ULTRASONICALLY ASSISTED LIPOSCULPTURING

Physical and technical principles, and clinical applications

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ABSTRACT

The physical and technical principles of ultrasonically assisted liposculpturing (UAL) are described and clinical experience through four years (1992—1996) of utilization of this procedure is presented.

The technique relies on the surgical use of ultrasonic energy which allows the selective destruction or emulsification of adipose tissue producing a “cream” which is then aspirated. The procedure produces less edema and bruising than traditional liposuction and allows a great degree of skin retraction due to “stimulation” of the dermis of the treated areas.

Clinical application of ultrasonic assisted liposculpturing is for lipodystrophy, secondary cases, difficult areas such as inner thigh, circumferential thigh, calf, and abdomen. There is little blood loss and a greater volume of fat tissue can be removed in one session. UAL can be used to treat obesity.

This method has been applied to surgery of the breast for volume reduction of the adipose components in the fatty breast (mostly in juvenile breast) and skin retraction after dermis stimulation for correction of minor degree ptosis. The main concept of this technique relies on the selective destruction of mainly the fluid fraction of the adipose tissue, which represents nearly 90% of all the adipose tissue’s volume.

Contrary to traditional liposuction, which attacks and destroys mechanically all the structures of the dermis which may have undesired side effects, UAL selectively destroys only the target adipocytes and spares the supporting structures of the skin and dermis, such as vessels, nerves, collagenic matrix, and elastic fibres, thus conserving the elasticity of the treated areas.

INTRODUCTION

Ultrasonic assisted liposculpture has developed as a modification of liposuction for body contouring and fat reduction. The effects of sound waves in the subcutaneous tissues is to emulsify the adipocytes and, at the same time, preserve the vessels and nerves.
PHYSICAL PRINCIPLES

The standard acoustic spectrum is comprised of a wide range, going from 1 hertz (hz) (infra-sound), to 100 hertz (hz) (audible-sound), to 10-100 megahertz (mhz) (ultrasound), which is too high to be perceived by the human ear. This frequency spectrum has been utilized in industrial application and medical application.

Audible sound range varies from 100 hz to 10,000 hz and the medical application range varies from 105 to 107 hz.

Ultrasound waves are the result of the transformation of normal electric energy into high frequency energy (over 16 khz — 16,000 cycles/second) These waves are produced by high power ultrasonic generators which produce and transform the electric energy into ultrasonic energy. 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. Other medical applications of ultrasound are dental cleaning, phacoemulsification for cataract surgery, diagnostic imaging, kidney calculi fragmentation, and in neurosurgery.

CAVITATION (Bubble Mechanism)

Cavitation can be defined as a peculiar activity induced by the application of ultrasound waves in a liquid or liquid-like material, that contains bubbles or pockets of gas or vapor.

The consequences could be the production of 1) stable or 2) transient cavitation. In order to allow the cavitation to occur, the following conditions must be met:

1) Must have dissolved fat in the tissue.

2) Must have nucleation site at which microbubbles form.

2) Density/viscosity of the medium must not be very high.
Therefore, fatty tissue cavitates easier than compact tissue, turnescent infiltration makes cavitation easier, increases the fragilization of the target cell (adipocyte), and acoustic intensity must exceed a threshold to cause the bubbles to grow.

As a consequence of the cavitation phenomenon, implosion of bubbles results in cell disruption and fat emulsification.

Zocchi\textsuperscript{1} established a formula to determine the cavitation number.

**CAVITATION NUMBER (N)**

\[
N = \frac{PA + PH + PV}{(D/2) — V^2}
\]

\[
PA = \text{Atmospheric Pressure}
\]
\[
PH = \text{Hydrostatic Pressure}
\]
\[
PV = \text{Vapor Pressure}
\]
\[
D = \text{Density}
\]
\[
V = \text{Velocity}
\]

The cavitation number expresses the cavitation mechanism. Cavitation is the consequence of an alternation of peak compressional pressure (Pc) and peak rarefactional pressure (Pr) which alternate as a function of time.

