

Multifrequency Ultrasound-Assisted Liposuction: 5 Years of Experience

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Abstract

Background The use of ultrasound in liposuction was first introduced by Kloechn. The ultrasound frequencies used in this technology have a high degree of selectivity for fat cells, thus reducing blood loss, postoperative edema, and ecchymosis and avoiding contour irregularities. The authors report their 5 years of experience with a multifrequency ultrasound generator and describe their series with the aim to focus attention on the problems linked with ultrasound use.

Methods A total of 797 patients were selected to receive ultrasound assisted liposuction (UAL). Accurate preoperative planning was conducted for all the patients before admission to the surgical quarter. Liposuction was performed using general anesthesia for 538 patients (63 %), peripheral anesthesia for 220 patients (25.76 %), and local anesthesia for 96 patients (11.24 %). The ultrasound generator device was set by choosing the better working protocol (continuous or pulsed mode) according to the tissue characteristics, and the frequency test was performed. A photo of the patient was taken before surgery and at every follow-up visit to estimate the results and to have an objective evaluation of the outcome. The patient's opinion of the results also was recorded using a graduated scale.

Results The results were excellent in 204 cases (25.4 %), good in 356 cases (44.6 %), moderate in 174 cases (22 %), and poor in 63 cases (8 %).

Conclusions For body contour improvement, UAL is an essential procedure. The introduction of multifrequency UAL, or rather the possibility of using the better working frequency during the treatment, allows better results, thus improving patient outcome.

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Keywords Body contouring · Cavitation · Klein solution · Liposuction · UAL · Ultrasound

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The use of ultrasound in liposuction (ultrasound-assisted liposuction [UAL]) was first introduced by Kloechn [6]. The first generation of ultrasonic devices used a solid probe that extended surgery, allowing additional time for tissue sonication before fat extraction [6]. To reduce the length of surgery and better control the amount of fat extraction, in 1995, Zocchi and Maxwell [12, 21] introduced the second generation of ultrasonic devices using perforated cannulas, which at the same time administered ultrasonic energy and generated a negative pressure to remove emulsion.

In traditional UAL, the power of ultrasound energy is a function of the cannula diameter, necessitating the use of a larger cannula [4, 17]. The third generation of ultrasound machines uses a solid probe with a smaller diameter [17].

The ultrasound frequencies used with this technology primarily affect tissue with the lowest density, defined as tissue impedance. Fat has the lowest tissue impedance, and

wetting of the adipose tissue with saline infiltration can lower the impedance value even further [15]. The result is a high degree of selectivity for fat cells, thus reducing blood loss, postoperative edema, and ecchymosis and avoiding contour irregularities [17].

Many devices are available, but they operate using different frequencies (high or low). Which is better remains under question. Penetration depth is the fundamental parameter. The energy contained in a sound beam attenuates as it propagates along tissue due to reflection and absorption phenomena [14, 20]. In experimental conditions, considering only one wavelength cycle and excluding the attenuation phenomena, the penetration depth is equal to the wavelength, so low-frequency ultrasound penetrates deeper than high-frequency ultrasound and thus should be preferred.

The interaction between fat tissue and ultrasound waves induces a series of contractions and expansions of cells, raising the fragmentation of the cytoplasmic membrane and inducing adipocyte death. This phenomenon is called cavitation [2, 7, 21].

An important way to induce the cavitation effect is to select a better working frequency. Cavitation is known to be a dynamic phenomenon linked to the surrounding environment (e.g., temperature and moisture) and can modify the resonance frequency. To use a better frequency in all conditions, maintaining the maximum effectiveness, a new technology was introduced. This technology, Liposystem LP-100, uses a last-generation microchip to find the best resonance frequency every 10 s by measuring tissue humidity and impedance.

The authors report on their 5 years of experience using this technology. They aim to focus attention on the problems linked with ultrasound use.

Materials and Methods

Surgical Device

The ultrasound generator device (Liposystem LP-100; Lain Electronic S.r.l., Milan, Italy; Technosinergie Medical Technology, Pomezia, Rome, Italy) is composed of a high-frequency generator, a radiofrequency transmission cable, and a probe with piezoelectric crystal. The device uses modern microprocessors capable of monitoring the session peak cavitation to manage the enormous amount of energy produced by low-frequency ultrasound and to maintain a better resonance frequency (19–23 KHz; power, 50 W).

The device is equipped with three titanium probes as follows and concentrates the low-frequency ultrasound only on the tip, thus reducing the risks or effects related to thermal damage:

- Small probe 18.5 cm in length and 3 mm in diameter
- Medium probe of 22 cm in length and 4 mm in diameter
- Long probe 32 cm in length and 4 mm in diameter.

