Histologic Effects of Ultrasound-assisted Lipoplasty

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**Background:** In spite of the increasing popularity of ultrasound-assisted lipoplasty (UAL), questions remain about the effects of ultrasound energy on soft tissues, indications for the technique, and parameters for safe application and optimal results.

**Objective:** This study was undertaken to evaluate the tissue effects of UAL and to correlate those effects with parameters based on clinical experience.

**Methods:** Histologic evaluation with standard histologic staining was done on abdominoplasty specimens treated with UAL on one side and standard liposuction on the opposite side in patients undergoing both abdominoplasty and UAL. Additionally, 100 consecutive patients treated with UAL were reviewed.

**Results:** It was found that optimal results correlated with submaximal amplitude settings, loss of tissue resistance to probe movement, and change in color of the aspirate from pale yellow to pink or tan as end points for the application of ultrasound. Histologic evaluation revealed that these parameters were associated with minimal effect on connective tissues and blood vessels. Longer application times were associated with disruption of collagen and elastin structures.

**Conclusions:** This study confirms that UAL is an effective and safe technique in experienced hands when attention is given to easily observed end points for application of ultrasound energy.

Since its introduction by Zocchi and Kloehn, ultrasound-assisted lipoplasty (UAL) has been increasing in popularity as experience is gained with the technique. Several questions remain, however, about its safety, indications, and even its precise effects on adipose and connective tissues. Understanding of these possible effects has been based on speculation about the physical properties of ultrasound energy in biologic environments, extrapolation from analysis of in vivo sonicated tissue aspirate, and clinical experience. Misconceptions abound, including the belief that very large volume fat removal in obese patients is made safer by the use of ultrasound energy, that longer operating times are necessary, and that skin retraction is stimulated. None of these claims have been proven, and rigorous evaluation of the potential benefits and risks of this relatively new methodology is lacking. This study was done to evaluate the acute and delayed effects of UAL by analyzing abdominoplasty specimens treated with UAL on one side and standard liposuction on the opposite side in several patients undergoing both abdominoplasty and UAL. Additionally, 100 consecutive patients treated with UAL were reviewed.
Early in my experience, UAL was applied conservatively, with relatively short application times but full recommended amplitude settings. As increasing experience generated increased confidence in the technique, longer application times (in the range of 15 to 20 minutes per area) were used. With these longer application times, patients began to complain of dysesthesia and experience more postoperative swelling. These problems lessened as shorter application times and lower amplitude settings were used; more importantly, clinical end points were recognized. Patients who were undergoing both abdominoplasty and UAL provided an opportunity to evaluate the human tissue effects of UAL.

Material and Methods

The 100 patients were treated over a 1-year period between January 1997 and January 1998. All patients were treated with the Lysonix® 2000 system (Lysonix Inc., Carpeteria, CA), using the 4-mm and 5-mm flat-tip “golf tee” hollow cannulas with occasional use of the bullet-tip probe. Standard “superwet” anesthesia with monitored anesthesia sedation was used (infusion was used in an estimated 1:1 ratio to the aspirate; this resulted in tissue turgor or “tumescence” in some areas). The ultrasonic portion of the procedure was performed with simultaneous low-pressure aspiration, followed by an “evacuation” phase with 3-mm suction-assisted lipectomy (SAL) cannulas, as recommended in the standardized UAL teaching seminars. Patients were kept in pressure garments for 3 to 6 weeks, and postoperative massage was used selectively.

