lipoplasty Society of North America (LSNA), and the Aesthetic Society Education and Research Foundation (ASERF), the learning curve for UAL is longer than that for standard lipoplasty.

Specifically, practitioners must learn how to work close to the subdermal layer with a solid titanium probe and to defat this layer and obtain good skin retraction while avoiding complications, such as skin burns and skin necrosis. To safely work close to the skin, 2 conditions are mandatory: the surgeon must be experienced in ultrasound-assisted body contouring, and the right ultrasound device (one that is able to maximize the cavitation effect while minimizing the thermal effect) must be selected.

Skin necrosis. A photograph of a case of necrosis was sent to me by a surgeon who used an incorrect technique (Figure 15). After performing a standard breast-reduction procedure, the surgeon tried to further debulk the lateral and medial breast flaps by using ultrasound. No tumescent infiltration was administered before application of the ultrasound energy. The consequent skin necrosis and skin burns were the natural consequence of the failure to minimize the undesired thermal effect of ultrasound by infiltration of a wetting solution.

Fat necrosis with secondary tissue induration is a typical sequela of ultrasound surgery. When it is localized in small areas, such necrosis can be treated with massage or local infiltration of corticosteroids to soften the area.

Loss of sensation. Loss of sensation is generally limited to the first 3 weeks after surgery. Recovery is rapid because the central cone of the breast is composed mainly of pure parenchyma and is not touched during surgery. Skin sensation is recovered in a few weeks' time.

Hematoma. Hematoma formation is another potential complication, though no cases occurred in this series. A photograph of a case of hematoma in a patient treated by another surgeon was sent to the senior author (Figure 16). This hematoma was localized in the subaxillary region, where the tumescent infiltration was initially administered. The surgeon who performed the operation revealed that the anesthesiologist, who regularly performed the tumescent anesthesia infiltration, incorrectly used standard sharp needles rather than blunt infiltration cannulas. The formation of the hematoma, which appeared immediately after the infiltration, was thus related to an incorrect tumescent infiltration technique, and not to the breast reduction with UAL.

Mastitis. Mastitis, an inflammatory response of the breast parenchyma to surgery, occurred in a few patients early in the series. Once surgery was avoided for patients at or near their menstrual period, only a minor inflammatory response was noted. When encountered, mastitis rapidly subsided with immediate treatment consisting of oral anti-inflammatory drugs and large-spectrum antibiotics for 3 days.

Seroma. Seroma formation is a potential complication of any breast surgery. Regular application of suction drainages and breast compression for several days with a brassiere and foam pads dramatically reduced the incidence of this complication.

Discussion

Ultrasound waves are the result of the transformation of normal electric energy into high-frequency energy (higher than 16 kHz [–16,000 cycles/s]) by a high-powered ultrasound generator. The energy from the generator is transmitted to a piezoelectric quartz crystal or ceramic transducer and then transformed into mechanical vibrations that are amplified and transmitted.

As described by Loomis[9] and then reported by Suslick[18] and Fisher,[19,20] the physical effects of ultrasound on biologic tissue include mechanical effects, thermal effects, and cavitation effects. Any device expressly developed for UAL should be able to enhance the cavitation effects while minimizing the mechanical and thermal effects.

Cavitation refers to the formation of partial vacuums in a liquid by high-frequency sound waves. In a living system, gases exist in solution in the form of microbubbles. At a certain frequency, ultrasound energy can cause expansion and compression cycles, with a progressive growth of the bubbles until a critical size has been obtained (stable cavitation). The oscillating bubbles can cause a secondary motion in the fluid of the medium, termed *microstream-*