The ultrasound generator can work in continuous mode for soft tissue or in pulsed mode for fibrous or difficult areas (male breast, secondary liposuction). To find the better resonance frequency before surgery, the device starts an automatic frequency research test, dipping the probe tip in a water case.

Patient Selection

From February 2006 to October 2011, 976 patients were referred to our operative units to receive liposuction. All the patients underwent a meticulous interview to identify the reality of their wishes and to reach agreement on a satisfactory treatment plan. A complete physical examination, laboratory analysis (Table 1), and regional echography scan were performed.

The current study included 797 patients (81.6 %) chosen to receive UAL liposuction. The exclusion criteria are presented in Table 2. The main exclusion criteria specified a high degree of obesity, and a body mass index (BMI) exceeding 30 kg/m² was chosen as a cutoff (Table 3).

The procedures were performed by different surgeons using similar techniques. However, the surgical procedure

Table 1 Laboratory analysis

Blood count, transaminase, total bilirubin, direct bilirubin, indirect bilirubin, protein assays and quantification, coagulation profile, creatinine, blood electrolytes, glycemia, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglycerides

Table 2 Exclusion criteria

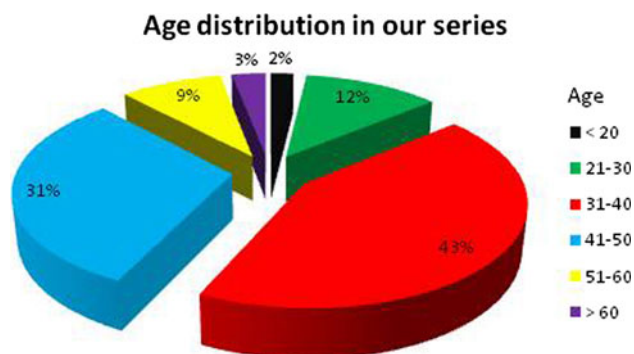
High degree of obesity (BMI, >30), presence of hernia at the operative site, low skin elasticity, significant striae (local score >2 according to the Pittsburg Weight Loss Deformity Scale), internal metallic prostheses, previous oncologic breast treatment, suspicion of adipose neoformation such as lipoma, pregnancy, coagulation diseases, active inflammation process

Table 3 Excluded patients (*n* = 179)

Disease	Patients (<i>n</i>)	%
High degree of obesity	98	54.7
Skin laxity	49	27.3
Lipoma	24	13.5
Blood anomalies	8	4.5

Table 4 Patients' demographic characteristics

Males	145
Females	652
M:F	1:4.5
Average age (years)	38.7
Range	18–65

**Fig. 1** Age distribution of the series

did evolve during the period of study. To ensure reproducibility every month, we conducted a meeting to modify and standardize the surgical protocol (type of movement, device setting, patient selection criteria, and treatment time). The demographic characteristics of our clinical series are reported in Table 4 and Fig. 1.

Surgical Procedure

To avoid thrombosis, all patients should start adequate antithrombosis prophylaxis (a low-molecular-weight heparin consisting of enoxaparin sodium 2,000 U for low- or medium-risk patients and 4,000 U for high-risk patients administered subcutaneously every 24 h) the day before surgery and continue it for 15 days. Preoperative planning was done for all patients placed in the upright position before admission to the surgical quarter.

Liposuction was performed using general anesthesia for 538 patients (63 %), epidural anesthesia for 220 patients (25.76 %), and local anesthesia for 96 patients (11.24 %). The choice was made based on the number of anatomic regions to be treated, the theoretical amount of excess fat, and the preferences of the anesthesiologist and patient.

The peripheral blocks were obtained using hyperbaric bupivacaine (10 mg) in the epidural space. Local anesthesia, reserved for treatment of a small area (theoretical lipoaspirate < 400 ml), was achieved by injecting absolute lidocaine into the access point and then using an infiltration cannula to administer Klein solution. A pain medication or oral sedation was used when more than two anatomic areas had to be treated.

In all cases, Klein solution, containing lidocaine (0.05 %), epinephrine (1:1,000,000), and sodium bicarbonate (12.5 mEq/l), was administered 20 min before the surgery [11]. The amount of tissue infiltration was linked to the theoretical amount of excess fat to be removed, respecting the ratio of 1:1 used in traditional wet liposuction.

The ultrasound generator device was set with the better working protocol (continuous or pulsed mode) chosen according to the tissue characteristics, and the frequency test was performed.