In order to produce this mechanism, a special titanium probe attached to the piezoelectric transducer is able to convert the ultrasonic energy into the tip of the probe with 100\% of the energy translated into ultrasonic energy at the tip of the probe. The cycle of ultrasound waves is passed through the titanium probe and causes an alternation of circle waves with nodal points of energy concentrated along the probe and into its tip. 100\% of the energy will be concentrated in a perfectly functioning and efficient system.

The amount of cavitation is not just a theoretical mathematical expression, but expresses clearly the efficiency of the system. The higher the number, the higher is the specificity of the system and the higher is the chance to target fat cells as sole recipients of the ultrasonic action.

Instrumentation of UAL:

— Power console

- Piezoelectric transducer
— Titanium probes
— Cannulas: 2-4 mm in diameter
- Skin protector
— Manual remodeling instrument

The piezoelectric transducer has two frequencies, serial and parallel, which are resonant and anti—resonant frequencies. The equipment can be designed using either resonant or anti—resonant frequency to deliver exactly the same output parameters without interfering with the equipment safety or efficiency.

The bubble mechanism (cavitation) causes the formation of bubbles of progressively increasing size in the fatty compartment. The alternation of positive and negative pressures, with an expansion and contraction at a frequency corresponding to the ultrasonic wave, leads to the progressive instability of the bubbles and microcavities already formed until their final explosion (Fig. 1) Expansion and compression, implosion and explosion, related to alternate cycles, are the phenomena causing cavitation which leads to the final destruction of the target cells, the adipocytes.

The quick compression of gas inside a microcavity generates heat that causes an increase in temperature and creates a local “warn point.” Even if the temperature can reach very high values, the cellular volume involved in this thermal phenomenon is so small that the heat generated is immediately dispersed toward surrounding structures where the temperature does not vary.

Effects of UAL

The effects of UAL on adipose tissue are:

1) Micromechanical effect:
The consequence of damage produced by direct action of the ultrasonic waves and the organic intracellular molecules which are violently moved and displaced in the extracellular spaced with subsequent breaking up macromolecules.

2) Cavitation effect:

The cellular fragmentation from cavitation determines the diffusion of the lipid matrix (fatty acids) of the adipocytes into the intercellular space where a stable emulsion with interstitial fluid and infiltration solution occurs. The formation of free radicals and the denaturization of the lipoproteinic components of the cellular membranes may lead to a progressive lipolytic action which will partially continue even after the ultrasonic treatment has ended.

3) Thermal effect:

A hyperemic secondary mild effect is associated with the friction action of the titanium probe moving through the tissues. These effects are restrained and negligible if the technique is properly applied. Thermal effects do not cause any damage to cells, structures, or fluids involved and do not cause any undesired biological reaction, especially at the protein chain level.

Ultrasonic energy is a wet and dynamic technique and should not be applied to dry tissue and following these two basic rules, thermal injuries should not occur. If injury does happen it is related to improper utilization of the method. There should be adequate infiltration of the tissues before applying ultrasonic energy and the hand piece and probe must be moved constantly along the planned tunnels into the fatty compartment.

Mistakes due to lack of experience and proper training are:

1. Lack of uniform infiltration in the area to be treated.
2. Poor infiltration (lack of tumescence).
3. Loss of tumescence over time during surgery.
4. Energy applied without moving the probe.
The author has verified experimentally that a burn occurs when there is continuous application of ultrasonic energy at a single point of the skin for more than a minute. Superficial burns are probably due to lack of proper tumescence in the treated area.

