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# Ultrasound-Assisted Lipoplasty: A Review of Over 350 Consecutive Cases Using a Two-Stage Technique

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**Abstract.** Ultrasound-assisted lipoplasty (UAL) was developed in Europe and South America. Its introduction into the mainstream of United States surgery in 1997 was initially received with great enthusiasm. Soon, however, anecdotal reports surfaced describing limitations and complications related to the emerging technology. Among the concerns expressed were burns and postoperative seroma formation.

The etiology of these complications was speculated to be a result of prolonged ultrasonic energy time. Consequently, some authors recommended limiting the amount of ultrasonic energy time per site and even complete avoidance of UAL in certain body areas.

Our review includes over 350 consecutive cases of internal UAL performed by two surgeons utilizing a similar technique. 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. The mechanism of action of UAL and the surgical technique are described.

The procedure is a two-stage technique, including tumescent infiltration followed by energy application and simultaneous hollow titanium cannula aspiration. Suction-assisted lipoplasty was *not* a component of the procedure.

The results, including complications, are outlined. Complications were few and not severe. There was no correlation between length of ultrasonic energy time and rate of postoperative complications. The advantages and disadvantages of UAL are discussed. UAL alone is the authors' preferred technique for body contouring to all body areas, except in the female breast.

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Traditional liposuction has been the mainstay of body contouring since its introduction in the 1970s. Complications related to the procedure surfaced almost immediately thereafter. These complications were largely related to the non-selective destruction of vascular and subcutaneous connective tissue associated with the procedure. Several refinements, including preoperative infiltration of wetting solutions, have been made to the original liposuction technique in an attempt to improve the results and diminish the rate and severity of complications.

Ultrasound-assisted lipoplasty (UAL) was developed in Europe and South America. Its entry into mainstream US plastic surgery was initially received with great enthusiasm. However, anecdotal reports soon surfaced describing limitations and complications related to the emerging technology. Among the concerns expressed were the risk of burns and postoperative seroma formation. The etiology of these complications was speculated to be a result of prolonged exposure to ultrasonic energy. Consequently, some authors recommended limiting the amount of ultrasonic energy time per site and even avoiding UAL completely in certain body areas. In addition, greater reliance has been placed on the "mopping up" phase utilizing traditional suction-assisted lipectomy (SAL).

Our review includes over 350 consecutive cases of internal UAL performed by two surgeons utilizing a similar technique. 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 basic rules of UAL are: (1) Never apply ultrasonic energy to dry tissues. (2) Never apply ultrasonic energy without probe movement [18–20].

## Mechanism of Action

The use of ultrasonic energy is not unique to plastic surgery. Energy in the ultrasonic spectrum has been utilized in medicine in both a diagnostic and therapeutic capacity. The application of this energy is an extension of the concept of conversion of electrical energy to a mechanical wave. The wave is propagated down a titanium cannula shaft with a specific length producing a nodal sine wave pattern. The wave is calibrated to intersect at the tip of the titanium cannula producing a specific vibratory frequency of approximately 20–27 kHz. It is this precise calibration that prohibits bending of the titanium UAL cannulae.

The specific frequency of 20–27 kHz produced by the vibratory tip will affect primarily tissue with the lowest density, defined as tissue impedence. Fat has the lowest tissue impedence. Wetting the adipose tissue with tumescent infiltration can even further lower the impedence value. The result is an energy absorption specific to adipocytes. Ultrasonic energy absorption by adipocytes at a frequency of 20–27 kHz creates internal cellular instability leading to cell wall fragmentation and implosion. The phenomenon known as cavitation produces cell destruction leading to fat emulsification.

The end result is that ultrasonic energy yields selective destruction of fat tissue, largely sparing other types of connective tissue. This tissue selectivity is fundamental to the principles of UAL and is evident at both a gross and microscopic level. In addition, in vivo endoscopic videos by Tazi [14] and Perez [12] have demonstrated successful fat removal with preservation of soft tissue parenchymal architecture after application of ultrasonic energy.

