29 The Clinical Applications of Multifrequency Ultrasound Technology in Body Reshaping

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Abstract

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. US alters adipose tissue through micromechanical disruption and cavitation with minimal thermal effect. The cavitational effect is a dynamic phenomenon, triggered by the accomplishment of resonance frequency of cell membrane. Resonance frequency is dependent on the kind of tissue and surrounding environment characteristics that usually change continually during treatment. To use the better frequency in all conditions and to maintain the maximum effectiveness, the MAUL technology was introduced. This new technology uses last-generation microchips to determine the best resonance frequency every 10 s by measuring tissue humidity and impedance. By maintaining the better frequency during treatment, the new technology concentrates the entire ultrasound energy on the adipose cells minimizing the thermal effect on the cutaneous deeper layer and maximizing the lipoclastic effect.

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29.1 Introduction

Sound wave is the result of a sequence of compressions and decompressions through a medium (gaseous, solid, or liquid). This definition encloses the base of sound traveling, that is, the presence of a substance lets the wave propagation (Fig. 29.1) [1]. According to its frequency, the sound spectrum can be divided into audible, infrasound, and ultrasound (Fig. 29.2) [1]. The infrasound frequencies are felt as vibrations by a body, whereas the ultrasound cannot be perceived by the human ear [1–3].

Infrasound has a few clinical applications, e.g., kidney stones or tendon disease treatment [4–7]. Ultrasound waves are generally applied in diagnostic procedures due to the absence of interactions with biological tissues; the discovery of particular wavelengths having the ability to interact with them, thus activating collagen metabolism or inducing cell apoptosis, led to the use of ultrasounds as therapeutic tool [4–7]. Ultrasounds in plastic surgery are generally applied to destroy the adipose tissue during body reshaping [8–11].

Their use in liposuction began with Kloehn [12, 13] who introduced a harmonic probe for administering sound energy to the fat tissue. Then, several machines have been commercialized but most of them had a high complication rate.

Zocchi and Maxwell [9, 14] designed the second generation of ultrasound generators providing a solution to the extended time needed with the old device. The new technology used a cannula which, while being a solid probe, provided ultrasound energy and suction at the same time. The second-generation cannulas were more manageable but they presented a not negligible risk to damage the skin [8, 9, 14]. In fact, as the power of ultrasounds in those devices was related to cannula dimension, it was necessary to use large cannulas to reach an effective energy even if this increased the mechanical and thermal damage to surrounding tissue [15].

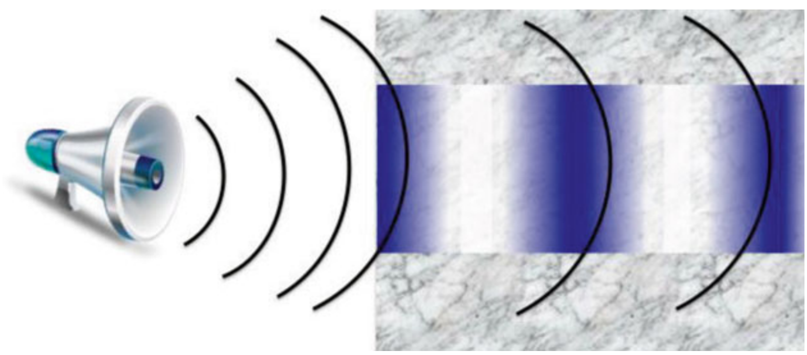

Fig. 29.1 Sound propagation through a solid medium. In *blue* the phenomenon of compression and decompression of molecules at the base of sound traveling

Fig. 29.2 Classification of sound wave according to its frequency

The last generation of US devices has been introduced and uses again a solid probe, but the new materials and technology increased the selectivity for adipose tissue improving the effectiveness and reducing the risk of skin damage [8, 16].

The ultrasound energy, generated by these probes, induces adipocyte destruction through the cavitational effect. The oil and the fatty acid released by cells are drained away or caught out by phagocytes. Suction with traditional cannulas could be also performed, if a quick result would be achieved.

29.2 Physics of Ultrasound Wave

Ultrasound (US) is a sound wave with a frequency higher than 20 KHz that, in presence of a medium, is transmitted from one molecule to the next [1]. The characteristics at the base of US are:

1. Wavelength (λ) is the distance between two consecutive wave peaks and derives from the rapport of propagation speed and frequency ($\lambda = v/f$) (Fig. 29.3).
2. The frequency (f) is the number of cycles of compression and rarefaction repeated every second in a specific point of the conduction medium. According to their frequency, ultrasound can be divided into three categories: low frequency between 20 and 100 KHz, medium frequency among 100 KHz and 1 MHz, and high frequency up to 10 MHz.
3. Propagation speed ($v = \lambda \times f$) depends on the conduction medium. In biological tissues, it is about 1500 m/s with the exception of the bone tissue (3360 m/s).
4. Attenuation is the amount of lost energy passing through a medium. This is due to two physical phenomena, absorption and dispersion. In soft tissues, 80 % of attenuation is caused by absorption (Fig. 29.4).

In front of these wide possibilities, which should be the frequency to choose? What is the frequency that has the deeper penetration (δ)? The theoretical physics provides the answer to these questions. Considering the same number of cycle wavelength, low-frequency ultrasound penetrates deeper than the high-frequency ultrasound. Theoretically, using a single wave cycle so that the phenomenon of attenuation is excluded, the penetration depth is equal to the wavelength $\lambda = \upsilon/\nu$. The amount of energy that reaches a specific site depends on the US characteristics and the tissues it travels through. So, at higher frequencies, the sound beam will have less sound energy available to propagate through a tissue since more energy is absorbed (Fig. 29.5) [16].