After the operating area had been prepared for adequate skin incision, the ultrasonic probe was inserted in the fat tissue. To achieve optimal fat emulsification, the ultrasound supply was conducted in multiple layers, starting from the deeper and progressing to the superficial layers using “fan-shaped” movements with repeated and overlapping sweeps. The time of treatment was less than 10 min for each anatomic area. The theoretical duration of energy application per 100 ml of estimated aspirate was 1 min. The emulsified tissue was always followed by fat extraction using a 3- or 4-mm blunt cannula connected to an electric negative pressure generator.

A drain was positioned for cases in which the aspirate amount was more than 1,000 ml and maintained *in situ* until the amount of drain fluid was less than 30 ml (average time, 5 days). Areas of surgical access were left open to allow the outflow of residual emulsification and infiltration. A compressive girdle was worn for 30 days as a postoperative dressing.

Result Collection and Evaluation

The patient was photographed before surgery, then after 2, 3, and 6 months to estimate the results and to have an objective evaluation of the outcome. The photos were taken in frontal, side, and three fourths views.

The parameters chosen in our scale were as follows (Table 5):

- The variation of circumference and projection estimated using a tape measure
- The reduction of orange peel estimated by macrophoto under the pinch test
- The lift of tissue and skin retraction evaluated by clinical comparison of the skin tightening and confronting tissue position in the patient photos before and after surgery.

The degree of improvement was estimated by picture and data overlapping using a computer graphic program (Anthology; DEKA me.la S.r.l., Calenzano-Florence. Italy) following our outcome scale.

The patients' opinion of the results also were recorded and elaborated by a blinded physician not belonging to the

Table 5 Outcome scale

Valuation	Parameter
Excellent	Optimal circumference/projection reduction, resolution of orange peel, excellent regional lift, absence of skin irregularities
Good	Good circumference/projection reduction, improvement of orange peel, good regional lift, improvement of skin irregularities
Moderate	Partial circumference/projection reduction, improvement of orange peel, no regional lift, persistence of some skin irregularities
Poor	Partial circumference/projection reduction, persistence of orange peel and skin irregularities, no regional lift, asymmetry, complications onset

surgical team who was provided with an anonymous questionnaire. The answers were standardized using a graduated scale with the options “excellent,” “good,” “moderate,” and “poor.” The administered questions and related criteria for evaluation are reported in Table 6.

Results

The clinical result was graded as “excellent,” “good,” “moderate,” or “poor.” Grades were given according to the outcome scale and reported complications. All the patients had follow-up visits at 7 and 30 days, then at 2, 3, and 6 months, and finally at 1 year. A total of 854 procedures were performed, and 57 procedures were the second or third liposuction (48 second and 19 third surgeries).

An immediate postoperative diameter reduction was observed, and a progressive reduction also was shown, especially after 24 h (Fig. 2). The results were excellent for 204 patients (25.4 %) (Figs. 3, 4, 5, 6) good for 356

patients (44.6 %), moderate for 174 (22 %), and poor for 63 patients (8 %).

The most treated area was the trochanteric area in females and the abdomen in males. The distribution of treated areas and the relative lipoaspirate range are reported in Table 7.

The patients’ opinions are reported in Table 8. We recorded a complication rate of 13.4 %, Table 9.

The incidence of seroma was progressively reduced in parallel with shortening of the sonication time. The other complications were burning of surgical access (14 patients, 1.6 %) and asymmetry (76 patients). These patients required a second surgery to correct the defect. Only one case of thrombophlebitis was recorded.

Discussion

In the United States, UAL developed mainstream popularity during the mid to late 1990 s after several years of development and application in Europe and South America [22]. The basic rules of UAL as described by Zocchi were followed without regard to other limitations such as ultrasonic energy site times, body areas, and level of tissue planes. Zocchi’s [22] basic rules of UAL are (1) never apply ultrasonic energy to dry tissue and (2) never apply ultrasonic energy without probe movement [15].

It is postulated that the energy of ultrasound will have a minimal effect on intervening connective tissue and other structures. The safety and efficacy of the method have been shown in several papers [12, 19]. The method has been advocated as a technique for treatment of obesity, and surgeons have reported removing fat volumes of 27 l or more [19].