## Materials and Methods

The present study represents 351 consecutive cases treated with internal UAL over a three-year period. The procedures were performed by two surgeons employing similar techniques. The surgical technique did, however, evolve during the period reviewed as described below.

Surgical procedures were performed in the US and the Netherlands using the Mentor Contour Genesis and LySonix 2000 devices.

Selection criteria for UAL were similar to those utilized for patients undergoing traditional liposuction. Exceptions included patients with internal metallic prostheses and treatment of the female breast because of unresolved medical and legal concerns in the US. All procedures were performed proximal to the elbows and knees.

### *Surgical Technique*

The proper selection of patients is as important with UAL as it is with traditional liposuction. Patients in this series were in generally good overall health.

An important component of the patient selection process is an assessment of skin elasticity. Patients with significant striae or skin laxity should be counseled regarding options for skin resection procedures such as abdominoplasty or thigh lift.

In our series, UAL was not considered the primary modality in obese patients. Patients who intended to use UAL as a weight-loss method were excluded. However, an overall diet and exercise plan is encouraged in conjunction with skin resection procedures and/or ultrasonic lipoplasty.

The preoperative evaluation of patients for UAL is similar to those for other aesthetic procedures. The presence of metallic devices in the vicinity of treatment areas, such as hip prostheses, were excluded because of the concern of interaction of the prosthesis with ultrasonic energy. However, additional clinical data is needed to support this claim.

The majority of patients were treated under general anesthesia administered by physician anesthesiologists, in addition to infiltration of tumescent fluid.

On the day of surgery patients are preoperatively marked by the surgeon while standing. Our preference is to use a one-color, conventional, topographic marking technique with simple concentric circles or arcs.

The patient is brought to the operating room and anesthesia is administered. The patient is laid down in the prone position with special care to protect the airway and bony prominences. This position facilitates access to the upper back, flanks, and posterior-lateral regions of the thigh. Posterior and lateral stab incisions are made in the appropriate areas. The incision should measure approximately 7 mm. It must be of sufficient length to accommodate a 5-mm wound protector. However, too long an incision will not permit an adequate anchoring.

Infiltration of tumescent fluid is then performed. All posterior sites are infiltrated at the outset of the procedure using a peristaltic pump. At a rate of 500 cc/min the entire treatment area can be easily infused in minutes.

Wound protectors are introduced into the incisions to prevent friction injury. In cases involving shorter treatment periods, such as the neck or knees, it is possible to forego the wound protector in order to minimize the incision size. However, care must be taken to keep the incision site wet using a continuous saline drip. A wet towel is used to protect the skin around the entry point from cannula shaft injury.

The ultrasonic energy level and cannula size may vary depending upon the treatment area. The posterior flanks, generally regarded as a fibrous and bloody site, are treated with a 5-mm cannula and an energy level of 70–85%.