29.3 US and Adipose Tissue Interaction

US alters adipose tissue through micromechanical disruption and cavitation with minimal thermal effect [13, 17, 18]. Thermic effect is due to

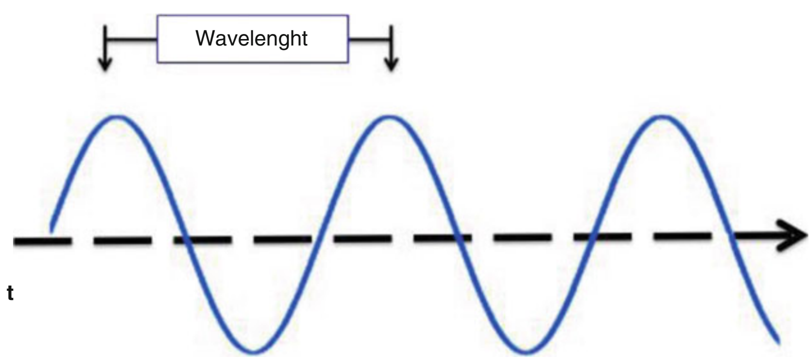

Fig. 29.3 Definition of wavelength: the distance between two consecutive wave peaks

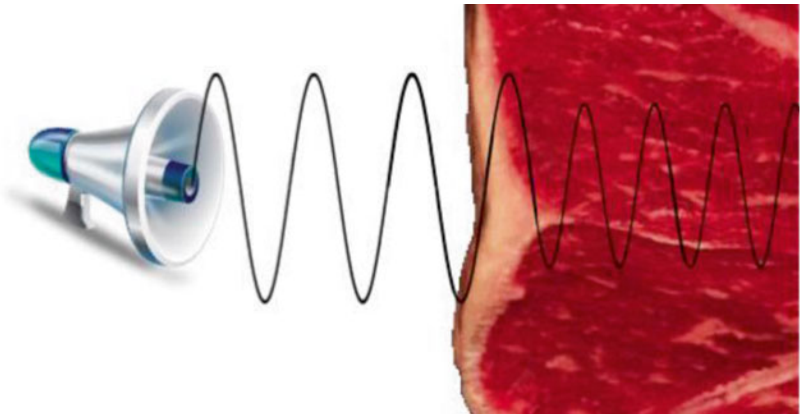

Fig. 29.4 Phenomenon of attenuation. Ultrasound loss of energy traveling through a medium. Soft tissue adsorbs 80 % of the energy

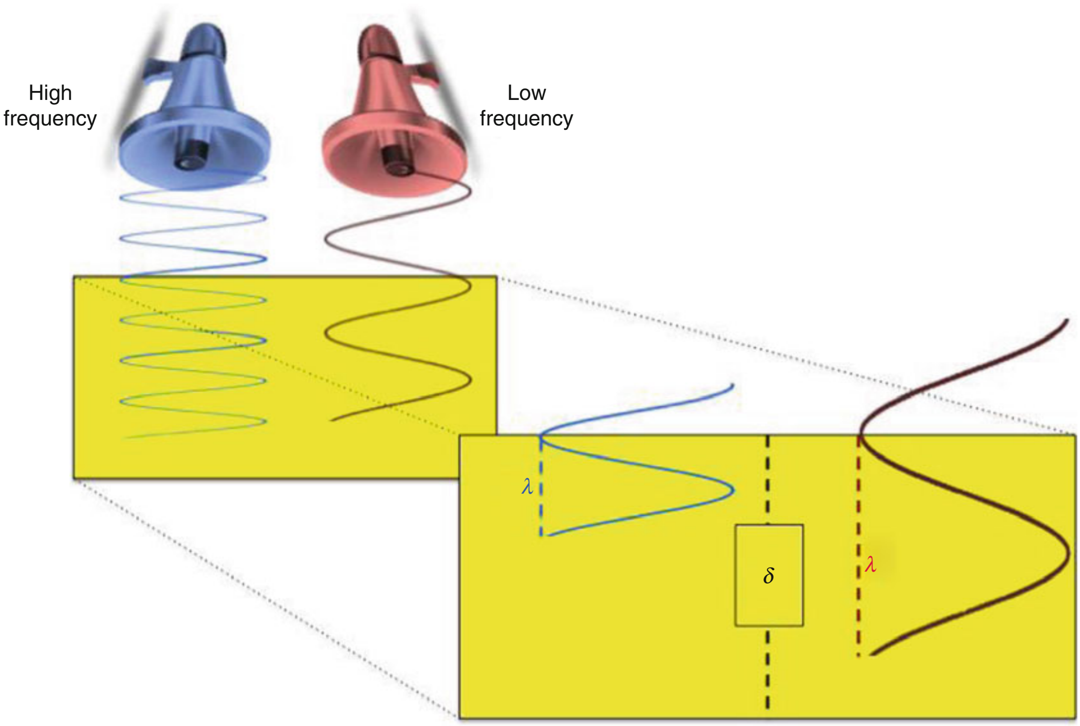

Fig. 29.5 The different penetrations of high-frequency (*blue*) and low-frequency (*brown*) ultrasound. In the *right square* the experimental condition to explain why low frequency penetrates deeper than high. Considering only one wave cycle, in order to exclude the attenuation, the penetration is equal to the wavelength ($\delta = \lambda$)

the increase in molecular kinetic energy: by Joule's law, the potential energy of moving electric charges is partly released as heat with consequent increase in temperature of the treated material. Mechanical effect is linked to the compression and decompression of biological membrane under wave action.

Cavitational effect, by causing microcavities in the adipose tissue with consequent cell destruction and fat liquefaction, is considered the most important mechanism through which US causes tissue disruption, even though the micromechanical effect produced directly by the action of the ultrasonic waves on organic molecules should also be considered [13, 16, 19]. Cavitation refers to the oscillatory activity of vapor-filled bubbles and produces important cell fragmentation and diffusion of the lipid material through the intercellular space (Fig. 29.6) [13, 16, 19]. Of note, the cavitational effect is not extinguished immediately after treatment's end, leading to a progressive destruction of adipose cells [16]. It was also shown that as ultrasound induces the activation of cell apoptosis cascade which could be responsible of the prolonged lipoclastic effect [16].

29.4 What about Multifrequency Technology

The cavitational effect is a dynamic phenomenon, triggered by the accomplishment of resonance frequency of cell membrane [8, 16]. Resonance frequency is dependent on kind of tissue and surrounding environment characteristics (e.g., temperature and moisture).

Numerous available devices can work with different frequencies, but no one can modulate the frequency during the procedure. Of note, the initial device setting allows the ultrasound generator to choose the best frequency on the basis of the environment. A continuous frequency adjustment during the treatment is indeed fundamental because the environmental parameters change continually 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. To use the better frequency in all conditions and to maintain the maximum effectiveness, a new technology was introduced. This new technology uses last-generation microchips to determine the best resonance frequency every 10 s by measuring tissue humidity and impedance [8, 16].