A hospital Institutional Review Board approval was obtained for the study of abdominoplasty specimens. Three patients who were scheduled for both UAL and abdominoplasty participated in the study. A fourth patient was treated with UAL and SAL in the lower abdominal area 3 weeks before the abdominoplasty, to evaluate the subacute effects of the techniques. These patients were marked before surgery to outline the area of tissue to be resected. One side of this area on the lower abdomen was then treated with UAL for an arbitrarily selected time from 2 to 5 minutes, with tumescent anesthesia used and care taken to avoid contact with the fascia or coming close to the margin of the specimen. These treatment times were selected on the basis of clinical correlation to end points of color change of the aspirate from pale yellow to pink or tan and loss of resistance to cannula advancement. The opposite side was treated for an identical time with a standard cannula. The liposuction

<table>
<thead>
<tr>
<th>Complication</th>
<th>Cases</th>
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<tbody>
<tr>
<td>Prolonged swelling</td>
<td>8</td>
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<tr>
<td>Dysesthesia</td>
<td>6</td>
</tr>
<tr>
<td>Seromas</td>
<td>2</td>
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<tr>
<td>Drain site infection</td>
<td>1</td>
</tr>
<tr>
<td>Skin burns</td>
<td>0</td>
</tr>
<tr>
<td>Deep venous thrombosis/pulmonary embolus</td>
<td>0</td>
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<tr>
<td><strong>Total</strong></td>
<td>17</td>
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Note: Since this study was completed, an additional 75 patients have been treated without complications.

Figure 1. A, Abdominoplasty-treated specimen from 2-minute treatment times. B, The UAL-treated side (right) shows more thorough fat removal, although treatment times of longer than 2 minutes caused formation of a cavity in the treated area.
procedure was then completed, followed by the abdominoplasty. The specimens were submitted fresh for gross and microscopic evaluation by one pathologist. The specimens were bisected from the posterior surface, revealing a cavitated area with easily recognized gross margins. Specimens were taken from the edges of this area laterally, as well as from the superficial aspect (toward the dermis). The microscopic evaluation was done with hematoxylin and eosin (H&E), trichrome, and elastin staining. All interpretations are those of the pathologist.

Results—Clinical Study

The series consisted of 100 consecutive UAL cases, six men and 94 women, ages 24 to 64. Total aspirate volume ranged from 300 mL to 6075 mL. Early in my experience with the procedure, it was routine to use maximal amplitude settings to 60% for the 5-mm cannula and 50% for the 4-mm cannula with longer application time; these settings were decreased to 50% for the 5-mm cannula and 40% for the 4-mm cannula toward the end of the series. There were 200 treatment areas in the 100 patients as follows: bilateral thighs (n = 68), hips (n = 53), abdomen (n = 51), bilateral arms (n = 16), and back (n = 12). Simultaneous plastic surgical procedures were performed in 30 of the 100 patients: abdominoplasty (n = 16), facial surgery (n = 7), breast surgery (n = 5), and thigh lift (n = 2). All complications occurred within the first 60 cases (Table). Prolonged swelling was defined as any detectable edema after 6 weeks, and dysesthesias were typically described as an “aching numbness” and

Figure 2. A., H&E stain of 2-minute SAL-treated specimen at edge of treated area (top) (original magnification × 10). Note intact blood vessel and minimal structural disruption. B, H&E stain of 2-minute UAL-treated specimen, edge of treated area (original magnification × 10). There is minimal structural disruption. C, Trichrome stain of 2-minute SAL-treated specimen. Note orderly arrangement of collagen strands (blue) and extravasated red blood cells. D, Trichrome stain of 2-minute UAL-treated specimen. The large blood vessel is undamaged.
resolved within 90 days in all patients. Dysesthesias and seromas occurred in association with prolonged swelling. A single drain site infection cleared rapidly with oral antibiotics, and drains are no longer used. Two patients underwent revisions, and all others recovered with a satisfactory end result. A total of 17 minor complications occurred in nine of the 100 patients, and there were no skin burns or major complications such as deep venous thrombosis/pulmonary embolus. The benefits of UAL to the operator in fibrous areas compared with my previous clinical experience with SAL were apparent, especially in the upper abdomen, gynecomastia, and the back and posterior hips, as well as in male patients in general. The histologic evaluation of abdominoplasty specimens revealed that UAL was more effective at debulking as compared with the side treated for the same time with standard liposuction (Figure 1). This was consistent with the clinical impression that the UAL procedure is not associated with longer operating times when the hollow cannula is used with simultaneous aspiration.