However, anecdotal reports soon surfaced describing limitations and complications related to the emerging technology [1, 3, 13]. The increase in complications such

Table 6 Administered questions and related criteria for evaluation

Topic	Excellent	Good	Moderate	Poor
Intraoperative pain (reserved for patient who received local or peripheral anesthesia)	No pain felt during the entire procedure	Pain control suitable, pain felt sometimes	Pain control sufficient, pain felt often	Pain control insufficient, pain felt during the entire procedure
Intraoperative comfort (reserved for patient who received local or peripheral anesthesia)	High degree of comfort: warm operating room, complete treatment tolerability, no annoyances	Medium degree of comfort: warm operating room, minor annoyances, good treatment tolerability	Moderate degree of comfort: cold operating room, some annoyances, not complete treatment tolerability	Lower degree of comfort: Very cold operating room, several annoyances, treatment tolerable
Postoperative pain	No pain felt	Pain felt sometimes, no painkillers requested	Pain felt often, some painkillers requested	Pain felt always, painkillers requested often
Body-contouring improvement	“The result was better than I’ll hoped”	Completely satisfied	Not completely satisfied	The result was missed
Relationship with surgical team	Always professional, empathetic, helpful	Often professional, helpful, empathetic	Often professional, helpful, sometimes aloof	Unprofessional, aloof, ornery

Fig. 2 Progress of average diameter reduction after surgery. The highest values were recorded immediately after surgery (mechanical effect of ultrasound) and after 24 h, when adipocyte apoptosis reached the highest values. The progressive reduction of volume is correlated with progressive postoperative edema absorption

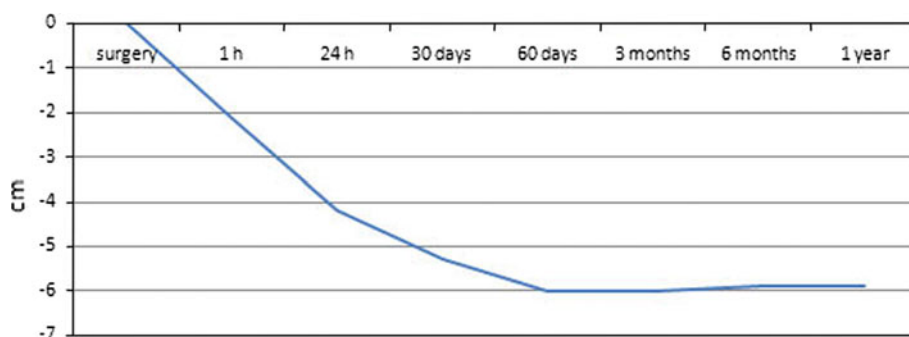
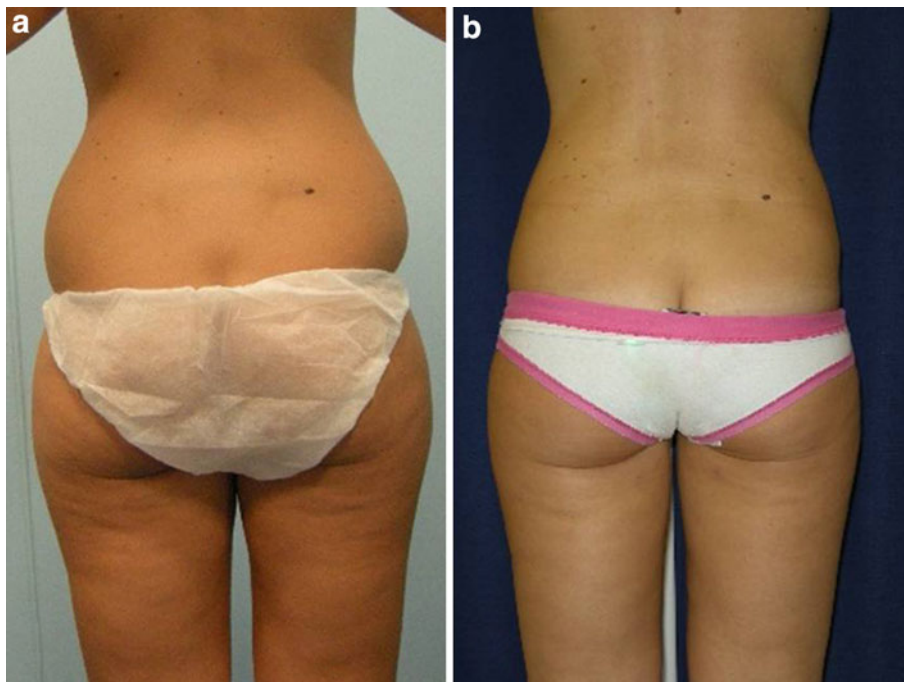


Fig. 3 A 32-year-old woman. **a** Preoperative view. **b** View after a 6-month follow-up period. Trochanteric, flanks, and inner thigh aspect were treated



as postoperative anemia, loss of albumin, tissue necrosis, and skin burns [13, 19] led to a reduction of indications, reserving UAL for localized fat excess or body contouring in patients with a low degree of obesity [6, 13, 15, 16]. The etiology of the complications was speculated to be a result of prolonged exposure to ultrasonic energy.