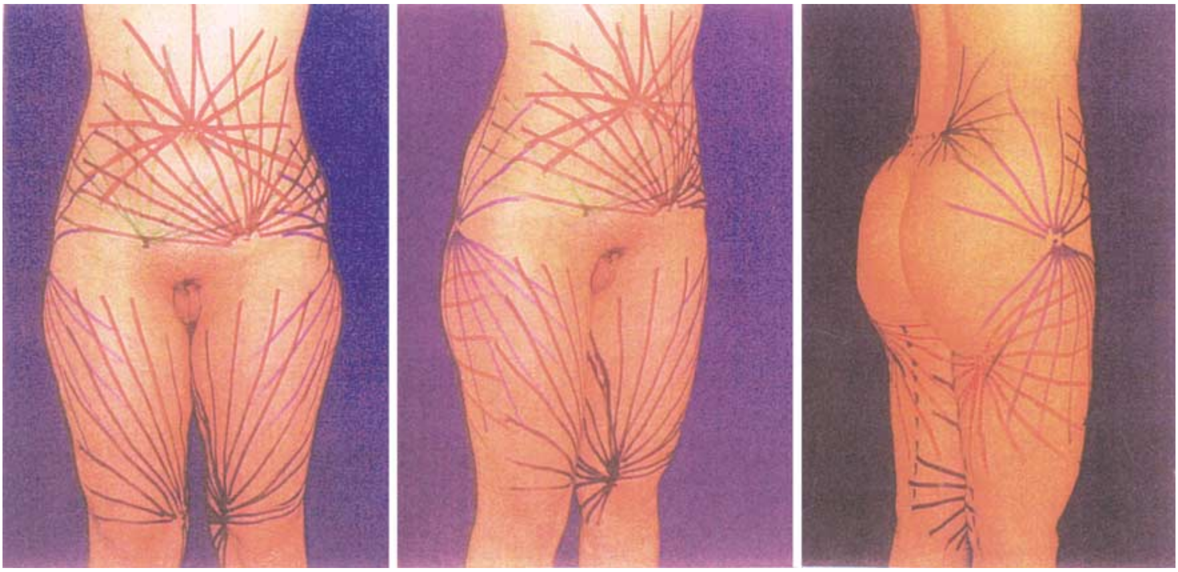

**Fig. 1.** UAL titanium cannulae cannot be bent. Therefore, the entry incisions must allow maximal multi-directional motion and access to each treatment area.

**Table 1.** Detecting the UAL endpoint

- Inspection of tissue
- Palpation of tissue (the "pinch" test)
- Tissue resistance to cannula strokes
- Rate of emulsified aspirate
- Quality (color) of aspirate
- UAL volume*
- UAL energy time*

*Relative endpoints for contralateral side.

**Table 2.** Patients who underwent additional procedures

| Procedure | No. of cases |
|---|---|
| Abdominoplasty | 40 |
| Bleph | 22 |
| Breast Aug. | 22 |
| Face | 26 |
| Neck | 23 |
| Other | 13 |

A multi-directional approach, or crisscross pattern, is utilized to maximize efficiency (Fig. 1). The flanks, for example, are first treated via posterior incisions, then from a lateral approach. Finally, when the patient is turned into the supine position, anterior entry portals are used.

Application of ultrasonic energy is combined with simultaneous aspiration. We prefer not to use a sheath with simultaneous irrigation because the additional fluid can sometimes obscure the endpoint.

The procedure is begun in the superficial plane. The superficial plane is defined as a depth of less than 10 mm from the underside of the subdermis. The dermis is neither tented nor raked in order to avoid injury to the subdermal vascular plexus. In addition, simultaneous suction is *not* applied in the immediate subdermis. Slow, smooth, fan-like strokes are utilized. Each pass progressively widens the fan and deepens the treatment plane. Palpation by the non-dominant hand is critical to this step, and the skin should be wet to improve tactile feedback.

The quality and quantity of the aspirate are carefully assessed. We use no predetermined limits of ultrasonic energy time to a given treatment site (Table 1).

Aspiration of the emulsified fat is accomplished simultaneously with the application of ultrasonic energy. In our initial cases, evacuation was regarded as a separate stage of treatment, using thin traditional liposuction cannula with a low suction pressure. Our technique later evolved into a two-stage procedure, employing tumescent infiltration as the initial stage and eliminating a separate "mopping up" phase. Manual tissue remodeling and aggressive expression of residual fluid completes the treatment to each area. A roller device and a capable assistant are useful for this task. The incisions are left open until completion of all the treatment areas. The dermis is approximated with a single subcuticular stitch to allow for fluid egress postoperatively.

The patient is then turned to the supine position. Anterior sites are accessed in a similar fashion as described above. Upon completion of the procedure, a compressive garment is applied. The patient is instructed to wear the garment for approximately six weeks. Postoperative massage is also encouraged and may include topical heparin cream.