Technique

UAL requires a longer period of learning compared to standard liposuction. The steps of the technique are:

1) Preoperative planning
2) Patient set up
3) Tumescent infiltration
4) Ultrasonic treatment
5) Emulsion suction
6) Manual remodelling
7) Postoperative care

Preoperative Evaluation and Planning

The clinical difference from traditional liposuction is that the fat is not removed immediately and continuously as the procedure proceeds and therefore, does not have the visual view of the result as the surgery proceeds. It is important to preoperatively mark the areas to be treated, placing markings at the outer limited of the areas, and then topographic markings to indicate progressively thicker areas of fat to be liquefied and removed. These topographic markings thus demarcate areas that need greater or lesser amounts of ultrasonic energy applied. The usual preoperative evaluation of subcutaneous tissue thickness with the pinch test and the rolling test is helpful in determining where to place these markings.
Criss cross tunnels are also marked since these indicate the lines of ultrasonic energy application which must be taken into account. In order to liquefy fat, the passage in a single tunnel is repeated at least 7—8 times with a gentle, slow motion.

When operating upon the trochanteric area, the G point (Gasparotti point) is marked in the natural infragluteal fold (Fig. 2). Areas where skin retraction is essential are marked so that a thickness of 5-10 mm. will be obtained.

Plasma triglyceride levels should be monitored. Zocchi\(^2\) reported a significative drop of triglycerides from 84.3 mg/ml preoperatively to 75.1 mg/ml postoperative. These parameters were followed at 24 hours, 1 week, and 1 month after surgery. Free fatty acids are eliminated progressively and this reduction continues for weeks after surgery.

Patient Set Up

UAL is a longer procedure than liposuction.

In order to decrease the surgeon’s discomfort the author developed a new way of patient positioning on the operating table. When treating the gluteal, trochanteric, circumferential thigh, knee and calf, the patient is positioned face down with a rolling plastic bar to support the abdominal area. The rolling bar is larger than the operating table and the table is positioned higher than the surgeon who sits beside the table. The complete leg is sterilized and wrapped in order to accomplish movement during surgery. The leg can be lifted, moved forward and backward, moved laterally, or off the operating table, recreating the natural gravitational position as when standing. This helps evaluate body mass behavior before and after surgery in order to judge how the body fat distribution is changed by the procedure.

When the leg is dropped the surgeon evaluates the effect of gravity without the muscle tone activity. Under local anesthesia with full patient cooperation, this gravitational effect is immediate.

Catheterization is mandatory in the majority of the patients, where large quantity of tumescent infiltration is utilized.
Tumescent Infiltration

Zocchi\(^2\) modified the Klein’s formulation for standard liposuction. He realized a hypotonic solution would reduce the density of subcutaneous tissue and facilitate cavitation of the subcutaneous fat. The hypo-osmolarity of the solution weakens the lipocyte membrane, swells the cells, and aids the liquefaction process produced by the ultrasonic energy. The standard physiologic solution is diluted 50% with distilled water to obtain the hypotonic solution which is injected with the Klein infiltration pump. The author prefers a pump manufactured by SMEI that has the advantage of recording the total amount of fluid effectively infiltrated, has a control of the speed of the infiltration (which is recorded on the monitor), and can be utilized as a peristaltic aspirating system for cleaning (Fig.3). Zocchi’s tumescent infiltration solution for ultrasonic liposculpturing is:

- Lidocaine 500 mg (50 ml of 1% lidocaine solution)
- Epinephrine 1 mg (1 ml of a 1:1,000 solution of epinephrine)
- Sodium Bicarbonate 12.5 mEq (12.5 ml of an 8.4% NAHCO solution)
- Normal Saline 500 ml of a 0.9% NaCl solution
- Distilled water 500 ml
- Chondroitinsulfatase 1,000 TRU* in 20 ml

* TRU = Turbidity reducing unit

This solution is utilized when performing UAL under local anesthesia and/or with intravenous sedation. When performed under general anesthesia, the quantity of lidocaine is reduced to 200 mg per liter of solution which is enough to ensure postoperative analgesia. There are reports which advocate that chondroitinsulfatase could increase the absorption of lidocaine which would decrease the usual total dose of lidocaine utilized with the tumescent technique. Dr. Klein suggests that dexamethasone can be substituted for chondroitinsulfatase which would reduce postoperative edema, help working in fibrotic areas, but not affect the lidocaine absorption rate.\(^3\) In my clinical experience, I found no significative difference in
utilizing distilled water instead of normal saline. The author utilizes the original Klein solution since there does not appear to be any significant difference adding distilled water or chondroitin sulfatase.