The principal problem is the scarcity of studies that demonstrate the effects and effectiveness of ultrasound. Although several studies reported in the literature describe clinical series or technical tricks, few investigate the interaction of ultrasound and fat tissue. For this reason, parallel to the beginning of the clinical ultrasound use, we performed experimental research simulating UAL on specimens of human adipose tissue collected after body-contouring surgery. The results are reported in the literature [14].

It is known that interaction of ultrasound energy with adipose tissue generates three effects:

1. *Mechanical effect:* Membrane disrupts the fat globule and all other intra- and extracellular biologic structures.
2. *Thermal effect:* Ultrasound waves increase molecular kinetic energy. By Joule's law, the potential energy of moving electric charges is partly released as heat, with a consequent increase in the temperature of the treated material. At temperatures exceeding 37 °C, protein denaturation begins. The thermal effect increases intra-adipocyte lipase activity.
3. *Cavitation effect:* Ultrasound waves through fat tissue create microcavities, with a series of expansion and compression cycles on cell membranes leading to cell disruption and fat liquefaction.

The last effect is the most exploited in clinical activity. The cavitation effect is a dynamic phenomenon linked to the surrounding environment, (e.g., temperature and moisture), which can modify the resonance frequency. Numerous available devices can work with different frequencies, but it is impossible to modulate the frequency during the procedure.

To use the better frequency in all conditions and to maintain the maximum effectiveness, a new technology

Fig. 4 A 33-year-old man. **a** Preoperative view. **b** View after a 6-month follow-up period. Upper and inferior abdomen, flanks, and thorax were treated

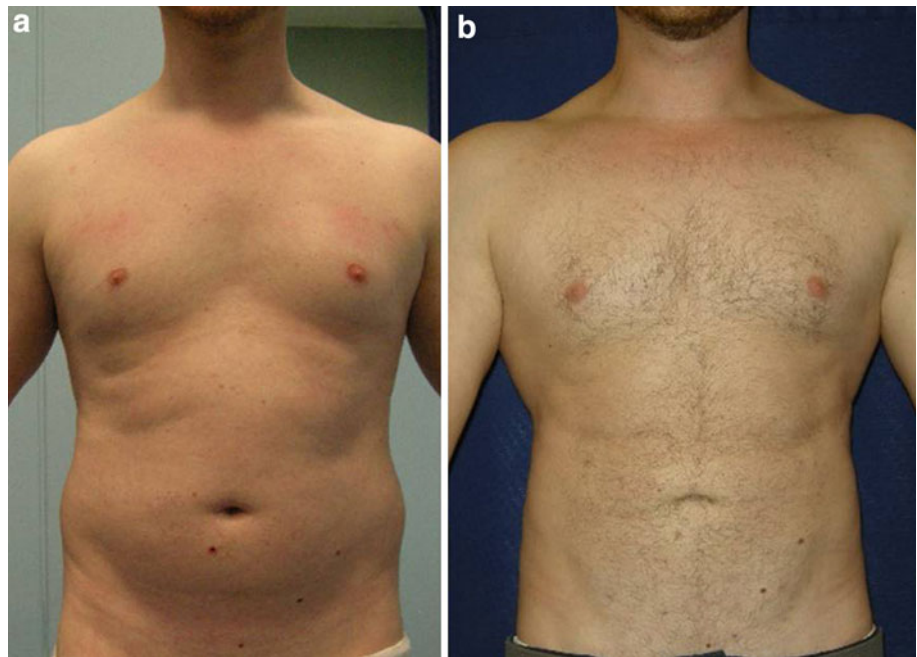


Fig. 5 A 36-year-old woman. **a** Preoperative view. **b** View after a 6-month follow-up period. Trochanteric and inner aspect of the thigh and knee were treated



was introduced. This new technology, Liposystem LP-100, uses last-generation microchips to determine the best resonance frequency every 10 s by measuring tissue humidity

and impedance. The initial device setting allows the ultrasound generator to choose the best frequency on the basis of the environment, but the continuous frequency

Fig. 6 A 41-year-old woman. **a** Preoperative view. **b** View after a 6-month follow-up period. Trochanteric, gluteal and subgluteal region, and inner aspect of the thigh were treated