Results—Histologic Study

Grossly, both the UAL-treated specimens and the standard SAL specimens showed a well-demarcated cavity as intended. The UAL specimens had more thorough defatting at all treatment times. The 4-minute and 5-minute UAL specimens had a cavity with macerated walls and destruction of the fibrous septae, whereas the 2-minute specimen retained grossly normal architecture within the treated area.

Microscopic analysis was performed by sectioning the areas at the margin of the treated abdominoplasty specimen areas, with H & E, trichrome, and elastin staining. The 2-minute UAL specimens showed preservation of blood vessels, collagen fibers, and elastin (Figure 2); the specimens were generally indistinguishable from those on the standard liposuction side. Nerves could not be located in the specimens, although the possible effects on myelin sheaths would be of interest. No effects on the dermis were seen (UAL was not directed into the superficial plane). The specimens from the 4-minute and longer UAL treatment times demonstrated fragmentation of collagen structures, to a greater extent than changes seen on elastin fibers (Figure 3). “Micromaceration” was the term used to describe the pattern of disruption of connective tissue changes. The end point indicators (loss of tissue resistance to probe movement and change in color of the aspirate from pale yellow to pink or tan) corresponded to approximately 2 minutes of UAL application to one side of the abdominoplasty specimen. No complications were observed that could be assigned to the pretreatment of the patients undergoing abdominoplasty with UAL.

No all of the tissue effects of UAL may be manifest acutely. Subacute changes from damage to collagen may be manifest by fibroblast-mediated deposition of mucopolysaccharide, which results in the uptake of the stain used to identify elastin (hence, the term “elastosis”). To rule out any such effect that would be missed in the specimens removed acutely after the treatment and to identify any other possible subacute tissue effects, one patient was treated with 2 minutes of UAL and with SAL 3 weeks before the abdominoplasty. No evidence of elastosis was seen, and the area showed only mild inflammatory changes.
consistent with healing from a controlled surgical wound. The UAL side was microscopically indistinguishable from the standard liposuction side treated for the same time (Figure 4).

Discussion

UAL is rapidly evolving into an important adjunct to standard body contouring procedures. Initial enthusiasm has been dampened by reports of high seroma rates, concerns about long operating times, skin burns, and failure of the technique to safely expand the limits of lipoplasty to include obesity treatment and patients with poor skin tone. The limitations of single-session fat removal with any lipoplasty procedure are most likely related to the volumes of fluid required for the requisite wet technique, rather than blood loss, which could easily be compensated for by autologous transfusion. Also, the use of liposuction in the obese patient seems unlikely to produce consistently satisfying long-term results. This study does not demonstrate any controlled contraction of dermal collagen; however, because UAL was not directed into the superficial plane, the use of UAL for the purpose of stimulating skin retraction cannot be evaluated in this study.

As with all new procedures, experience and attention to detail help to flatten the learning curve. The keys to predictable success with the procedure were determined to be the use of submaximal amplitude settings except in the most fibrous areas, and adherence to defined end points for the ultrasonic phase of the operation. These end points are loss of resistance to cannula movement and change in the color of the aspirate from pale yellow to pink or tan. (This color change cannot be seen with external ultrasound, which lacks clear indicators for duration of application, or with a solid internal probe.) Use of these end points usually resulted in shorter application times. Although the indicators correlated to a 2-minute treatment time for one abdominal quadrant, times will vary depending on the area treated. Presumably the indicators are a marker for complete emulsification of the area. The final end point for the lipoplasty procedure is still defined by satisfactory contour, after completion of the evacuation phase with small (3 mm or less) diameter cannulas. This second portion of the procedure is necessary because the small internal diameter of the hollow ultrasonic cannula makes it less effective at evacuation of the emulsion created by the ultrasound energy. The evacuation phase also provides an opportunity for fine-tuning the result by feathering the edges of the UAL-treated area.