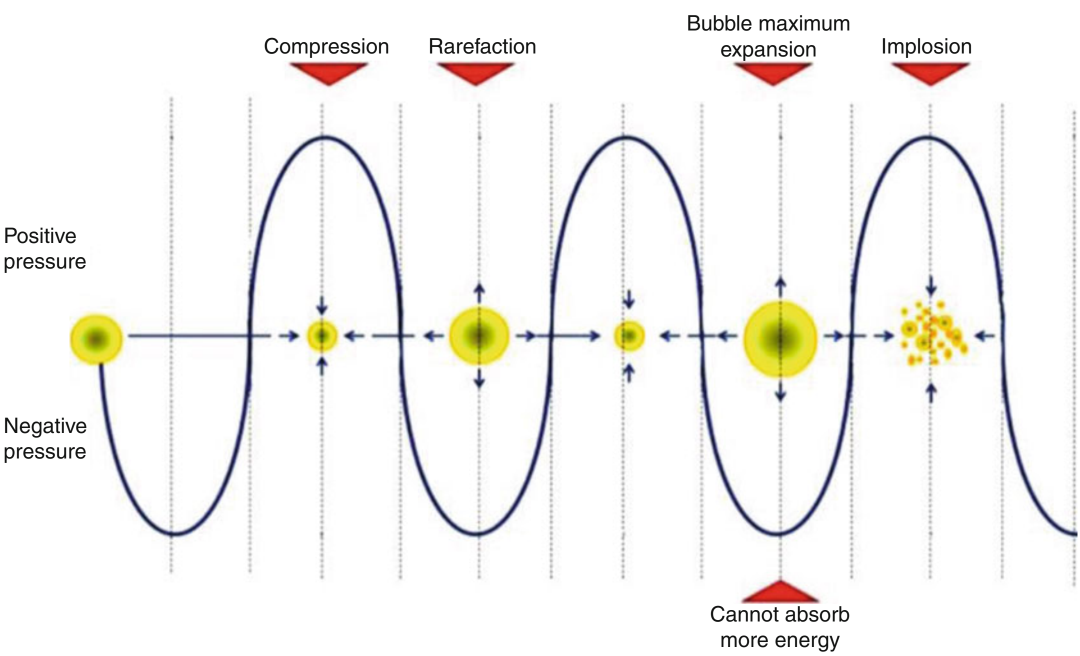

Fig. 29.6 The cavitation phenomenon. According to the wave phases, adipocyte membranes were compressed and decompressed; this causes an increase in kinetic energy and the formation of steam bubbles until they cannot absorb more energy, leading to a cell implosion

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.

The ultrasound device (Microlipocavitation, Lain Electronic S.R.L., Milan, 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 US (37.2–42.2 kHz).

29.5 Clinical Practice

The multifrequency technology can be used in a lot of conditions: localized fat deposit, defect contour, massive liposuction, orange peel, pannicolopatia edemato-fibro-sclerotica (PEFS), and skin tone loss are the principal indications. Modulating the amount of administered energy and the kind of handpiece as well, all of those can be treated. In fact US energy can be administered in different ways according to the clinical features of defect target by a surgical probe or transcutaneous handpiece.

There are few criteria at the base of this methodology guiding the machine setup. Tissue tone and the defect extension are the most important. Tissue texture has to be checked because fibrotic area or organized edema should be treated in pulsed mode. The mechanical effect reaches the peak at the beginning of the cycle, and then the effect of shock wave is progressively reduced until the resonance frequency is reached. Mechanical effect acts more on fibrous than on adipose tissue where the continuous mode is more indicated. An accurate examination has to be done on tissue tone. Skin tightening is more achievable by a surgical probe than a transcutaneous treatment because the effect on deeper structures is higher.

The transcutaneous probe is useful to treat wide and superficial defect or small localized fat deposits.

There are a few contraindications to ultrasound treatment: medical conditions such as coagulative disturbances, in both ways hyper- or hypocoagulation, anomalies in lipid metabolism, or cardiac implantations (pacemaker, defibrillator) are considered absolute contraindications. Whereas hearing prosthesis or other metal implantations could be considered as relative.

29.6 Surgical Application

In the United States, UAL developed mainstream popularity during the mid- to late 1990s after several years of development and application in Europe and South America [9]. 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 [9] basic rules of UAL are (1) never apply ultrasonic energy to dry tissue and (2) never apply ultrasonic energy without probe movement [20].

It is postulated that the energy of ultrasound will have a minimal effect on intervening connective tissue and other structures (Fig. 29.7). The safety and efficacy of the method have been shown in several papers [14, 21].

The introduction of multifrequency technology improves the selectivity of ultrasound for adipose tissue, and the construction of new harmonic probes that stay cooled during the sonication reduced the surrounding tissue damage. The first multifrequency probe had a maximum diameter of 6.5 mm and a diameter of 4.2 mm at the tip. The probes of multifrequency are made in titanium present diameter reduction along their length in order to concentrate and accelerate the ultrasound energy.

During clinical and experimental use of these probes, the authors noted that they had a temperature increase at those points and transmitted heat to surrounding tissue. The reduced 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, a silicon protective tro-

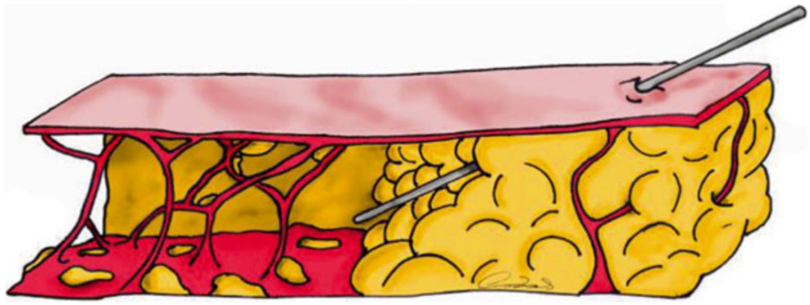

Fig. 29.7 A drowning of MUAL surgical probe function liquefying fat tissue without damaging the other structures

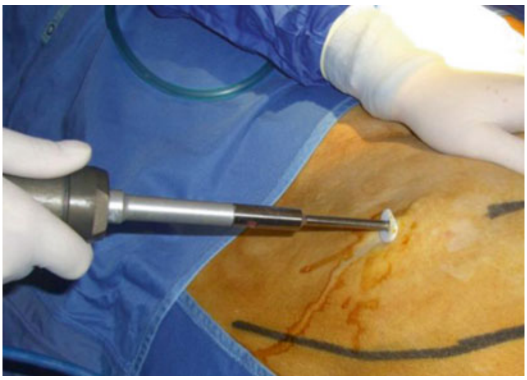

Fig. 29.8 The old MUAL probes were hotter than newer damaging the surrounding tissue. In order to protect the skin, a trocar was placed before sonication

car is used, which necessitated a 10-mm skin incision (Fig. 29.8).