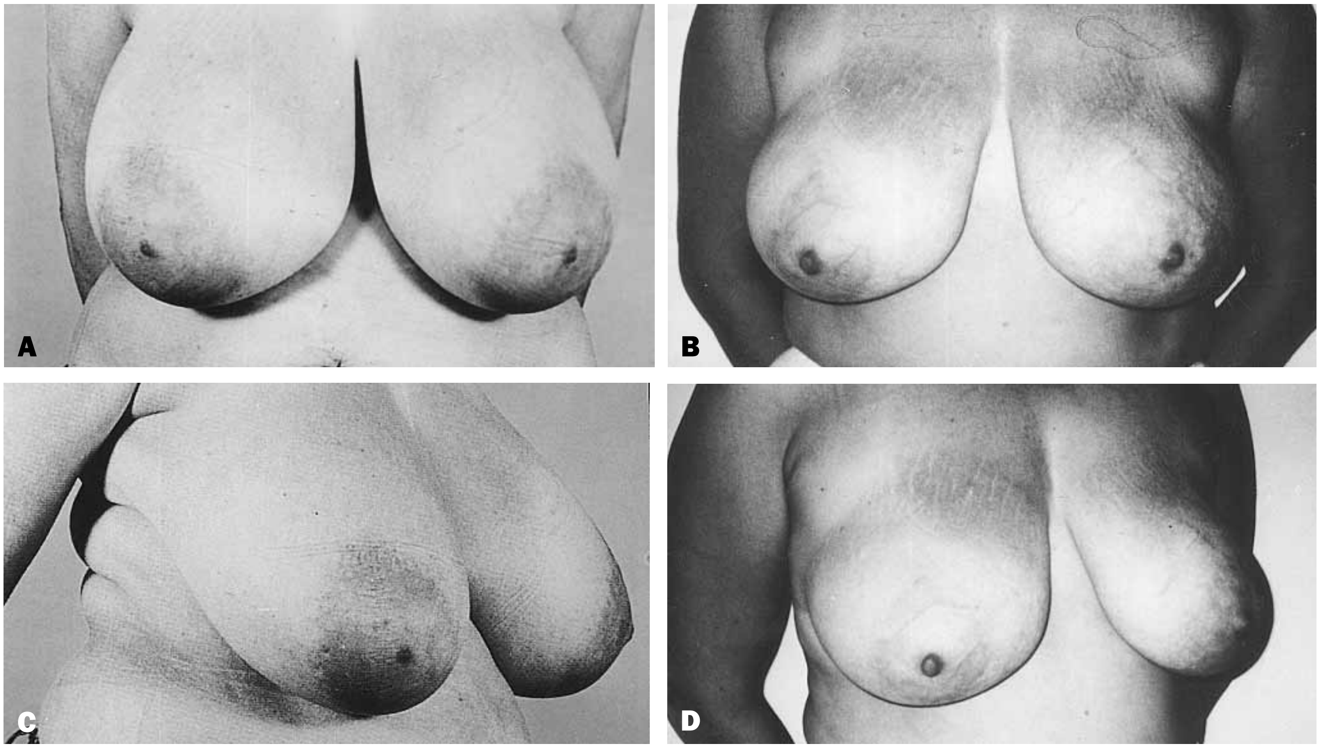


Figure 13. A, C, *Preoperative views of a 67-year-old woman.* **B, D,** *Postoperative views 6 months after removal of 1000 mL of aspirate and 5-cm elevation of the nipple-areolar complex.*