**Infiltration Solution For Local Anesthesia**

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lidocaine</td>
<td>500 – 1,000 mg: concentration depends on fibrosis of target areas.</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>1 mg</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>12.5 mEq</td>
</tr>
<tr>
<td>Normal Saline</td>
<td>1,000 ml</td>
</tr>
</tbody>
</table>

**Infiltration Solution For General Anesthesia**

- Lidocaine 200 mg
- Epinephrine 1 mg
— Normal Saline 1,000 ml
When performing procedures where more than 2,500 — 3,000 ml of infiltration may be used the patient should be catheterized at the time of surgery. Normally the tumescent solution will compensate for the loss of fluids with the UAL method, however, an intravenous line should be inserted. No more than 500 - 1,000 ml I.V. fluids are given for moderate fat removal (< 5,000 ml). Intravenous sedation is sometimes administrated with Propofol (Diprivan), dose depending on patient weight and operation time. In major cases, when more than 5,000 ml infiltration is performed, diuretics are routinely administered intravenously to avoid overloading the cardiac and renal systems. Continuous monitoring of the patient is accomplished during surgery.

O₂ saturation by a peripheral finger tip pulse oximeter, blood—pressure, pulse, and breath frequency are monitored as well as urine output. Diuretics can improve the urine output during surgery depending upon the circumstances. The author prefers that the anesthesiologist handle fluid balance, monitoring, and analgesia.

Anesthetic Solution Used With Tumescent Technique

<table>
<thead>
<tr>
<th>AREA</th>
<th>VOLUME RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdomen, upper and lower</td>
<td>800 – 2000 ml</td>
</tr>
<tr>
<td>Hip (flank or love handle), each side</td>
<td>200 – 800 ml</td>
</tr>
<tr>
<td>Lateral thigh, each side</td>
<td>500 – 1,000 ml</td>
</tr>
<tr>
<td>Anterior thigh, each side</td>
<td>500 – 1,000 ml</td>
</tr>
<tr>
<td>Proximal medial thigh., each side</td>
<td>250 – 600 ml</td>
</tr>
<tr>
<td>Procedure</td>
<td>Volume Range</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Knee, each side</td>
<td>200 — 500 ml</td>
</tr>
<tr>
<td>Male breast, each side</td>
<td>400 - 800 ml</td>
</tr>
<tr>
<td>Female breast, each side</td>
<td>500 - 800 ml</td>
</tr>
<tr>
<td>Submental (chin)</td>
<td>100 — 200 ml</td>
</tr>
</tbody>
</table>

Knize and Pepper (1996) stated that tumescence is realized when a ratio of 1:1 to 1:1.5 is followed between the proposed total aspiration and the volume infiltrated. There is no need to infiltrate with anesthetic solution 2-3 times the amount of aspiration planned. The epinephrine vasoconstrictive affect is not changed by infiltration of the tissue with excess solution. There is no further diminution in bleeding when an excessively large amount of tumescent solution is infiltrated.

Ultrasonic Treatment

After the tissues are infiltrated solid titanium probes are connected to the ultrasonic generator via a handle that contains the ceramic piezoelectric transducer and are introduced into the subcutaneous tissue through small incisions. The probe is moved through the tissues with a slow, regular manner in a criss-crossing pattern. In this way, the high frequency vibrations are directly conveyed through the titanium probe to the tissue being treated.