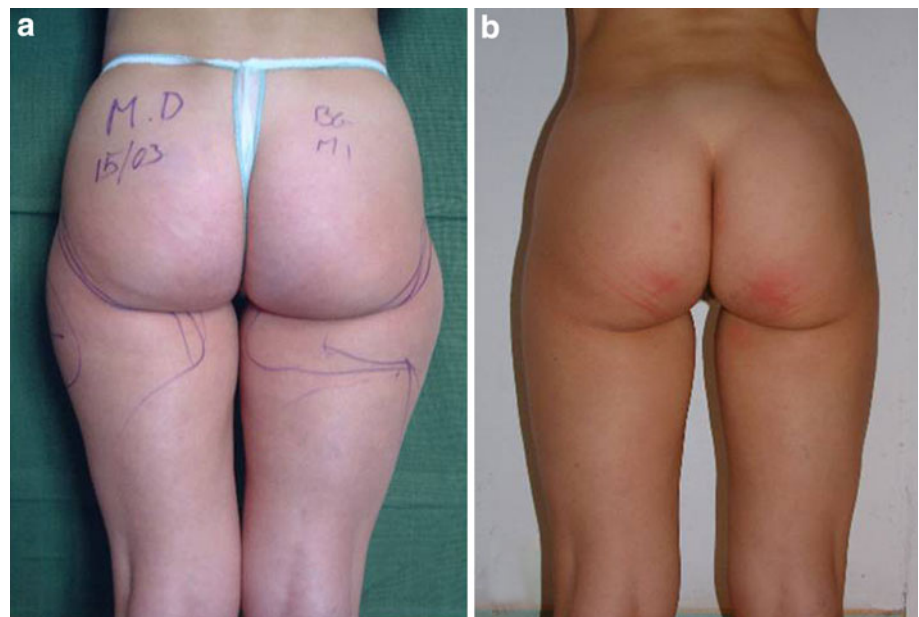


Table 7 Distribution of treated areas, relative lipoaspirate range, and sonication length

Anatomic region	M	F	Total	Lipoaspirate range (ml)	Sonication length (min)
Trunk	112	201	313		
Superior abdomen/breast				300–1,400	3–10
Inferior abdomen				150–700	1–6
Dorsum/flank				300–900	3–8
Pelvic girdle	5	318	323		
Trochanteric				700–1,400	7–10
Inner thigh				200–700	2–6
Gluteal region				250–850	2–8
Knee		92	92	100–500	1–3
Thorax	33		33	200–400	2–4
Chin	7	15	22	30–100	0.5–1
Upper limb		71	71	150–600	2–4
Total	157	697	854		

Table 8 Patient opinion

Valuation	Patients (n)	%
Excellent	239	30
Good	375	47
Moderate	159	20
Poor	24	3

Table 9 Complications

Complication	Patients (n)	%
Seroma	15	1.7
Burning of surgical access	14	1.6
Asymmetry	76	9
Thrombophlebitis	1	0.1

adjustment during the treatment is fundamental because less than perfect tissue infiltration, draining of solution, and an increase in temperature influence the environment and reduce the efficacy of ultrasound. The environmental parameters change during ultrasound administration. Due to the lymphatic drain, the amount of fluid infiltration

decreases, and fat acids and triglycerides increase due to adipose cell destruction.

Under these conditions, the tissue impedance decreases and reduces the selectivity of ultrasound for adipose tissue. By maintaining the better frequency during treatment, the new technology concentrates the entire ultrasound energy

on the adipose cells, thus reducing the sonication time, minimizing the thermal effect on the cutaneous deeper layer and maximizing the lipoclastic effect.

In the early cases, managed without insertion of the drain, seromas developed. At the beginning of our experience, we tried to use treatment of obese patients that allowed a better evaluation of treatment effectiveness. However, extracting more than 2,500 ml of lipoaspirate caused persistent edema and a high risk of seroma. As our experimental study demonstrates, the overall effects of ultrasound irradiation do not appear immediately after treatment but persist over time and are significantly more relevant 18 h from the end of ultrasound irradiation.

As the data for our series show, the average diameter reduction during the follow-up period was greatest 24 h after surgery (Fig. 2). These findings led us to position a drain to avoid seroma formation in cases of extensive liposuction, with theoretical aspirate exceeding 1,000 ml.

Leaving the skin incision open allows the postoperative outflow of residual emulsification, which continues for 2 days. When we closed the surgical access, persistent edema appeared, and persisting pain was present until the edema disappeared.