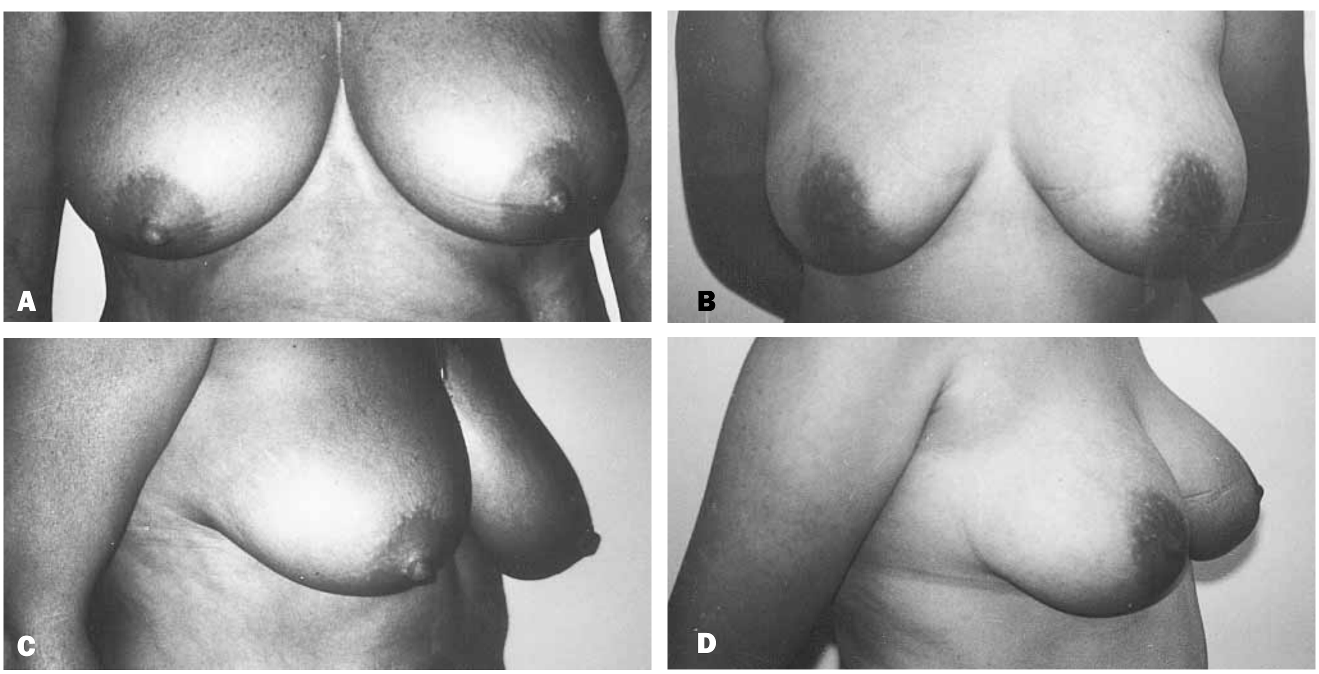


Figure 14. A, C, *Preoperative views of a 33-year-old woman.* **B, D,** *Postoperative views 6 months after mastopexy.*

Figure 15. *Skin necrosis of the breast medial flap. The surgeon performed a standard breast reduction and then attempted to debulk the medial flap without infiltration of tumescent solution. Skin necrosis resulted, with spontaneous healing after 3 weeks. (Patient referred from another surgeon.)*

Figure 16. *Breast hematoma caused by infiltration of Klein solution with incorrect instrumentation. The anesthesiologist used a sharp needle rather than the classic atraumatic blunt needle. The hematoma required evacuation, after which regular healing followed. (Case referred by another surgeon.)*

ing. These 2 mechanisms (cavitation and microstreaming) can lead to a localized region or regions of very high shear and stress that are sufficient to break down subcellular structures. When adipose tissue is targeted, the application of ultrasound energy results in the progressive emulsification of fat.[6]

The use of UAL in breast surgery is a relatively new technique. Lipoplasty was first used by several surgeons as an adjunctive procedure for breast reduction. Since the work of Illouz,[21] Pitman,[22] Lejour,[13] and Lejour and Abboud,[14] many authors have suggested that lipoplasty could have a significant role in breast contouring.

Zocchi[1-6] and Goes[7] started to use the ultrasound probe to dissolve and emulsify the fatty component of breast tissue. Later, other authors, including Toledo and Matsudo[23] and Grazer,[24] reported the aspiration of breast fat to reduce the volume. Becker[25] and Courtiss[26] reported a few cases in which volume reduction of the breast was accomplished with a sharp cannula to suction glandular as well as fatty tissue. Suctioning of glandular breast tissue, however, is quite another matter. Most investigators recommend the suctioning of only fat from the breast and the use of blunt, not sharp, cannulas, which do not penetrate the parenchyma.[27]

Initially, lipoplasty of the breast was used as a temporary measure in juvenile fatty, hypertrophic breasts until breast growth was complete and a more definitive operative procedure could be performed. More frequently, lipoplasty has been performed to complete a standard open-surgery breast reduction to defat the axillary aspect of fatty breasts.