In order to avoid friction injuries or burns to the site of entrance of the titanium probe, a plastic skin protector is utilized, at all times. Solid titanium probes are preferable to stainless steel probes because the titanium conducts a significantly greater amount of energy and consequently results in better cavitation. Steel can create too much heat and can easily break.
The type of probe used depends on the body area being treated. For volume reduction and skin stimulation, a 35 cm probe with a diameter that ranges from 5.5 mm in the proximal portion to 4 mm in the distal portion is used. For treatment of the face and neck, a 21 cm long probe (diameter, 3 mm. to 4.4 mm.) is utilized. A shorter 12 cm long probe (diameter, 2.5 mm to 4 mm) is used for the breast and for surgical undermining. A solid probe has been found more efficacious than hollow probe (Fig. 4) A hollow probe is not as strong and could break in the tissue as the result of the vibrations produced when the ultrasonic energy is applied.

Some ultrasonic devices are being sold that are hollow probes with holes on the side of the tip so that fat emulsion can be aspirated at the same time as the fat destruction.

A double circuit system allows the application of ultrasonic energy and immediate aspiration of the fat emulsion. This reduces the duration of surgery. Standard UAL consists of fat destruction with ultrasonics and, then aspiration with a low power aspiration system (cleaning or aspiration phase of the technique). Placing holes on the side of the tip of the hollow titanium probe reduces the specificity and efficiency of the system.

The technique is less specific for fat destruction, and for subcutaneous skin “stimulation” in order to allow skin retraction. This cannula could be utilized in the deeper planes in order to speed up surgery, but are at risk when utilized in the superficial fat layer when skin retraction is required. Being less specific for fat tissue, the instrument can cause burns more easily. When atmospheric pressure is decreased during aspiration, cavitation is diminished, and thus the specificity and efficiency of the system purely for fat is decreased.

Scheflan and Tazi (1996) tested several prototypes of ultrasonic machines, assessed then clinically, and observed endoscopically their effects in real time. Some of the machines were wholly ineffective, while others seemed promising but functioned inconsistently. They concluded that the ideal machine should have a 2—4 mm hollow cannula that emits effective, consistent, and controllable ultrasonic energy at the tip, does not heat up, and simultaneously aspirates. The rod should be teflon coated to reduce friction and should be malleable to improve “reach.” The cannula ports should be small, well rounded, and
atraumatic and the pump should be designed to aspirate with low negative atmospheric pressure. Such a machine is technologically possible and will reduce the surgeon’s fatigue, will save time in surgery, and will be more effective by increasing the volume that may be aspirated in one session and tightening the skin envelope.

Skin Retraction

The application of the ultrasonic probe must be in the subdermal area in order to induce postoperative skin retraction.

The duration of the procedure and the amount of energy required to liquefy the excess fat varies with the character of the tissue, volume of the planned reduction, and type of lipodystrophy. Hypertrophic lipodystrophy is easier to treat than mixed lipodystrophy or hyperplastic lipodystrophy. Less energy is required when the adipocytes contain large volumes of fluid as compared to tissues that are firm and the fat content and the ratio of tissue to fat are less. For instance, in the treatment of inner thighs, application of ultrasonic energy set at 65% power for 10 to 12 minutes is required to obtain a volumetric reduction of 250 cc and to give good skin “stimulation.”

Clinical experience is helpful in establishing the time of application of the ultrasonic energy. The author applies up to one hour of ultrasonic energy to defat the abdomen. The number and location of access incisions also vary according to the treatment site. For the abdomen, usually, only a 2 cm suprapubic incision is required for good radial energy application. The addition of two 3 mm. incisions in the upper lateral sides of the abdomen allows the removal of the oily emulsion with a traditional small teflon—covered cannula connected to a low—pressure (0.3 atm) vacuum. For the buttocks and lateral and posterior sides of the thighs, two 2 cm incisions located in the middle portion of the infragluteal fold on each side are utilized.
Aspiration — Cleaning

Removal of the fat emulsion is with a low level of suction (not more than 0.2 to 0.3 bar) performed with a clear tubing in order to monitor the aspirate. When whole adipocytes are observed in the aspirate, suctioning is immediately ceased. A 2 or 3 mm teflon coated cannula manipulated with very slow back and forth movements is utilized. Aspiration should not be performed concurrently with ultrasonic energy application. Suctioning reduces the volume of fluid which was added to enhance the cavitation effect and this would reduce the degree of cavitation and increase the amount of heat generated producing significant side effects.