Operating times are not necessarily longer when the hollow cannula is used with simultaneous aspiration. Seromas and skin burns are avoidable when defined end points are used consistently. Excessive application of internal ultrasound energy will result in cavity formation and a high seroma rate. The longer incisions required can be compensated for by careful attention to placement; fewer incisions are needed because “cross-tunneling” seems to be necessary less often. Small counter-incisions can be used, if desired, for additional contouring with small cannulas.

This study confirms that UAL is a safe and effective modality when used selectively and when the end point parameters are respected. Claims that the technique selectively emulsifies fat while sparing vascular and connective tissue structures are confirmed, provided that treatment
times are limited. No evidence of unintended effects from ultrasound energy was found. ■

I thank Don Nakonechny, MD, for processing and interpreting the specimens.

References


Commentary

Dr. Baxter's article has succinctly reviewed his 1-year experience with ultrasound-assisted lipoplasty (UAL) and evaluated the tissue effects of UAL in four of his patients. He describes the treatment of 100 consecutive patients who underwent UAL alone or in combination with other aesthetic procedures. During that time period, he notes, his technique evolved into a more conservative use of UAL. Specifically, he states that his optimal results seemed to correlate with lower amplitude settings: decreasing from level 6 to level 5 with the 5-mm cannula and from level 5 to level 4 with the 4-mm cannula (Lysonic® 2000). Additionally, he notes that decreasing treatment time from 15 to 20 minutes/site to 2 to 5 minutes/site has markedly decreased the incidence of prolonged postoperative swelling and dysesthesia. The lower treatment times correlated with his recognition of loss of tissue resistance and a change in the color of the aspirate as we have previously described.1

Dr. Baxter's conclusions closely parallel those of many of us who have incorporated UAL into our practices. Early in our experience we were intrigued with the potential effects that UAL had, not only on the hard-to-treat fibrous areas but also on the skin. We were impressed with Dr. Zocchi's results and attempted to attain them in our patients. Long treatment times, higher amplitudes, and insufficient evacuation led to high seroma rates and inconsistent dermal contraction.1,3 In October 1998, we reviewed our 2-year experience with UAL.4 During that time, we treated a little more than 400 patients; 74% underwent UAL alone, whereas 26% had UAL in combination with other procedures. There were seven complications: four seromas, two prolonged dysesthesias, and one superficial skin burn. Six patients had revisions: two contour additions and four contour reductions. Although we were able to obtain consistently good results with UAL with regard to fat contouring, we found that UAL's effect on dermal contraction remained inconsistent and often unpredictable.

In our hands, UAL complements suction-assisted lipoplasty (SAL) in circumferential body contouring. In fact, UAL begins where SAL ends, extending the role of liposuction in body contouring procedures. Its use results in consistent, reproducible results. The use of established UAL end points and the three-stage technique (infusion, UAL- and SAL-evacuation) helps prevent most UAL-associated complications.

The second part of the article discusses the histologic effects of UAL. To examine this, Dr. Baxter took three of his patients undergoing abdominoplasty and treated one side of the pannus with UAL and the contralateral side with SAL. The pannus was excised and evaluated histologically. A fourth patient was treated similarly 3 weeks before abdominoplasty. After the excision, the specimen was submitted for histologic evaluation of the potential subacute effects. He found that the 2-minute treatment time preserved the fibrous septae, blood vessels, collagen fibers, and elastin, whereas longer treatment times caused cavity formation resulting in a macerated “appearance” on the margins. In contrast, the 4-minute treatment time demonstrated “fragmentation of collagen structures and micromaceration.” The one specimen evaluated for subacute changes did not have elastosis, suggesting that collagen was not damaged. The histologic evaluation failed to distinguish between the side treated with UAL and the SAL-treated side.

We similarly evaluated the tissue effects of UAL using a porcine model.5 In our study, one side of the animal was treated with standard SAL techniques, whereas the con-