The technique outlined above represents an evolution by the authors from the traditional three-stage procedure. Conventional suction lipectomy as a final

**Table 3.** Sites where UAL was performed

| Site | Avg. volume in | Avg. volume out | Avg. time | No. patients |
|---|---|---|---|---|
| Abdomen | 1161 | 681 | 23 | 163 |
| Flanks | 900 | 683 | 26 | 130 |
| Outer thigh | 1118 | 838 | 24 | 143 |
| Inner thigh | 878 | 516 | 21 | 105 |
| Back | 616 | 345 | 11 | 16 |
| Knees | 518 | 320 | 14 | 30 |
| Face | | | 4 | 26 |
| Other | 744 | 469 | 18 | 68 |
| **Total** | 2202 | 1983 | 42 | |

phase has been eliminated. Greater emphasis has been placed on the multidirectional approach to specific sites as well as the reliance on energy application as the exclusive treatment modality.

## Results

A total of 351 consecutive patients in our series underwent UAL. There were 288 females (82%) and 63 males (18%). The patients ranged in age from 17 to 77 years, with a mean age of 42. Patients undergoing additional procedures are outlined in Table 2. Preoperative weight, compared to the patient's calculated ideal body weight (IBW) was 1.17% IBW with a range from 0.89–1.92%. The mean postoperative follow-up period was eight months.

Data collection for all patients included: tumescent infiltration volume per site, total aspirate volume per site and total ultrasonic energy time per site (Table 3). Typical UAL aspirate contained approximately 85% supernatant fat, 14% serous fluid, and less than 1% blood.

Cases were small to moderate in volume, ranging from a negligible total aspirate (facial cases primarily to enhance skin contraction) to the largest volume case of 7050 cc. Mean aspirate volume, excluding negligible volume cases, was 1983 cc.

Average tumescent infiltration volume, aspirate volume and ultrasonic energy time per site is outlined in Table 3. The maximum ultrasonic energy time for a single site was an abdomen treated continuously for 64 min. No untoward sequelae occurred.

Complications are outlined in Table 4. The most frequent complication was prolonged dysesthesias, defined as uncomfortable cutaneous sensory symptoms lasting greater than six weeks. A total of five cases were identified (three thigh sites, two flank sites). The average ultrasonic energy time per sensory-affected site was approximately 12 min.

There were three postoperative seromas, all to abdominal sites. They were all managed conservatively with serial aspiration (Patient 1, male, 400 cc total; Patient 2, female, 150 cc total; Patient 3, female, 50 cc total) and no further sequelae. The average energy time to the abdominal sites in those patients was 23 minutes. Two patients developed postoperative cellulitis treated successfully with oral antibiotics. There were no burn/devascularization injuries or other significant complications.

**Table 4.** Complications

| Complications | No. patients |
|---|---|
| Prolonged dysesthesia | 5 |
| Seroma | 3 |
| Infection | 2 |
| Burns/devascularization | 0 |
| Anesthesia/medical complications | 0 |

## Discussion

Ultrasonic assisted lipoplasty developed mainstream popularity in the United States in the mid to late 1990s following several years of development and application in Europe and South America.

Several authors have described the use of UAL with a three-stage approach, including tumescent infiltration, ultrasonic energy application, followed by SAL.

Complications related to UAL have been infrequent, and with few exceptions, not severe. Among the most commonly discussed untoward events anecdotally ascribed to UAL are burns and seroma formation. Speculation has been raised that correlates these complications with the length of applied ultrasonic energy time. Guidelines have even been suggested to limit ultrasonic energy time per site or even avoidance of the superficial plane or certain body areas altogether. Combined treatment—using limited UAL followed by SAL—has been recommended. However, data is lacking to support these assertions.

The results of this combination regimen have also been used as a basis for comparison with SAL alone [2,5]. The flaw with this comparison, in our opinion, is that any application of SAL will diminish the benefit of UAL tissue selectivity. Consequently, a procedure composed of 50% or more SAL should not surprisingly produce results similar to SAL alone (Fig. 2).