Manual Remodelling

After the liquefied subcutaneous fat is removed with suction, the residues of the lipocytes and the connective tissue containing autologous collagen remain in place. The area is manually remodelled utilizing a device (roller) developed for this purpose. This maneuver removes the residual fluid, modifies the shape of the tissues remaining at the treated site, and creates a regular, homogenous skin surface.

Total surgical time of a typical case of lipodystrophy in which trochanteric areas, inner thigh, and knees are treated varies from 2 to 2 1/2 hours. A major case of total body remodelling, with major volume reduction (7,000 cc), can easily require 5—6 hours of surgery. Despite the increased length of surgical time (40% more), ultrasonic liposculpturing broadens the indications for traditional liposuction.

Hematocrit

The final result of the application of ultrasound energy to the fat tissue compartment is the destruction of the adipocytes, the creation of a fat emulsion, represented by the liquid part of the fat fragmentation (as a result of the adipocyte implosion) plus the fluid of the tumescent infiltration utilized preoperatively. This creamy emulsion is what characterizes the ultrasound technique in comparison with standard...
liposuction. The former is a gentle fragmentation of the adipocyte, with creation of a fatty emulsion which is then aspirated; the latter is a mechanical destruction of the fatty compartment, with aspiration of the destroyed elements. The former is a selective destruction of the fatty cell, since UAL is able to target only tissue with low density and low molecular cohesion, as fat tissue. Vessels, nerves and the elastic—connective fibers of the subcutaneous structures are preserved. The latter is an unselective methodology, being unable target only the adipocyte; all the anatomical components are attached and destroyed, such as vessels and elastic fibers. This explains why UAL is accomplished with low blood loss, and the hematocrit drop after surgery is considerably reduced. This is clearly shown in clinical experience.

Traditional suction assisted lipectomy (SAL) removal of 150 cc of aspirate results in 1% decrease in hematocrit. Lewis (1989), using the syringe SAL, showed that 1% hematocrit drop resulted from 300 cc of fat aspiration. With the introduction of Klein tumescent technique, SAL in combination with tumescent infiltration leads to a 1% decrease in hematocrit with 450 cc of fat removal. Zocchi (1993) reported high volume fat removal with UAL combined with the tumescent technique resulted in 1% drop in hematocrit was related to 1050 cc aspiration. This gives reason why, which UAL, more fat removal is realizable without great blood loss.

In our clinical experience, 6,000—8,000 ml of aspirate could be removed, after at least the same amount of Klein modified solution infiltration, without transfusion. Scheflan and Tazi (1996) reported aspiration up to 20 liters of emulsion using SAL using only one or two units of blood (autotransfusion).

Endoscopic Evaluation

Tazi and Scheflan (1995) introduced endoscopic evaluation of ultrasonic assisted liposculpture. The author began using this method with a Stortz endoscopic system and camera. Tumescent technique was used in the inner thigh area and the abdomen. The
instrument was placed in the superficial layer of the subcutaneous fat verified by needle depth. UAL was performed with criss—cross tunnels, recording the technique by video.

An adjacent area was treated with standard liposuction. The results were:

1) Standard liposuction appears to be a more aggressive technique, with mechanical destruction of the subcutaneous tissue including vessels, nerves, and supporting structures.

2) Ultrasonic liposculpting is a gentler, selective method which is aggressive only in the fatty compartment of the body, sparing vessels, nerves, and elastic supporting fibers. Alterations in the tissue resulting from the use of SAL are a thickened dermal undersurface, markedly thickened vertical collagenous fibers, intact lymphatic vessels, and intact blood vessels.