We are not in agreement with some authors who do not perform fat aspiration after sonication because they believe that the combination of UAL with suction-assisted liposuction (SAL) would diminish the benefit of UAL tissue selectivity, thus affirming that the results of these combined procedures are similar to those of SAL alone [5, 8, 15]. It is our opinion that the use of a third-generation device, or rather the use of solid probes, is to be preferred despite the use of a sonic perforated cannula with the older device because simultaneous ultrasound administration and liposuction extraction lead to reduction of free fluid in adipose tissue, reducing the ultrasound propagation and consequently the efficacy of the treatment.

The use of the third-generation device did not require a particular learning curve. In our opinion, five procedures are sufficient for an expert surgeon in traditional liposuction to achieve complete procedure control. The surgical procedure did not remain the same, but rather evolved, especially at the beginning of the study. The modification of ultrasound probes played the main role during procedure evolution. After 2 years of using this technology, we suggest that the probe architecture of the device should be modified.

The old-generation probes were reduced in diameter along their length to concentrate and accelerate the ultrasound energy. The large probe had a maximum diameter of 6.5 mm and a diameter of 4.2 mm at the tip. During clinical and experimental use of these probes, we noted that they had a temperature increase at the points and transmitted the increase to surrounding tissue. The reduced

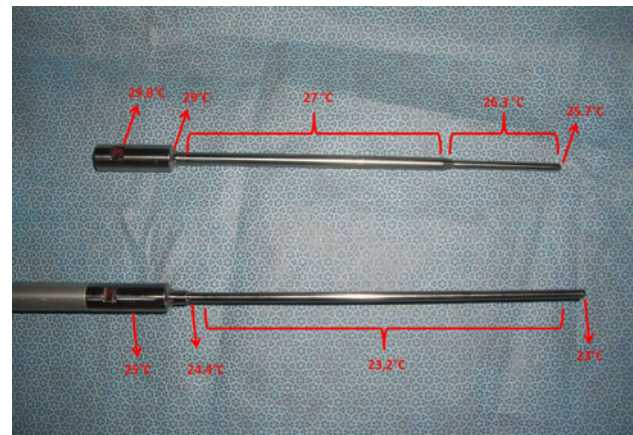


Fig. 7 Probe temperatures estimated by a thermocouple at a room temperature of 22 °C. The upper panel shows the old-generation probe

diameter, proximal to the handle, reached high temperature and damaged the skin near the surgical access point. To avoid this effect in early cases using the older-generation cannula, we used a silicon protective trocar, which necessitated a 10-mm skin incision. Therefore, we currently prefer to keep the surrounding skin wet to avoid using the skin protector device.

The new-generation probes have only one diameter reduction in a place that does not contact the skin during the procedure. These probes, which have a constant diameter, stay cold during treatment and maintain a lower temperature along all of their length (Fig. 7).

The introduction of the new-probe profile eliminated thermal injury to the skin. All cases of burning the surgical access reported in this study were observed using the old-generation probes. The lack of a diameter transition zone reduces the friction injury on the skin, thus improving the skin-healing quality. No hyperchromic scars have been observed.

The high effectiveness of the new-generation probe allows us to reduce the ultrasound administration time and the secondary damage to surrounding tissue, thus allowing us to avoid trocar positioning or keeping the surrounding skin wet.

To have a better control of the results and to avoid an excessive reduction of fat thickness, we prefer to begin the treatment from the deeper layer with slow fan-shape movements and gradually move toward the superficial level. As reported in the literature, leaving 10- to 15-mm of adipose tissue guarantees a high degree of safety from skin irregularity and prevents thermal injury [10, 13].

Also, the length of treatment is an important parameter to consider during surgery. Excessive sonication does not improve the result, and there may be a risk of excessive fat removal or damage to surrounding tissue. In our opinion, the ideal treatment time may be about 8 to 10 min for large

areas such as the abdomen or the trochanteric region, with a shorter time used for narrow areas such as the inner aspect of the upper limb or knee. According to Millán and Vaquero [13] and Tebbetts [18], the appropriate energy application per 100 ml of estimated total aspirate is 1 min.

The average times required for ultrasound administration related to the anatomic area are reported in Table 7. Our values are similar to those reported by Millán and Vaquero [13] but shorter than those previously reported by Perez and Tetering [15] and Graf et al. [6].

To achieve good retraction, it is important to treat the superficial part of fat tissue differently than in traditional superficial liposuction, which stimulates collagen contraction by direct mechanical action of the cannula on the dermis. In UAL liposuction, the ultrasound energy and the thermal effect stimulate collagen shrinkage, as confirmed by experimental study [14].