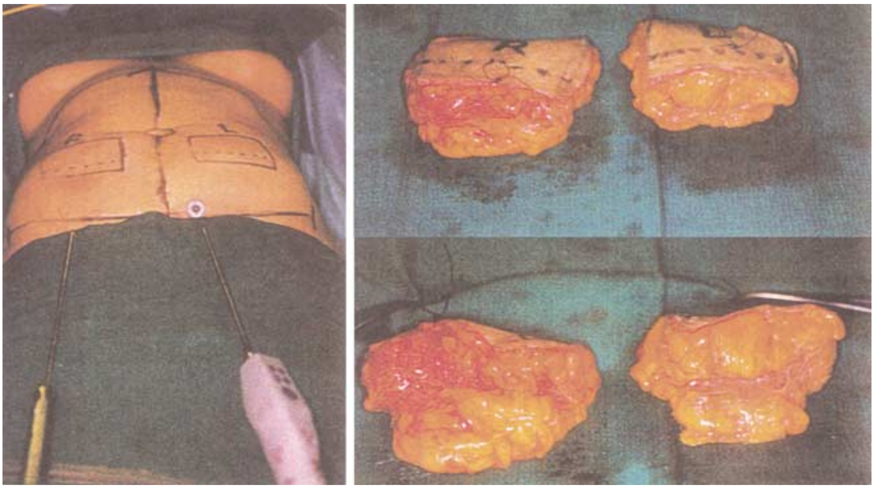

**Fig. 2.** A comparison between SAL and UAL. (**A**) Two areas were marked prior to elevation of an abdominoplasty flap. Both areas were infiltrated with 150 cc of tumescent solution, followed by 2 min of treatment in the intermediate subcutaneous plane, and aspiration of 100 cc. The patient's right side was treated with traditional SAL, using a 3.7-mm cannula. The patient's left side underwent UAL, using a 4-mm hollow titanium cannula. Both cubes of tissue were immediately excised and inspected. (**B**) Note that a subtle irregularity in the skin is already visible on the SAL side. (**C**) A view of the intermediate level subcutaneous architecture for both sides.

**Table 5.** Burn mechanisms and prevention

| Mechanism | Avoidance |
|---|---|
| 1. Entry portal (access incision) friction | Wound protector |
| 2. Proximal skin "stripe" burn | Moist towel |
| 3. Subdermal devascularization or thermal injury | Avoid tenting of the flap |
| (e.g. "end hit" or broader skin necrosis) | Avoid subdermal energy with simultaneous suction |
| | Strict adherence to the two basic rules of UAL |

Furthermore, our data suggests that limiting UAL energy time is not necessary. Zocchi has emphasized correctly that UAL is a wet and dynamic technique. As long as the surgeon strictly adheres to the two basic rules of UAL as described by Zocchi there appears to be *no* correlation between the length of ultrasonic energy time and complications, such as burns and seroma formation. We prefer to apply ultrasonic energy to achieve the desired endpoints without limitation by a specified amount of time [16]. These endpoints are outlined in Table 1.

Our technique has evolved into a two-stage procedure. The first part is infiltration of all treatment sites. This is followed by ultrasonic energy application and simultaneous aspiration using a titanium hollow cannula until the desired endpoint is obtained. Aggressive manual remodeling and expression of fluid is performed via all entry portals to minimize postoperative seromas.

Our data, as well as that of Maxwell [10] and others, suggests that the abdomen is at greatest risk for postoperative seroma formation. The explanation for this is likely a function of incomplete postoperative compression, since abdominal garments are not applied against a rigid bony surface such as the thighs or flanks.

Some authors have admonished the use of ultrasonic energy in the superficial tissue planes or even urged complete avoidance of certain body areas such as the face or knees. They speculate that the thinner flaps are more vulnerable to thermal injury. In contrast, Grotting [4] described indications for cervicofacial rejuvenation using UAL. In their series, the superficial plane procedure was safely performed in 26 patients. Two cases of temporary nerve weakness and one contour irregularity occurred.

Treatment in the superficial plane is intended to enhance skin retraction. We have performed UAL to 86 sites in the superficial planes of the face, arms, and legs without thermal injury. However, in these areas it is advisable to shorten treatment time and lower the energy amplitude, generally to settings of 50–60%. In addition, simultaneous aspiration should be avoided in the immediate subdermis.