Selectivity and specificity of ultrasound

Large amounts of fat are often found in patients with breast hypertrophy, even among thin adolescents. In their book on vertical mammoplasty, Lejour and Abboud[14] emphasized that once the fat is removed by lipoplasty before breast reduction, the proportion of glandular tissue, connective tissue vessels, and nerves is increased. These structures are important for maintaining vascularity, sensitivity, and lactation potential. Unlike fat, they are not likely to be affected by patient weight fluctuations. Lejour[13] affirmed that if the breasts contain substantial fat, the weight loss may result in breast ptosis; the degree of recurrent ptosis can be minimized if lipoplasty is performed preoperatively to reduce the fatty component of the breasts. This observation anticipated the great potential of UAL for breast surgery.

The clear limits of standard lipoplasty—mechanical indiscriminate destruction of fat and surrounding elements, followed by powerful aspiration of the destroyed tissue—

are particularly enhanced in breast surgery, where specialized structures (eg, lactation ducts, vessels, sensitive nerves, elastic bounding structures of the subcutaneous tissue) have to be preserved carefully.

Because it is a selective technique, UAL may be applied in breast surgery to destroy and emulsify only the fatty component of the breast tissue without affecting the breast parenchyma, for which the ultrasound energy has no specificity. The specificity of the technique is connected with the cavitation phenomenon, as mentioned earlier; the efficiency of the system hinges on the type of titanium probe used and the energy level selected. Lejour[13] argued that the suctioning of breast fat also made the breast more supple and pliable, which facilitated shaping, especially when the areola pedicle was long. This consideration is particularly important with fatty breasts, which have a less reliable blood supply. These benefits are significantly increased by the use of UAL because the specificity of this technique spares the vessel network.

The selectivity of UAL was demonstrated by Fisher[19,20] and by Palmieri[28] in their studies on the action of the ultrasound probe in rat mesenteric vessels. Later, Scheflan and Tazi[29] introduced endoscopic evaluation of UAL. They used a Stortz endoscopic system and camera (Stortz, Tuttlingen, Germany) to videotape the action of the titanium probe within the ultrasound device in the superficial layers of the subcutaneous fat, verified by needle depth, after standard infiltration with the tumescent technique. Ultrasound-assisted lipoplasty was performed with crisscross tunnels, and the procedure was recorded on videotape. An adjacent area was treated with standard lipoplasty. The technique was compared with standard lipoplasty, which was also endoscopically assisted and monitored. The authors found that standard lipoplasty appears to be the more aggressive technique, characterized by the mechanical destruction of the subcutaneous tissue, including vessels, nerves, and supporting structures, despite the use of 2- to 3-mm-wide blunt cannulas.

By contrast, UAL spared vessels, nerves, and elastic supporting fibers. Alterations in breast tissue resulting from the use of UAL were a thickened dermal undersurface, markedly thickened vertical collagenous fibers, intact lymphatic vessels, and intact blood vessels.

The authors suggested that the horizontal and vertical thickening and shortening of the collagen in the dermis and ligamentous fibers were responsible for the remarkable skin tightening that followed subcutaneous stimulation with the ultrasound probe. The closer to the skin and the more complete the removal of fat from the intermediate subdermal space, the greater the skin-tightening effect. This is of great value in breast surgery, where volume reduction has to be accomplished by skin redraping and recontouring of the breast shape.