In the new probes, the larger diameter has been reduced in the area which has no contact with the skin during the procedure. These probes, which now have a constant diameter, stay cold during treatment and maintain a lower temperature along all of their length (Fig. 29.9). The introduction of the new probe profile eliminated thermal injury to the skin. The lack of a diameter transition zone reduces the friction injury on the skin, thus improving the skin-healing quality. 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.

29.7 Indications and Contraindications

Multifrequency ultrasound-assisted liposuction (MUAL) can be used to treat several problems such as diffuse fat deposit or body reshaping. After an initial period in which the authors treated any kind of obesity, the limit to BMI was moved to 30 because liposuction in general cannot be considered an instrument to weight loss. Other contraindications are the same as those of the other surgical procedures and are reported in Table 29.1.

29.8 Surgical Procedure

29.8.1 Preoperative Planning

The patient must stand in order to identify contour defects; the areas have to be sonicated or those where the probe should be used switched off should be highlighted. Volume defects to be filled are identified. In those cases, according to the amount of tissue lack, a part of lipoaspirate extracted was not exposed to ultrasound.

29.8.2 Cavitation Effect and Infiltration

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

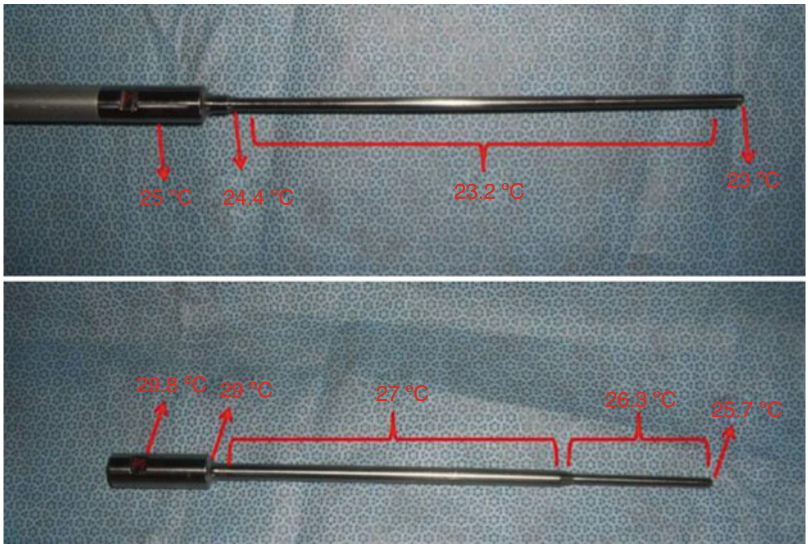

Fig. 29.9 MUAL probes (the upper is the new generation) with their temperature measured by a thermocouple after 20 min in ambient air. The new generation shows a lower and more constant temperature

Table 29.1 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 Pittsburgh Weight Loss Deformity Scale)
Internal metallic prostheses
Previous oncologic breast treatment
Suspicion of adipose neoformation such as lipoma
Pregnancy
Coagulation diseases
Active inflammation process

adipose tissue with saline infiltration can lower the impedance value even further [20]. The result is a high degree of selectivity for fat cells, thus reducing blood loss, postoperative edema, and ecchymosis and avoiding contour irregularities.

Ultrasound energy is known to propagate better in a wet environment, so before sonication, Klein's 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 the authors used it in their early experience [13, 20].

According to Millàn Mateo and Vaquero Pérez [22], tumescent infiltration does not allow optimal skin palpation. So UAL is performed using a super-wet technique. Ultrasound needs a wet environment to act, but the authors progressively reduced to the wet ratio of 1:1. No changes in the functional aspect were apparent, but clinical and technical advantages were observed, including reduced distortion of the area due to infiltration and reduced postoperative swelling [13].

29.8.3 Surgical Time

After infiltration is administrated, the appropriate probe according to the defect width is introduced under the skin. The sonication is activated and the probe is passed forward and backward in wide fan-shape movements. The vectors' orientation follows the principles of traditional liposuction (Fig. 29.10). Generally the treatment is begun from the deeper layers to the dermis plane. In fibrous area such as the male chest, dorsum or secondary treatment the ultrasound is supplied in pulsated way.

The average sonication time is 10 min each area. Is easy to get small districts like the inner aspect of the knee requires shorter time, whereas the abdomen needs more time to be treated. After the sonication is over, the fat emulsion is aspirated through a 3 mm blunt cannula connected to a vacuum (−80 mmHg). It reduces the inflammation triggered by the cell destruction.

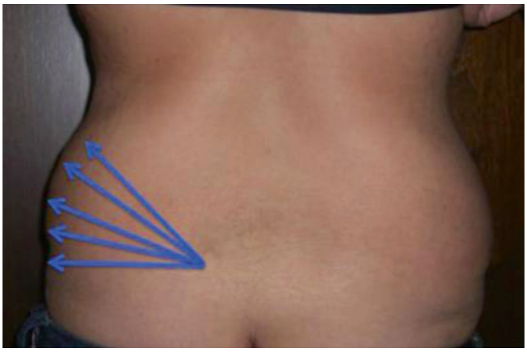

Fig. 29.10 How to administer ultrasound energy to the tissues by fan-shape (*blue arrows*) movements starting from the deeper layer to the dermis

After the authors had demonstrated in laboratory that the cavitation causes the apoptosis that carries to a tardive release of oil and cell debris [16], a suction drain is placed through the same incision every time the amount of lipoaspirate is more than 1000 mL. The device remains inserted until the amount of fluid is less than 30 mL per day. On the other hand, when the lipoaspirate is less than 1000 mL, the surgical access is left open to let the spontaneous evacuation of fluid.

After a treatment a compressive girdle is worn for 30 days. The compression encloses the treated and contiguous anatomic areas in order to have a more homogeneous cutaneous distribution during the healing process.

29.8.4 Postoperative Treatment and Patient's Activities Restarted

In massive liposuction (more than 2000 mL of aspirate) conducted under general anesthesia, fluids are given during the 24 postoperative hours in order to balance the equilibrium with the surgical loss. The patient's mobilization begins the following morning and then they return to their daily activities. Sporting activity is progressively restarted after 2 weeks.