Burns, or more accurately, thermal-ischemic injuries, occur via three mechanisms (Table 5).

An injury at the entry portal is typically a result of friction from the warm cannula strokes. It can be prevented easily with the use of a plastic wound protector inserted into the access incision.

A "stripe" burn occurs from the cannula shaft rubbing against the skin proximal to the entry portal. This area can be readily protected by a moist towel.

The third type of injury is a subdermal devascularization or thermal event. A punctate area is called an end hit. However, a greater degree of subdermal devascularization may lead to ischemia or frank necrosis over a broad skin surface area. The latter type of injury is rare but is the most severe. Prevention of the latter type of injury includes careful application of


**Fig. 3.** A 31-year-old woman who underwent UAL of the abdomen, flanks, and thighs. Total aspirate was 2500 cc. Ultrasonic energy was used for a total of 75 min. (**A**, **D**) Preoperative views. (**B**, **E**) Postoperative bruising six days later. (**C**, **F**) Postoperative views at five weeks.

energy in the superficial plane without tenting up the skin. Suction should not be applied while the cannula is in the immediate subdermal plane in order to prevent tissue dessication.

All three types of thermal-ischemic injuries can be largely avoided using the steps outlined above. It is unnecessary to limit ultrasonic energy time to avoid this complication. However, strict adherence to the two basic rules of UAL cannot be overemphasized. Conversely, thermal-ischemic injuries can occur within seconds if these rules are ignored.

The most common side effect of UAL is a temporary postoperative sensory neuropathy. The dysesthesia associated with UAL is self-limited but can exist for months after surgery. The proposed mechanism is a selective destruction of the adipose-laden myelin sheath, producing a "raw wire" effect in the subcutaneous tissue. Symptomatic relief can be obtained with Calamine lotion or Zostrix HP [12]. In our series, the occurrence of postoperative dysesthesias did not correlate with ultrasonic energy time (Figs. 2–5).

### *Advantages of UAL*

Proponents of UAL tout several advantages over traditional liposuction. The tissue selectivity of ultrasonic energy produces less destruction of desirable soft tissue elements including blood vessels, nerves and fibrous architecture. The clinical effect is less bruising and pain, fewer skin irregularities, and a faster postoperative recovery. In addition, UAL produces far less fatigue for the surgeon allowing greater control for soft tissue sculpting.

These observations are recognized empirically by surgeons experienced in both UAL and traditional liposuction. Our findings have been consistent with these assertions. Anecdotally, the authors have observed that the subset of patients undergoing UAL who previously had been treated with SAL have uniformly noted a significantly smoother recovery with UAL. Nevertheless, the benefits described are subjective and difficult to quantitate with existing methods. Definitive bilateral comparison of SAL and true UAL are limited by ethical considerations.

We have also observed far fewer problems with skin irregularities, both in terms of frequency and severity. However, dramatic skin retraction, an early and popular claim of UAL is rarely achievable in our hands.

### *Disadvantages of UAL*

The principal disadvantages associated with UAL are related to cost and training. Devices presently available are limited and manufacturers' have been slow to proceed to the next generation. The lack of market demand has impacted manufacturers' decision to