On the other hand, as noted by Lejour,[13] retraction of the skin after standard lipoplasty cannot be expected to be sufficient enough to produce a satisfactory breast shape. Subcutaneous aspiration must be extensive to obtain the necessary skin retraction, and the risk of localized skin necrosis resulting from excessive superficial liposuction cannot be ignored.[25]

Calcifications

Lejour[13] and Lejour and Abboud[14] also argued that the risk of postoperative fat necrosis or calcifications was the reason many surgeons avoided the use of lipoplasty in the breast. The main cause of fat necrosis is breast ischemia brought about by extensive dissection or mechanical direct damage, with resultant venous drainage. This phenomenon is typical in open breast surgery. Calcifications in breast reduction surgery may derive from areas of fat necrosis or breast necrosis and subsequent scarring. Such calcifications are most often located at the incision lines (periareolar, or vertical scar in the inverted T approach), where more tension is placed in approximating the lateral and medial flaps. However, when the tension is too high, areas of necrosis could arise from the approximating suture and later cause calcifications that are visible on mammography. However, the risk of such complications in UAL procedures is quite low.

Calcifications in breast parenchyma are to be expected after any mammoplasty procedure. In reduction mammoplasty, it is preferable that they be localized along the breast scars.[30] When lipoplasty is performed in addition to the mammoplasty procedure, benign macrocalcifications are slightly more numerous in the parenchyma than they are in breasts reduced without lipoplasty. This may occur because of the trauma caused by lipoplasty or because lipoplasty suction is applied to the most fatty breasts, which are more prone to liponecrosis.[31] However, 1 year after fatty-breast reduction with UAL, follow-up mammography revealed only a slight increase of small microcalcifications, similar to those found after other mammary procedures.

Potential risks

In November 1998, a conference on UAL safety and effects was held in St. Louis, MO, sponsored by the Aesthetic Surgery Education and Research Foundation (ASERF) and the Plastic Surgery Educational Foundation (PSEF).[32] The panel was organized in response to an article by Topaz[39] that raised questions about the safety of UAL. Topaz speculated that thermal effects and the free radicals generated during UAL might result in neoplastic transformation and other long-term complications, as a consequence of the physical effect known as *sonoluminescence*. Those attending the conference represented multiple scientific disciplines, including plastic surgery, physics, lipid chemistry, cancer biology, and mechanical biophysics. Participants agreed that scientists did not yet understand the mechanism of UAL action, though multiple mechanisms were probably involved, such as mechanical forces, cavitation, and thermal effects.

Additional research has revealed that long-term complications or negative bioeffects (including DNA damage and oxidation–free radical attack) are probably not serious safety concerns for UAL.

With reference to the application of UAL to breast surgery, we investigated the histology of the breast fat tissue before and after surgery (with serial biopsies at 6 months and 1 year after surgery) and the mammographic appearance of the breast before and 1, 2, and 3 years after surgery, particularly with respect to calcification. The results were evaluated by a senologist not directly involved with the clinical research.

Histologic investigations revealed an increased fibrotic response to thermal insult, with a prevalence of fatty scar tissue, in all specimens evaluated. Mammography showed a significant increase in breast parenchymal fibrosis, with a denser consistency and thicker breast trabeculae, that was constant over time.

The calcifications that appeared were benign and were typically small, round, less numerous, and more regularly shaped than those characteristic of malignancy. The senologist compared mammographic results typical of a standard breast reduction with those typical of breast reduction with UAL and concluded that microcalcifications are less likely to develop with the latter technique.

It is likely that scar tissue caused by breast reduction with electrocautery or by necrosis resulting from the tension of internal sutures may more frequently cause calcifications or irregular mammographic aspects of the operated parenchyma. Particularly, in standard breast-reduction surgery, they can appear at the areola line and at the site of the vertical scar.

In the present study, the senologist concluded that, from a mammographic viewpoint, the typical appearance of a breast reduction with UAL demonstrates predictably less scarring and fewer calcifications than occur in the standard open technique. Courtiss[26] reported similar mammographic evidences in a denser breast after breast reduction by lipoplasty alone. No malignancies were reported.

The question of whether potential lactation is affected by UAL remains unanswered. The technique was used for breast reduction and mastopexy in younger and older candidates. In the younger group, 16 patients breast-fed their babies regularly. The other 14 patients were lost to follow-up. However, none of these patients or their gynecologists reported any problems to the surgeon or the hospital, and no complications have been reported by other surgeons around the world who use this technique.