In small liposuction performed with local anesthetic, no fluids are administered and patients do not interrupt their activities. Every patient receives heparin according to their own weight for 15 days, and wide spectrum antibiotics are administered during the 5 succeeding days.

29.9 Case 1 (Fig. 29.11)

This 29-year-old woman with optimal skin tone and texture had MUAL of the abdomen, flanks, and inner thighs. All creases were treated in continuous mode, flanks and thighs were sonicated for 10 min each, whereas the abdomen was sonicated for 15 min.

29.10 Case 2 (Fig. 29.12)

A 36-year-old man with good skin tone and texture received pulsed MUAL of the chest and upper part of the abdomen. Lower abdomen and flanks were treated in continuous mode 10 min each.

29.11 Case 3 (Fig. 29.13)

This 35-year-old woman received MUAL for fat deposits of the abdomen, knees, and trochanteric areas. Knees were treated in pulsed mode, whereas continuous supply was preferred for the others.

29.12 Case 4 (Fig. 29.14)

A 41-year-old man had fat deposits localized on the back and at the flanks. The back received a pulsated MUAL treatment.

29.13 Transcutaneous Ultrasound Treatment

Nowadays the noninvasive treatment for fat tissue has become the most requested among the outpatient procedures. The possibility to improve the body contour without risk and downtime allows the diffusion of this technology. The low-frequency transcutaneous ultrasound hits the adipose layer without skin damage (Fig. 29.15).

Fig. 29.11 (*Left*) Preoperative. (*Right*) Postoperative

Fig. 29.12 (**a**) Preoperative. (**b**) Postoperative

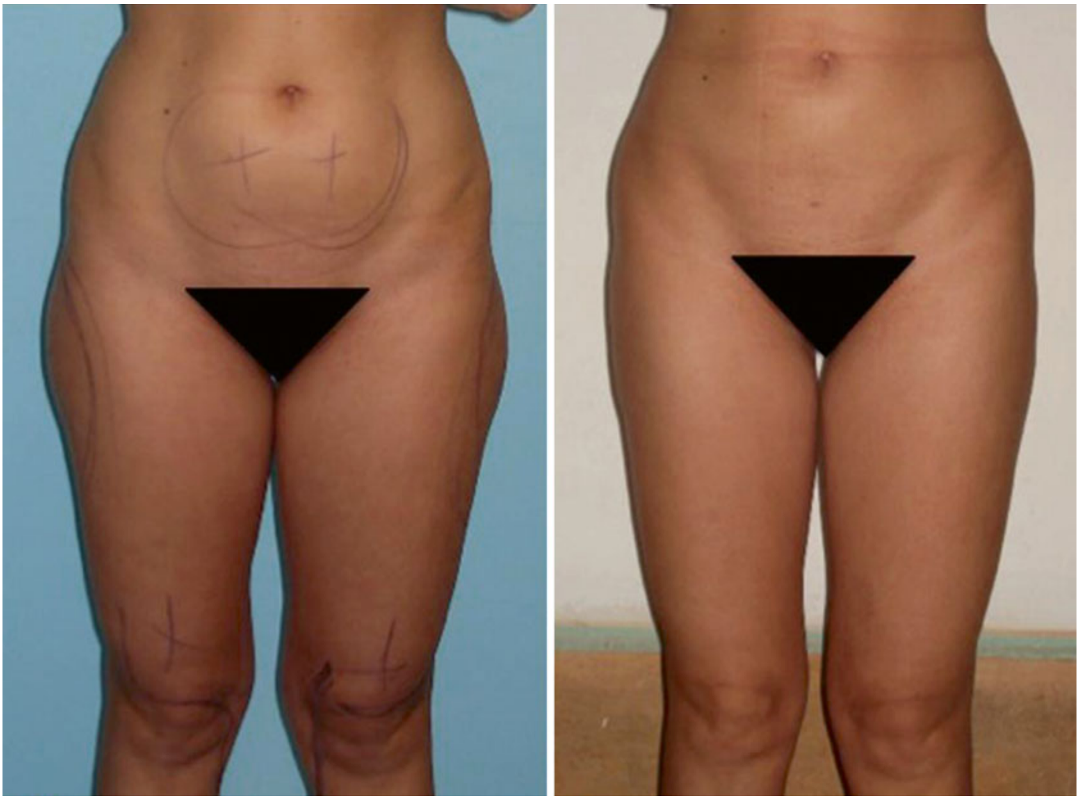

Fig. 29.13 (*Left*) Preoperative. (*Right*) Postoperative

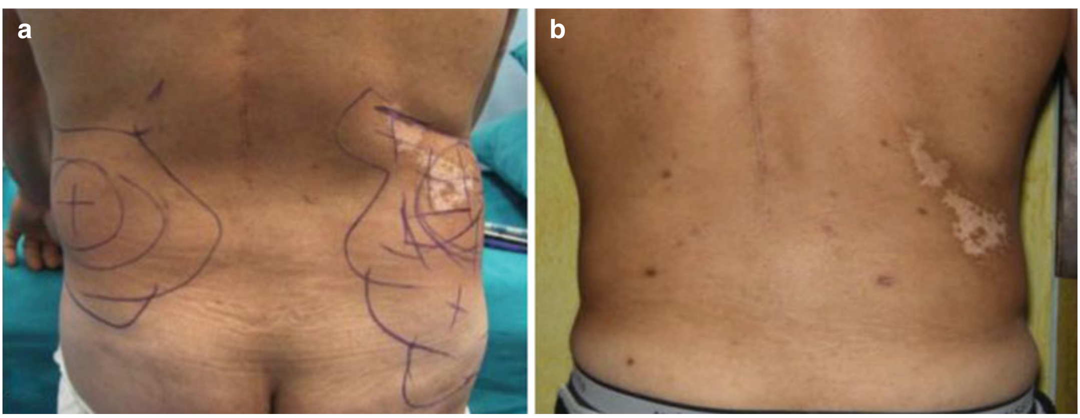

Fig. 29.14 (**a**) Preoperative. (**b**) Postoperative

That technology uses a different probe according to the energy intensity to administrate the ultrasound energy. The large probe provides the lowest energy intensity; the smaller gives the same energy amount of the bigger but through a small operative surface traducing it in a higher intensity (Fig. 29.16).