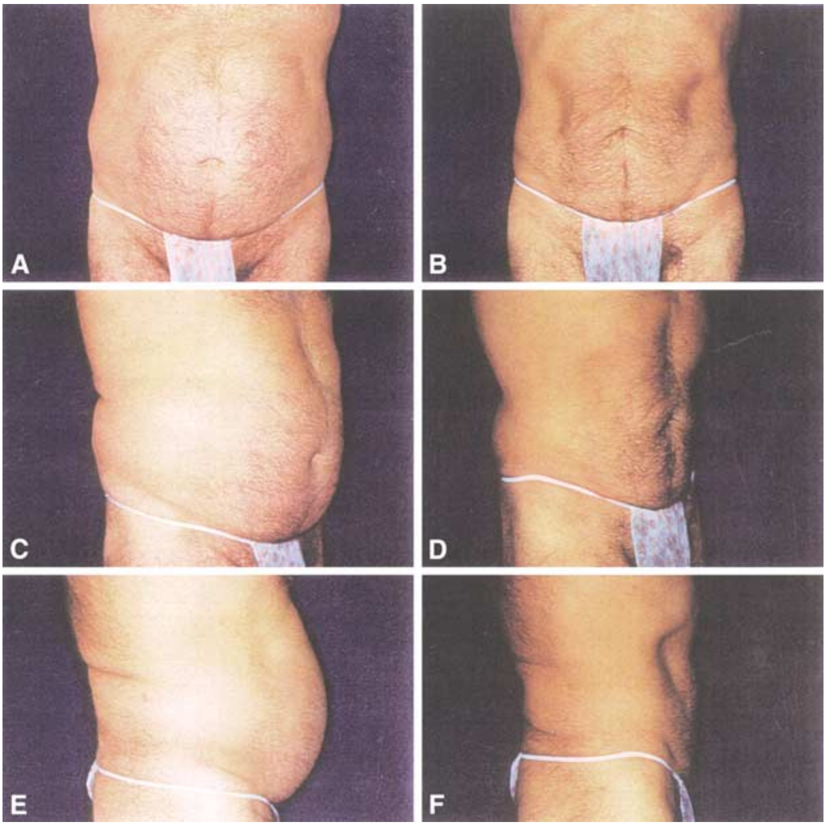


**Fig. 4.** A 56-year-old man who underwent UAL of the abdomen and flanks. Ultrasonic energy was used for a total of 75 min, including 45 min spent on the abdomen alone. Total aspirate was approximately 1900 cc. (**A**, **C**, **E**) Preoperative views. (**B**, **D**, **F**) Postoperative views at five months.

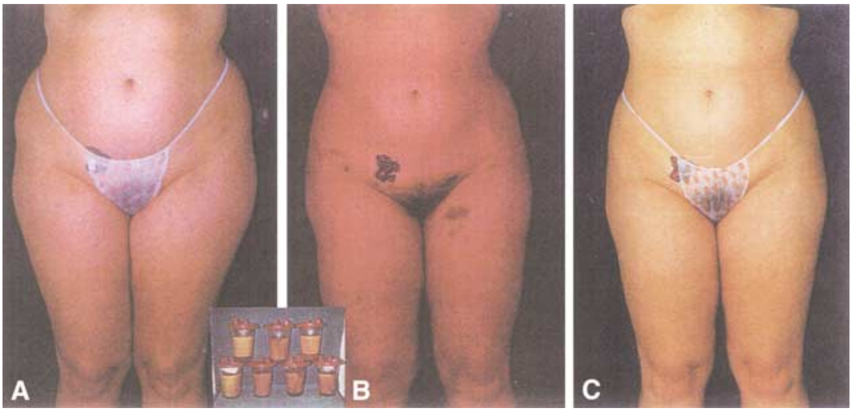


**Fig. 5.** A 27-year-old woman who underwent UAL of the abdomen, flanks, and thighs. Total infiltration was 6000 cc. Total aspirate volume was 7050 cc after 176 min of ultrasonic energy time. (**A**) Preoperative view. (**B**) Postoperative bruising after four days. (Inset) Approximately 7 L of typical UAL aspirate removed. (**C**) Postoperative view at four months. *Note:* The patient advised us at this visit that she was carrying a six-week unplanned pregnancy. Eight months later she delivered a healthy child.

invest in additional research and development, although newer prototype devices are currently under investigation.

As with any new technology, a learning curve also exists with UAL. In addition, surgeons have been intimidated by anecdotal reports of complications such as burns and seromas. Curiously, despite reports of devastating facial burns [3], laser resurfacing continues to enjoy widespread use among surgeons.

Nevertheless, the present study is intended to address some of these concerns. Our data confirm that prolonged ultrasonic energy time does *not* correlate with these complications. Moreover, we believe that, for certain body areas, shortened ultrasonic energy application is inadequate to produce sufficient cavitation to achieve the desired effect.