Conclusion

The use of UAL for reduction of fatty breasts and mastopexy is effective and safe when applied in selected patients and performed by a surgeon with expertise in ultrasound-assisted body contouring. The selectivity of UAL enables emulsification of the fatty component of the breast parenchyma while sparing the glandular tissue and vascular network. Furthermore, long-term mammographic studies have revealed no alteration of morphology of the breast parenchyma resulting from this technique. The typical mammographic appearance of breast tissue after UAL is a denser breast. ■

References

1. Zocchi M. Clinical aspects of ultrasonic liposculpture. *Perspect Plast Surg* 1993;7:153-174.

2. Zocchi M. The ultrasonic assisted lilpectomy (U.A.L.): physiological principles and clinical application. *Lipoplasty* 1994;11:14-20.
3. Zocchi M. Ultrasonic assisted lipectomy. *Advances in Plastic and Reconstructive Surgery*. Vol. 11. Mosby Year Book: St Louis, MO;1995.
4. Zocchi M. The ultrasonic assisted lipectomy, instructional course. ASAPS Annual Meeting, San Francisco, March 1995.
5. Zocchi M. The treatment of axillary hyperadenosis and hyperhidrosis using ultrasonically assisted lipoplasty. Presented at the Meeting of the International Society of Ultrasonic Surgery, Faro, Portugal, November 1995.
6. Zocchi M. Basic physics for ultrasound assisted lipoplasty. *Clin Plast Surg* 1999;26:209-220.
7. Goes JC. Periareolar mammoplasty: double skin technique with application of polyglactine or mixed mesh. *Plast Reconstr Surg* 1997.
8. Benelli L. A new periareolar mammaplasty: round block technique. *Aesthetic Plast Surg* 1990;14:93-100.
9. Di Giuseppi A. Mammoplasty reduction and mastopexy utilizing ultrasound liposuction. Mammographic study preoperative. Act from 460 National Congress of Italian Society of Plastic Reconstructive and Aesthetic Surgery. Venice, Italy, June 1997.
10. Di Giuseppe A. Reducion Mamaria y Pexia con la asistencia de la Lipoplastia Ultrasonida. Publication on Lipoplastia 1998.
11. Di Giuseppe A. Abstract at the 3rd European Congress of Cosmetic Surgery. Themes: Ultrasound Assisted Liposuction for Body Contouring, Breast Reduction and Face Lift. How to do it? Berlin, 23-25 April 1999.
12. Di Giuseppe A. Abstract at the XV Congress of the International Society of Aesthetic Plastic Surgery (ISAPS). Themes: Harmonic Lift or Ultrasonically Assisted Skin Remodelling of Face (Video). Ultrasonic Assisted Lipoplasty of the Breast (Poster). Tokyo, April 2000.
13. Lejour M. Reduction of large breasts by a combination of liposuction and vertical mammoplasty. In: Cohen M. *Master of Surgery: Plastic and Reconstructive Surgery*. Boston; Little, Brown: 1994.
14. Lejour M, Abboud M. Vertical mammoplasty without inframammary scar and with liposuction. *Perspect Plast Surg* 1990;4:67.
15. Kloen R. Liposuction with sonic sculpture: six years experience with more than 600 patients. *Aesthetic Plast Surg* 16:123-128.
16. Teimourian B. *Suction Lipectomy and Body Sculpturing*. St. Louis, MO: CV Mosby; 1987:219-251.
17. Teimourian B, et al. Reduction suction mammoplasty and suction lipectomy as an adjunct to breast surgery. *Aesthetic Plast Surg* 1985;9:97-100.
18. Suslick KS. Homogenous sonochemistry. In: Suslick KS, ed. *Ultrasound: Its Cehmical, Physical, and Biological Effects.* NY; VCH:1988:3-87.
19. Fisher PD. The use of high frequency ultrasound for the dissection of small diameter blood vessels and nerves. *Ann Plast Surg* 1992;28:326-330.
20. Fisher PD. Revised technique for cellulitis reduction in riding breeches deformity. *Bull Int Acad Cosm Surg* 1977.
21. Illouz YG. *La Sculputre Chirurgical Para Lipoplastie.* Paris; Arnette: 1988.
22. Pitman GH. Suction lipectomy: complications and results by surgery. *Plast Reconstr Sur*g 1985;76:65-69.
23. Toledo LS, Matsudo PKR. Mammoplasty using liposuction and the periareolar incision. *Aesthetic Plast Surg* 1989;13:9-14.
24. Grazer F. *Atlas of Suction-assisted Lipectomy in Body Contouring.* New York; Churchill Livingstone: 1991:145-146, 182-185.
25. Becker H. Liposuction of the breast. Presented at the Lipoplasty Society of North America meeting. September 1992.
26. Courtiss EH. Breast reduction by section alone. In: Spear S, ed. *Surgery of the Breast: Principles and Art.* Philadelphia; Lippincott-Raven: 1998.
27. Matarasso A, Courtiss EH. Suction mammoplasty: the use of suction lipectomy to reduce large breasts. *Plast Reconst Surg* 1991;87:709-717.
28. Palmieri B Studio sull' azione degli ultrasuoni sul tessuto vasculare del ratto. *Riv Ital Chir Plast* 1994;9:635-639.
29. Schleflan M, Tazi H. Ultrasonically assisted body contouring. *Aesthetic Plast Surg* 1991;16:117-122.
30. Mitnick JS, et al. Calcifications of the breast after reduction mammoplasty. *Surg Gynecol Obstet* 1980;171:409.
31. Abboud M, et al. Occurrence of calcification in the breast after vertical mammoplasty and liposuction. In press.
32. Topaz M. Possible long-term complications in U.A.L. induced by sonoluminescence, sonochemistry, and thermal effects. *Aesthetic Surg J* 1998;18: 19-24.
33. Young VL, Schorr MV. Report from the conference on ultrasound assisted liposuction safety and effects. *Clin Plast Surg* 1999;26:481-524.