Ultrasound energy is known to propagate better in a wet environment, so before sonication, Klein solution is administered. Numerous proportions of fluid infiltration and lipoaspirate are reported in the literature. In numerous studies, the tumescent proportion (more than 2:1) is preferred, and we used it in our early experience [6, 15]. According Millán and Vaquero [13], tumescent infiltration does not allow optimal skin palpation. To avoid this inconvenience, we try to perform UAL using a superwet infiltration (2:1) [16].

We accepted the fact that ultrasound needs a wet environment to act, but we progressively reduced it in the wet ratio (1:1). No changes in the functional aspect were apparent, but we noticed clinical and technical advantages, including reduced distortion of the area due to infiltration and reduced postoperative swelling [6].

In our series, 12 % ($n = 97$) of the patients underwent secondary liposuction, and there were 32 cases of gynecomastia. It is well known that the treatment of these conditions may be difficult due the strong tissue adherence that leads the surgeon to use a more aggressive cannula (e.g., the Mercedes or swallowtail cannula), which increases bleeding, the risk of tissue damage, and operator fatigue.

The introduction of ultrasound in liposuction allows easy treatment of these patients due to ultrasound action on fibrous areas, which removes the adherence. Despite the effectiveness of the continuous mode, to increase the ultrasound effect, our ultrasound generator can work using a pulsed mode. With this method, every pulse starts with the maximum energy power, increasing tissue emulsification.

We have had a number of excellent and good results. Optimal results are intimately linked with a standardized protocol and accurate patient selection. We emphasize that the high percentage of poor results (8 %) were included, in which the patients experienced complications or required a

second and third procedure to achieve the result. According to our patients' opinions, the percentage of satisfaction was higher than indicated by our outcome scale. We think this may be the result of the high emotional impact that the body-contouring anomalies have on the patients' lives. As a result, they tend to overestimate their satisfaction and are less critical of the results.

We emphasize the problem of evaluating ultrasound in skin retraction. In our study, we were obligated to choose a clinical parameter that is difficult to standardize, such as the increase in skin tightening or the modification of cutaneous folds. We actually began an experimental study to clarify the effect of ultrasound on collagen shrinkage in order to obtain a reproducible instrument for estimating skin retraction after ultrasound.

Postoperative dressing is important. To increase the tissue lift, we place an elastic dressing that follows the theoretical tissue movement during the healing process. Care must be taken in positioning the dressing because an overlapping edge or excessive tension may cause healing irregularities such as skin depression. Outside this dressing in our series, a compressive girdle was worn to reduce the dead space. The inner part of the dressing remained in place for 10 postoperative days, and the girdle was worn for 30–40 days.

We recorded 29 % of the complications in our experience. The most frequent complication was seroma. This untoward effect was frequent in early cases when we did not know the mechanism of interaction between ultrasound and adipose tissue. In fact, as demonstrated in the literature, the effects of ultrasound continue until 18 h after the end of treatment [14].

Ultrasound energy causes the reduction of fat mass through two different means: immediate and delayed. The first means is linked to the mechanical action of ultrasound jointly with the direct action of the probe. The much more interesting action is delayed fat reduction due to cell apoptosis resulting from activation of the caspase cascade by ultrasound. This phenomenon continued during the 24 h after surgery (Fig. 2) [14]. In this regard, parallel to improvement of results, in extensive liposuction, a retarded lipolysis caused an accumulation of free lipids and fat acids, triggering an inflammatory and edemagenic reaction.

Skin burns of surgical access were reduced using a protective trocar and totally disappeared with introduction of a new-generation probe. Only one major complication occurred, a case of superficial thrombophlebitis. To receive liposuction as soon as possible, the patient did not suspend intake of oral contraceptives and voluntarily hid this information. During the treatment, no adverse signs were evident, and the patient was discharged. After 5 h, the patient experienced onset of burning pain and swelling of the left lower limb. The patient was urgently readmitted to

our department and received appropriate diagnosis and therapy.

This finding underscores the importance of patient consensus for the surgery, and the anamnestic interview is essential to identify the reality of the patient's wishes and to establish the possibility of satisfying them. An excessively hasty patient who wishes to receive surgery quickly should be treated with caution.

Conclusions

In body contour improvement, UAL is an essential procedure, and despite its effectiveness, numerous complications can occur, especially in early cases. The introduction of multifrequency UAL, or rather, the possibility of using a better working frequency during the treatment, allows better results. The diffusion of the cold probe reduces the possibility of thermal injury, allowing the surgeon to treat superficial tissue layers safely and improve patient outcome. We conclude by reporting our agreement with the conclusion of Kenkel et al. [9], who clarified the safety of this technology for patients, surgeons, and operating room personnel.

Conflict of interest None.

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