Scheflan and Tazi\textsuperscript{5} hypothesize that it is this horizontal and vertical thickening and shortening of the collagen in the dermis and ligamentous fibers, that is responsible for the remarkable skin tightening. The closer to the skin and the more complete the removal of fat from the immediate subdermal space, the greater the skin tightening effect. Although infrequent, significant complications such as thermal burns and skin necrosis are possible.

Post Operative Care

Elastic compression of the treated areas is necessary for 4 to 8 weeks postoperatively in order to achieve a satisfactory long-term result. The author utilizes two pairs of high compression pantyhose worn over one another following the application of a soft elastic-compressive dressing (Restom - by 3M). The compressive dressing is removed after one week.
Broad spectrum antibiotics are administered routinely in the first 48 hours postoperatively. In treating the abdomen or breast, suction drainage is utilized for 1-2 days. After a period of 1 week of relative rest, the patient is encouraged to increase activity. A period of lymphatic drainage with minimal compression twice a week for 4—8 weeks will help to decrease postoperative edema when legs are treated. No massage is necessary since the area treated has minimal swelling and is soft. For local ecchymosis, Heparin—cream can be used for a week.

Skin incisions utilized for UAL are large (2 cm at least) and sutures are removed in 7 days. More incisions are used during surgery in order to allow clearing of the treated areas. These incisions allow drainage of the infiltrated solution which normally continues for the first 12—18 hours postoperatively. Healing time following ultrasonic liposculpturing is longer than after traditional liposuction.

Clinical Experience

In the male patients, the areas treated were chin and neck, breast for gynecomastia, abdominal area, and hips. Some of the cases were combined with other surgical procedures.

In the female patients, knees, calves, and ankles can be treated together with breasts, abdomen, trochanteric areas, gluteal areas, thighs, flanks, arms, chin, neck, and dorsum (Fig. 5). Many patients had combined surgery (with mammoplasty, rhytidectomy, and abdominoplasty).

Zocchi (1995)\textsuperscript{10,11} has used this technique to treat axillary hyperadenosis and hyperhidrosis, as well as for periosteal fat pads. It has also been used to remove large lipomas and cellulite. Scheflan and Tazi\textsuperscript{5} have used the procedure for partial omentum ablation.

Illouz (1988)\textsuperscript{12} and Pittman (1993)\textsuperscript{13} have suggested utilization of liposuction in the breast to improve body contouring and to reduce volume. Lejour (1994)\textsuperscript{14}, presented a review of the principles and clinical application of standard liposuction to breast tissue. Initially, Lejour tried to suction the juvenile fatty breast as a temporizing measure until breast growth
was complete and a more definitive operative procedure could be performed. Sometimes suction was combined with traditional open surgery, in order to better define the contour of the upper outer quadrant fat redundancies, or defat the mammary lateral or medial triangles.

Large amounts of fat are found in patients with breast hypertrophy, even thin adolescents. Although the amount of fat in the breast increases with age, especially after menopause fat in varying proportions can also be found in the breast of young patients. The amount of fat in the breast is variable as is its distribution. For this reason, not all women with large breasts are candidates for liposuction or UAL.

If fat is mixed with glandular tissue, it may be impossible to penetrate it with a blunt cannula and liposuction is not feasible. Preoperative mammography is necessary before considering the utilization of liposuction or UAL in the breast. Approximately 60%-70% of patients with large breasts are candidates for liposuction or UAL alone or combined with open surgery. Fat can be suctioned or destroyed selectively with UAL from all parts of the breast with the exception of the retroareolar region, which is mostly glandular. Subcutaneous aspiration must be extensive in order to obtain the necessary skin retraction and the risk of localized skin necrosis may be increased. Subcutaneous skin stimulation with UAL is an effective measure to obtain skin retraction and for correction of mild ptosis.