The slow, violin-like strokes required by UAL do create a longer surgical time. Patience is necessary on the part of the surgeon. It is important to resist the temptation for rapid movement in order to allow sufficient contact time between the cannula tip and the target tissue. In our experience, surgical time was approximately 25% longer than comparable cases using traditional liposuction. Some surgeons have reported no greater length of surgical time for UAL procedures. Nevertheless, we feel that the investment

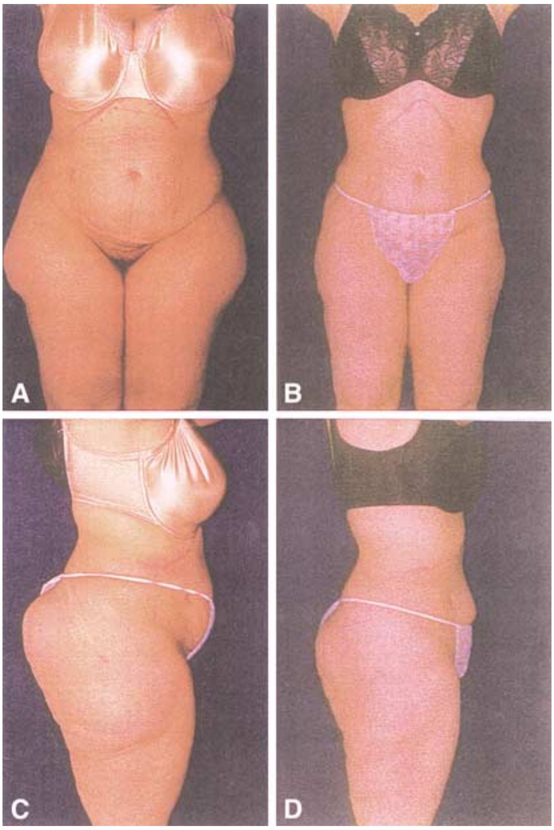


**Fig. 6.** A 33-year-old woman who underwent UAL of the buttocks and thighs. Approximately 115 min of ultrasonic energy was applied and 4600 cc of aspirate removed. (**A**) Preoperative views (weight, 137 lbs). (**B**) Postoperative views at two years (weight, 120 lbs).

of additional time, if any, produces a worthwhile benefit to the patient.

The cell wall destruction that occurs by the ultrasonic energy lyses adipose tissue. Consequently, the aspirate is composed of an oily emulsification and cellular debrid that is unsuitable for fat grafting. Tissue for fat injection must be harvested separately prior to UAL.

Another disadvantage of UAL is that the titanium cannulae cannot be bent. The titanium cannula is calibrated to a specific frequency and arching it will diminish its effectiveness. However, this inconvenience is easily overcome by using the multi- directional (crisscrossing) approach outlined above.

## Conclusion

Ultrasound assisted lipoplasty is a safe and effective method of body contouring in small and moderate sized cases. The procedure can be performed in two stages, including tumescent infiltration followed by energy application and simultaneous aspiration using hollow titanium cannulae. Traditional SAL and the "mopping up" phase are not a necessary component of the procedure.

We have reviewed our experience with over 350 consecutive cases performed over a three year period. Complications were few and not severe. Ultrasonic energy was applied until the desired endpoint was reached and was not governed by predetermined time limits. No burns occurred and seroma formation did not correlate with prolonged energy time. UAL is our procedure of choice for body contouring to all body areas with the exception of the female breast in cases performed in the US.

The advantages of UAL are related to selective adipose destruction and preservation of the desirable soft tissue elements contained in the subcutaneous parenchymal architecture. The clinical manifestations include less bruising and pain, fewer skin irregularities, and a faster postoperative recovery. However, it is important to adhere to the fundamental principles, as well as, the two basic rules of UAL, to achieve optimal results. The disadvantages of UAL are generally related to cost and training. UAL alone is an acceptable alternative to traditional SAL.

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