Commentary

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In 1988, Michele L. Zocchi described a revolutionary body-contouring technique based on the surgical use of ultrasound energy, which allows the selective disruption of adipose tissue only.[1] In 1996, Zocchi and Sampaio Goes treated 47 cases of breast hypertrophy with combined open surgery and ultrasound-assisted lipoplasty (UAL), with no major complications. Drs. di Giuseppe and Santoli have further expanded Zocchi's findings by examining 120 breast surgery cases—92 breast reductions and 28 mastopexies—all utilizing UAL.

Ultrasound-assisted lipoplasty is increasingly more accepted around the world and is used for the removal of more fibrous fat, such as that located in the back and flank areas. It is also used in certain cases of secondary lipoplasty where traditional suction-assisted lipoplasty may not be as effective. In addition, it is commonly used for the treatment of gynecomastia. Breast tissue is composed of glandular elements, fibrous connective tissue, blood vessels, nerves, and fat, and would appear to fall into the category of tissue in which the use of UAL is appropriate.

Drs. di Giuseppe and Santoli, realizing the implications of UAL in breast surgery, have used it to try to eliminate or shorten scars usually associated with mammoplasty. With UAL alone they have been able to move the nipple-areolar complex up a distance of 5 cm. They attribute this elevation to the decreased fat content of the breast parenchyma after UAL. The authors have limited their indications to patients with fatty juvenile breasts or postmenopausal involution characterized by a high percentage of fatty tissue. Patients with poor skin elasticity were also eliminated from consideration.