The effects of cavitation begin immediately after treatment and due to the triggering for the apoptosis continue during the following days.

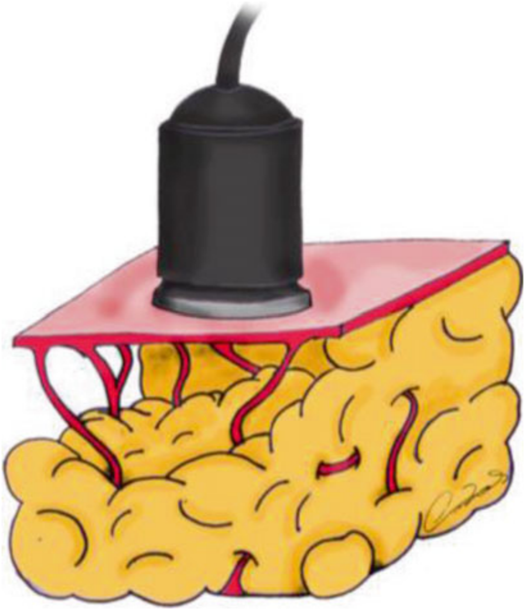

Fig. 29.15 A drowning of MUAL external probe function liquefying the subcutaneous fat without damaging the cutaneous structures

Fig. 29.16 MUAL external probes. All probes can administer the same amount of energy, but the small one (on the *left-hand side*) having a smaller active surface achieves a higher intensity

Clinically the effect is appreciable after two sessions by an improvement of skin texture or fluid retention as well, but to achieve a contour modification, more sessions are necessary.

29.13.1 Clinical Indication

The treatments of diffuse and superficial defects are the main indications for transcutaneous cavitation. Orange peel, PEFS, or skin contour irregularities find a solution in this technology, and also fluid retention can be approached; localized adiposities for which liposuction could be considered an overtreatment can be removed by external ultrasound.

The authors have tried to treat few small lipomas (<2 cm) with ultrasound, and this destroyed the tumor reducing its consistence; nonetheless recurrence was recorded in all cases where the surgical removal did not follow the sonication. For this reason and to avoid the risk to perform an improper treatment of malignancy, the authors leave off that procedure.

29.13.2 Preoperative Planning and Choice of Probe

With the patient in the upright position, the defect is highlighted and marked. It is important to treat bilaterally the anatomic areas stressing if some asymmetries are present. Normally six areas are treated with each session just to not prolong treatment length.

During the planning the fibrous area is marked where pulsed mode should be preferred. Generally the high-intensity probe is used where adipose tissue is more compact such as the inner aspect of the knee or trochanteric regions. That probe is indicated to treat localized fat deposit. The abdomen, inner aspect of the thighs, and gluteal region are treated with lower-intensity probe.

Although the cooled probe (max temperature 23 °C), the friction with skin could increase the temperature becoming intolerable for patients; ultrasound gel is applied on the skin allowing to better transmit the waves and lubricating and keeping cool the tissue.

29.13.3 The Procedure

As routine, the skin surface is cleaned with thermal water in order to remove some residue of cosmetic products. After an appropriate amount of ultrasonic gel is applied on the skin, the treatment starts.

The treatment is begun by setting the machines at 80 % of power and then increasing it until the highest tolerable energy for the patient is reached. Some patients prefer not hearing tinnitus that might be uncomfortable. Generally a sonication of 10 min is performed for each marked area stopping the treatment in case the patient feels pain.

Despite the well-documented selectivity of ultrasound for fat, in order to avoid reaching the deeper structure especially in the abdominal region, it is important to maintain oblique the probe on skin surface (Fig. 29.17). During the treatment the probe should be moved in a circular way pinching the skin to maximize the efficacy of US (Fig. 29.18). In that way more fat tissue is reached by ultrasound energy.

After the whole treatment is over, the skin is again cleaned with thermal water to remove the gel and to cool the skin.

Fig. 29.17 The external probe has to be positioned oblique on the skin surface

Fig. 29.18 Pinching the skin the probe has to be moved in a round way

29.13.4 Infiltration and External Ultrasound

The tissue infiltration allows a better ultrasound propagation through the tissue increasing the cavitational effect [16]. The same effects are valid of the external administration of ultrasound. As proved by the experimental study [16], the efficacy of ultrasound is twice in infiltrated tissue. Despite this finding the clinical activity is more complicated: the transcutaneous ultrasound treatment is considered as outpatient clinic procedure, and patients do not tolerate the infiltration procedure especially when they have to return immediately to their daily activity. It is preferred to explain to the patient that the infiltration increases the speed to reach the result, but it can be avoided if more treatments are scheduled.

29.13.5 Posttreatment Advice and Session Scheduling

After treatment no antithrombotic prophylaxis is prescribed. The patient is given some advice like drink more than 2 l of water during the following 2 days and avoid milk containing high quantity of fat. In order to eliminate the released fat and not to create a liver overload, the follow-up sessions are scheduled after 15 days. To achieve a satisfactory result, four to six sessions are appropriate.

29.14 Case 5 (Fig. 29.19)

The 26-year-old woman who had fat deposit at trochanteric area and orange peel had treatment with MUAL.

29.15 Case 6 (Fig. 29.20)

This 37-year-old woman with diffuse orange peel and adipose deposit in trochanteric area had MUAL treatment.

29.16 Case 7 (Fig. 29.21)

A 31-year-old woman with contour deformity at flanks and trochanteric areas had MUAL treatment.

29.17 Combined Treatments

Because of their proved efficacy, the authors have started to use external ultrasound in post-surgical patients. The main indication of post-operative US administration is after body contouring procedure. In those patients the administration of external ultrasound allows to increase the edema absorption reducing the contour irregularity. Furthermore after MUAL liposuction the external US reduces the irregularities and improves the skin tightening (Fig. 29.22).