Postoperative risk of fat necrosis or calcification is the reason why some surgeons avoid the use of suction lipectomy in the breast. Some calcification may develop in the breast after any mammoplasty procedure. The calcifications that occur after mammoplasty are more round, regular, and less numerous and should not be confused with those associated with cancer.

In the young fatty breast, volume can be reduced and ptosis corrected. Aspiration of 600-800 ml of emulsion (after infiltration with tumescent technique of the same amount of fluid) can results in a nice improvement of the breast contour and shape, together with elevation of 3—4 cm of the nipple which is visible on the first postoperative day. The breasts are soft and natural. It could be used as a temporizing procedure to reduce breast volume and
completed in a second stage, with a periareolar breast mastopexy, avoiding the longer scar (vertical type or L—type) of a standard mammoplasty. Further clinical experience is necessary in this technique.

COMPLICATIONS

Skin Necrosis

Skin necrosis may result from thermal and/or vascular compromise (fig. 6). The closer the surgeon works to the skin, the greater the risk of skin damage. With very loose skin, where skin retraction is required, the more “stimulation” applied the better the tightening effect. After UAL treatment of the target area, the skin envelope must be free enough that it can be plicated with the pinch test. The skin acts as a sort of “skin graft.”

The solid rod emitting ultrasonic energy liquefies wet fat but heats dry dense tissues. For this reason, extreme caution must be exercised when working directly under the skin. Burns at the entry site or on the skin surface may be caused by excessive friction or an overheated titanium rod. A rigid skin protector at the incision site will prevent burns at the entry site.

Fat Fibrosis and Fat Necrosis

Fat fibrosis and necrosis are manifested as a sensitive induration in the subcutaneous tissues. The areas of fat fibrosis persist for a long period time unless treated with pressure or intraleisional steroids. These areas may cause skin hypersensitivity, pain, and discomfort.

Skin Pigmentation

Brown pigmentation of the skin is due to hemosiderin deposits or post—inflammatory hyperpigmentation. Hyperpigmentation is long lasting and resistant to treatment, but will eventually fade. This is more frequent in fair, thin—skinned individuals, and is most common on the upper inner thigh.
Sensory Alternations

Paresthesia and dysesthesia may be present after UAL. This could be due to the ultrasonic energy stripping the sensory nerves of their phospholipidic envelope. This demyelination may result in depolarization of fine cutaneous sensory nerves. Hyperesthesia and dysesthesia have occasionally been reported after conventional liposuction, especially superficial liposuction, so it is possible that mechanical factors are also involved.

Manual lymphatic drainage massage or pressure garments are indicated when large areas of “pins and needles” are reported. Temporary neuropraxia of a branch of the mandibular branch of the facial nerve has been reported in a case of neck defatting and aggressive UAL skin stimulation for a neck lift. The neuropraxia resolved spontaneously in 3 weeks. Similar problems have been reported with standard liposuction of the neck and face.

UAL and Obesity

With the tumescent technique and UAL, the total amount of fat that can be aspirated in a single stage is increased (up to 21 liters). The author limits the total amount of aspirate in a single stage to 10 liters in order to avoid possible complications. The treatment of obese patients with UAL is combined with diet (Simmons gonadotropin diet). This regimen includes 40 days of treatment with low dose human chorionic gonadotropin (125 units I.M. daily) and 500 calories daily diet. The low amount of calories given is well tolerated because of induced depressive action of the appetite centers and fat mobilization from fatty deposits by gonadotropin. This double action leads to dramatic weight loss with little discomfort to the patient despite the low-calorie diet for a short period of time. Weight loss of 15-18 kg can be achieved without loss of strength or diminution in brain capability.
Conclusion

Ultrasonic assisted liposculpturing is a standardized method utilized in Europe and South America for at least the past five years. In the author’s clinical experience excellent results are achieved in cases of fat excess and base skin. UAL has a training curve, best gained by direct instruction from a surgeon fully versed in the procedure. The equipment is expensive and the technology is improving. The technique is a valuable adjunct to body contouring surgery.
References