Ultrasound-assisted lipoplasty, however, is not without its skeptics, particularly when applied to breast surgery. Zocchi investigated the potential for free radicals to cause harm to tissue parenchyma. This phenomenon was further described by Topaz in a 1998 article.[2] In November 1998, the Ultrasound-Assisted Liposuction (UAL) Safety and Effects conference was held in Saint Louis, Missouri. Experts from a variety of scientific disciplines concluded that long-term complications or negative bioeffects—including DNA damage and oxidation–free-radical attack—are probably not serious safety concerns with UAL.[3]

The use of ultrasonic technology is not new to the medical community. It is commonly used in the dissolution of kidney stones and brain tumors. If UAL had any potential for long-term carcinogenic effects, we might have expected to see these manifested in other surgical fields. To our knowledge, no link has been established. Nevertheless, as Gorney[4] has pointed out, the first time a patient who has undergone UAL of the breast subsequently develops breast cancer, questions will most assuredly be raised about a possible link between the two.

When operating on the breast, one must also be cognizant of potential breast changes in the form of calcifications.[5,6] Drs. di Guiseppe and Santoli performed preoperative and postoperative mammograms on all patients to assess fat distribution and determine the presence of any abnormalities. Patients with suspicious findings were excluded from the study. The authors encountered no suspicious calcifications or other abnormal radiographic findings after UAL, even up to 5 years after surgery. Histology revealed increased fibrosis, fatty scar tissue, and increased breast parenchymal fibrosis. Walgenbach and co-workers[7] studied biopsies of 10 patients treated with UAL of the breast and found intact glandular structures, with no signs of UAL destruction.

Presuming that UAL of the breast is a safe procedure, one must then ask whether it is efficacious for producing the desired result. In viewing Drs. di Guiseppe and Santoli's results, some postoperative breasts still appear significantly ptotic. It is only with the addition of a periareolar mastopexy that true visual improvement in shape is achieved. Ultrasound-assisted lipoplasty primarily appears to reduce volume, rather than to change breast shape significantly. Its best indication may be the patient with good native breast shape, high fat content, and good skin elasticity. Another excellent indication is the patient with unilateral hypertrophy where no procedure is planned for the opposite normal breast. We have operated on one such patient with a very satisfactory outcome.[8] Also, the current improvements in short-scar mastopexy and reduction mammoplasty may further narrow the potential benefits of the UAL approach.

In conclusion, Drs. di Guiseppe and Santoli are pioneers in a new field and we are very appreciative of their honest review. Can UAL be safely applied to breast surgery in the United States? In a strongly litigious society such as ours, it is prudent to be wary.[4] Ultrasound-assisted lipoplasty as an adjuvant in breast reduction in this country would require a well-informed, educated patient who is compliant and would not be lost to follow up. With this experience and others as pilot trials, we would propose a coordinated multi-center study to determine the feasibility of this new approach to breast reduction in selected patients.

References

1. Zocchi ML. Ultrasonic assisted lipoplasty technical refinements and clinical evaluations. *Clin Plast Surg* 1996;23:575-598.
2. Topaz M. Possible long-term complications in ultrasonic-assisted lipoplasty induced by sonoluminescence, sonochemistry, and thermal effect. *Aesthetic Surg J* 1998;18:19-24.
3. Young VL, Shorr MW. Report from the conference on ultrasound-assisted liposuction safety and effects. *Clin Plast Surg* 1999;26:481-524.
4. Gorney M. Caveat against using ultrasonically assisted lipectomy in aesthetic surgery. *Plast Reconstr Surg* 1998;101:1741.
5. Abboud M, Vadoud-Seyedi J, De Mey A, Cukierfajn M, Lejour M. Incidence of calcifications in the breast after surgical reduction and liposuction. *Plast Reconstr Surg* 1995;96:620-626.
6. Maillard GF, Scheflan M, Bussien R. Ultrasonically assisted lipectomy in aesthetic breast surgery. *Plast Reconstr Surg* 1997;100:238-241.
7. Walgenbach KJ, Riabikhin AW, Galla TJ, et al. Effect of ultrasonic assisted lipectomy (UAL) on breast tissue: histological findings. *Aesthetic Plast Surg* 2001;25:85-88.
8. Grotting JC. PSEF Teleplast. "Contoversies In Lipoplasty," January 2000.