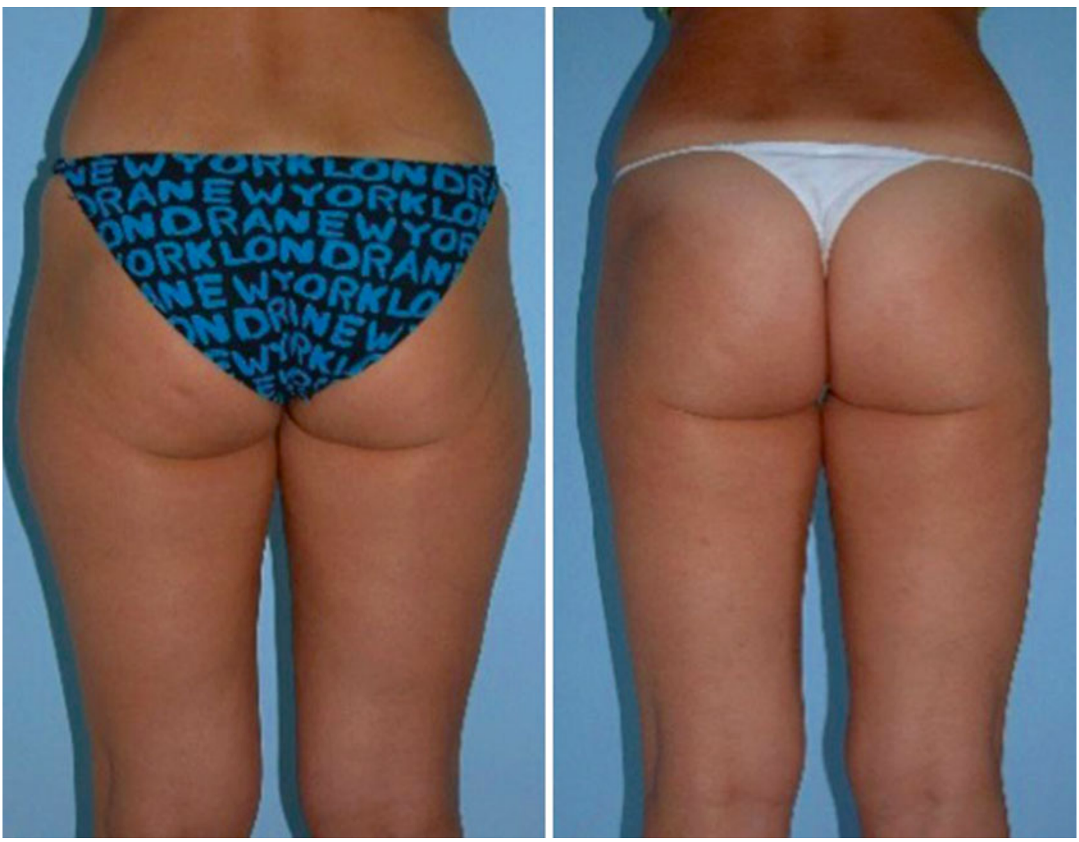

Fig. 29.19 (*Left*) Preoperative. (*Right*) Postoperative

Fig. 29.20 (*Left*) Preoperative. (*Right*) Postoperative

Fig. 29.21 (*Left*) Preoperative. (*Right*) Postoperative

Treatment begins after 10 days when the wound healing is almost complete and the risk of infection is dissolved. Three sessions are scheduled every 10 days.

Conclusions

The fat cavitation triggered by ultrasounds is one of the latest introductions to improve the body contour. It induces an immediate lipolytic

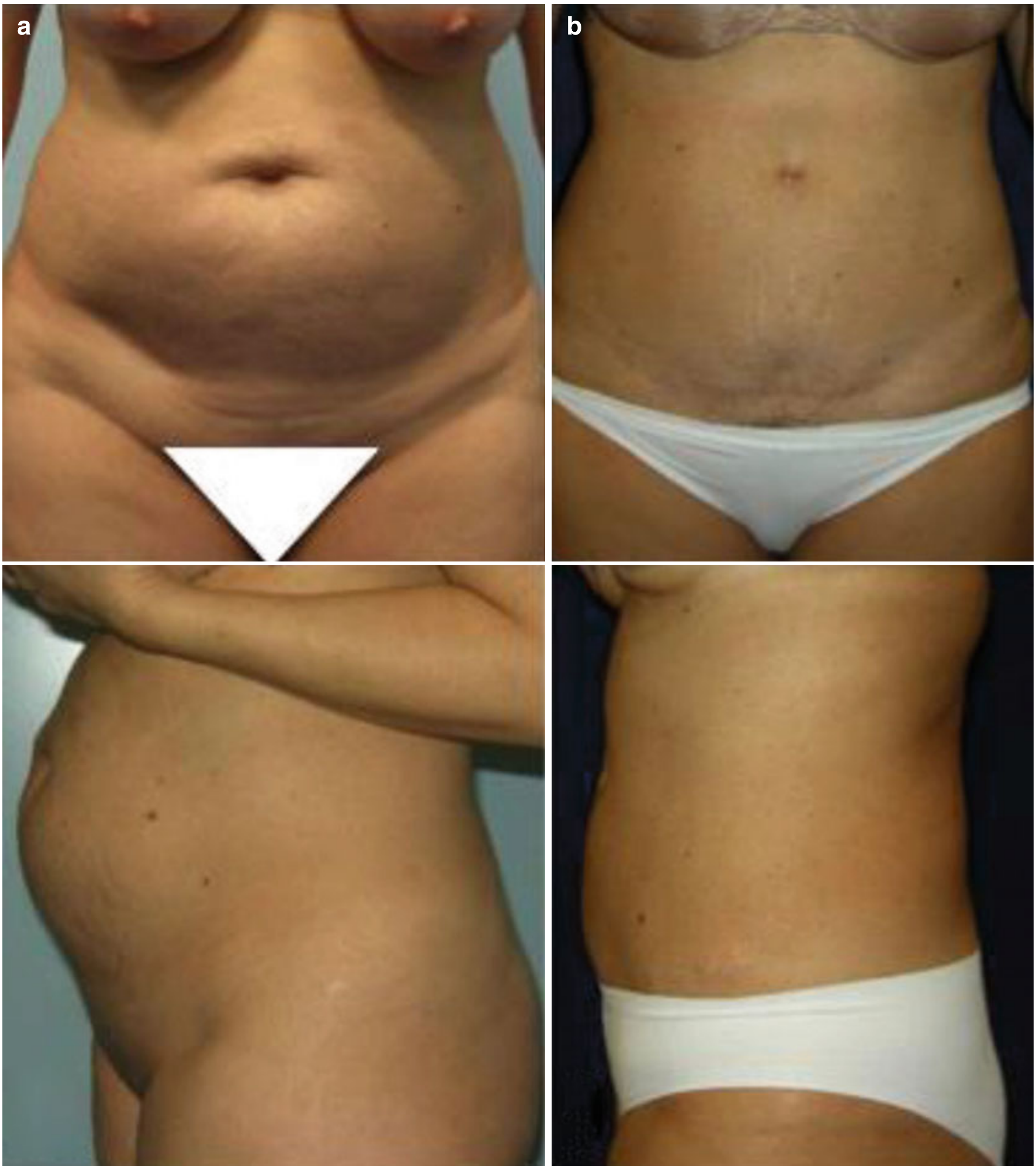

Fig. 29.22 A 42-year-old woman underwent MUAL and abdominoplasty. After 10 days a series of external US are started. (**a**) Preoperative. (**b**) Six months after surgery and three sessions of external US

effect that continues during the following 24–36 h improving the clinical results [16]. When the proper frequency is achieved, the ultrasound has the better selectivity for fat tissue, but changing the environment parameters the selectivity is progressively reduced parallel to its selectivity increasing the risk of surrounding tissue damage.

Multifrequency ultrasound technology keeps the proper resonance frequency during the whole treatment, modulating its setting every 10 s; it allows to maintain the highest selectivity degree for adipose tissue reducing the risk of skin burn. Although transcutaneous probe has a lower energy, requiring more treatments to achieve the result, it is completely tolerable by the patient who does not require downtime and can immediately return to his or her activities. That is the most important thing in a historic period where the requests of less invasive body reshaping are increasing.

The main indication is the orange peel treatment or small contour defect, but its use in the postsurgical patient is useful to reduce the downtime improving the patient outcome. On the other hand, the surgical handpieces are indicated in massive body reshaping where more energy is necessary. The high selectivity of this technology allows to aspirate a great amount of fat reducing the blood loss.

As known, many ultrasonic devices can damage the hand, ears, or gonads of the operator. In this context, we want to conclude reporting the conclusions of Kenkel et al. [23], who clarified the safety of this technology for patients, surgeons, and operating room personnel.

References

1. O'Brien Jr WD. Ultrasound-biophysics mechanisms. Prog Biophys Mol Biol. 2007;93(1–3):212–55.
2. Jewell ML, Solish NJ, Desilets CS. Noninvasive body sculpting technologies with an emphasis on high-intensity focused ultrasound. Aesthetic Plast Surg. 2011;35(5):901–12.
3. Wu J, Nyborg WL. Ultrasound, cavitation bubbles and their interaction with cells. Adv Drug Deliv Rev. 2008;60(10):1103–16.
4. Szabi TL. Diagnostic ultrasound imaging: inside out. Waltham: Elsevier, Academic; 2004.
5. Kennedy JE, Wu F, ter Haar GR, Gleeson FV, Phillips RR, Middleton MR, Cranston D. High-intensity focused ultrasound for the treatment of liver tumours. Ultrasonics. 2004;42(1–9):931–5.
6. Capla JM, Rubin JP. Discussion: randomized sham-controlled trial to evaluate the safety and effectiveness of a high-intensity focused ultrasound device for non-invasive body sculpting. Plast Reconstr Surg. 2011;128(1):263–4.
7. Sklar LR, El Tal AK, Kerwin LY. Use of transcutaneous ultrasound for lipolysis and skin tightening: a review. Aesthetic Plast Surg. 2014;38(2):429–41.
8. Zoccali G, Orsini G, Scandura S, Cifone MG, Giuliani M. Multifrequency ultrasound-assisted liposuction: 5 years of experience. Aesthetic Plast Surg. 2012;36(5): 1052–61.
9. Zocchi M. Ultrasonic liposculpturing. Aesthetic Plast Surg. 1992;16(4):287–98.
10. Shridharani SM, Broyles JM, Matarasso A. Liposuction devices: technology update. Med Devices (Auckl). 2014;7:241–51.
11. Roustaei N, Masoumi Lari SJ, Chalian M, Chalian H, Bakhshandeh H. Safety of ultrasound assisted liposuction: a survey of 660 operations. Aesthetic Plast Surg. 2009;33(2):213–8.
12. Kloehn RA. Liposuction with sonic Sculpture: "Six years" experience with more than 600 patients. Aesthet Surg J. 1996;16:123–28.
13. Graf R, Auersvald A, Damasio RC, Rippel R, de Araùjo LR, Bigarelli LH, Franck CL. Ultrasound-assisted liposuction: an analysis of 348 cases. Aesthetic Plast Surg. 2003;27(2):146–53.
14. Maxwell GP, Gingrass MK. Ultrasound-assisted lipoplasty: a clinical study of 250 consecutive patients. Plast Reconstr Surg. 1998;101(1):189–202.
15. Sadick NS. Overview of ultrasound-assisted liposuction, and body contouring with cellulite reduction. Semin Cutan Med Surg. 2009;28(4):250–6.
16. Palumbo P, Cinque B, Miconi G, La Torre C, Zoccali G, Vrentzos N, Vitale AR, Leocata P, Lombardi D, Lorenzo C, D'Angelo B, Macchiarelli G, Cimini A, Cifone MG, Giuliani M. Biological effects of low-frequency high-intensity ultrasound application on ex vivo human adipose tissue. Int J Immunopathol Pharmacol. 2011;24(2):411–22.
17. Igra H, Satur NM. Tumescent liposuction versus internal ultrasonic-assisted tumescent liposuction. A side-to-side comparison. Dermatol Surg. 1997;23(12): 1213–8.
18. Lawrence N, Cox SE. The efficacy of external ultrasound-assisted liposuction: a randomized controlled trial. Dermatol Surg. 2000;26(4):329–32.
19. Lawrence N, Coleman 3rd WP. The biologic basis of ultrasonic liposuction. Dermatol Surg. 1997;23(12): 1197–200.
20. Perez JA, van Tetering JP. Ultrasound-assisted lipoplasty: a review of over 350 consecutive cases using a two-stage technique. Aesthetic Plast Surg. 2003; 27(1):68–76.
21. Troilius C. Ultrasound-assisted lipoplasty: is it really safe? Aesthetic Plast Surg. 1999;23(5):307–11.
22. Millàn Mateo J, Vaquero Pérez MM. Systematic procedure for ultrasonically assisted lipoplasty. Aesthetic Plast Surg. 2000;24(4):259–69.
23. Kenkel JM, Johns DF, Rohrich RJ, Adams Jr WP, Roeser RJ. Hearing and ultrasound-assisted liposuction: the effect on surgeon and patient. Plast Reconstr Surg. 2000;106(1):150–3.