Quantitative Assessment of Results of Ultrasound-assisted Lipoplasty With Dual-Energy X-ray Absorptiometry: A Preliminary Report

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Current measures for assessing the results of body contouring surgery are limited. The goal of our study was to analyze objectively and quantitatively the results of ultrasound-assisted lipoplasty by use of dual-energy x-ray absorptiometry (DEXA). A prospective study of nine patients who underwent ultrasound-assisted lipoplasty (Lysonics 2000® generator) was performed. Each patient underwent preoperative and postoperative DEXA scanning (Lunar®). All patients were women, and the average age was 42 years (range 26 to 57 years). The amount of emulsion was recorded, and analysis of the emulsion demonstrated that approximately 40% was infiltration solution, serum, and blood. The average patient follow-up period was 14 weeks (range 8 to 22 weeks). The amount of fat that was measured after aspiration (adjusted for infiltration solution, serum, and blood) was consistently less than the fat reduction demonstrated by DEXA. Fat reduction by DEXA was shown to be 45% and 46% greater than the measured aspirated fat from the right and left thighs, respectively. For both the right and left hips, the difference was 48%, and for the abdomen, DEXA recorded a 30% greater fat reduction than was aspirated.

DEXA can be used to assess objectively and quantitatively the results of ultrasound-assisted lipoplasty. Furthermore, DEXA more accurately reflects total fat reduction, including aspirated fat and resorbed emulsion, as well as any prolonged lipolytic effect that may be caused by thermal injury or any regional toxic effect of the emulsion.

Initial favorable experience with ultrasound-assisted lipoplasty has led to high expectations for improved performance, with a low rate of complications and revision surgery.1,2 Ultrasound-assisted lipoplasty has recently been introduced in the United States with an in-line suction system assessment. However, the objective and quantitative assessment of results has been limited. The purported advantages of ultrasound-assisted lipoplasty include the selective destruction and removal of fat while sparing vessels, nerves, and connective tissue. The result is the ability to remove massive amounts of fat with less tissue trauma, less blood loss, better skin retraction, and improved body contouring.3
Current outcome measures for lipoplasty include photographs that allow subjective assessment of improvement but do not afford objective comparison between patient populations or new techniques. Measurements of circumference and weight do not necessarily reflect the overall improvement. Satisfaction surveys by their nature are subjective and tend to be inherently biased. This study demonstrates that the amount of extracted fat does not accurately reflect the total fat reduction. The goal of this study was to assess objectively and quantitatively the results of ultrasound-assisted lipoplasty by use of dual-energy X-ray absorptiometry (DEXA).

Material and Methods

A prospective study of a single-surgeon series of nine patients with lipodystrophy who underwent ultrasound-assisted liposuction (Lysonics 2000® generator, Medical Device Alliance, Inc., Las Vegas, NV) with a minimum follow-up of 8 weeks was conducted. Medical Device Alliance has gained 510(K) approval from the U.S. Food and Drug Administration to use the Lysonics 2000® generator for soft tissue removal in plastic surgery. The procedures were performed with intravenous sedation and the standard tumescent technique. The amount of fat aspirated from each region was recorded for all patients.

When the emulsion was allowed to settle for 7 days at room temperature, it was found to consist of 40% infiltration solution, blood, and serum (Figure 1).

Each patient was enrolled in a University of Pittsburgh Institutional Review Board certified study (IRB no. 97011) for preoperative and postoperative regional fat content assessment by use of body composition densitometry (Figure 2). Regional and total body fat content was calculated with DEXA. DEXA measurements were performed with a total body composition scanner (model DPX, Lunar Radiation Corp., Madison, WI). The Food and Drug Administration has given 510(K) approval to Lunar® for clinical applications of DEXA for body composition assessment. Current techniques for measuring body composition are indirect and depend on the physical properties or chemical constants of the body. DEXA uses a constant X-ray source and a k-edge filter, and the differential attenuation of soft tissue and bone mineral at the two energy levels is detected by the scanner. The calculation of fat content is then determined by the ratio of these measures. DEXA directly measures three principal chemical components of the body: fat mass of soft tissue, lean mass of soft tissue, and total-body bone mineral. Each scan requires 10 to 20 minutes. The radiation dose is minimal (about 0.02 μGy) and is roughly equivalent to that of a standard chest radiography procedure.

Studies have shown the DPX scanner to accurately measure fat content in meat samples and animal carcasses. The DPX model compares well with other noninvasive techniques such as hydrodensitometry in measuring fat content. It has been shown to measure fat content accurately in obese subjects in whom hydrodensitometry and other techniques have been less reliable. DEXA scanning has been shown to be highly accurate in calculating...
the fat content in the lower extremity, with accuracy reported as high as 96%.
However, in this same study DEXA scanning underestimated the fat content of the abdomen, with an accuracy of only 55%. The authors postulate that the inaccurate assessment in the truncal region may be related to "numerous bone regions interspersed with soft tissue, particularly in the area of the ribs, making the extrapolation process more complex and prone to error." In an effort to minimize this effect, our technique was later modified.

**Results**

The patients were all women and ranged in age from 25 to 57 years (mean 42 years). Follow-up ranged from 8 to 22 weeks, with a mean follow-up of 14 weeks. The average preoperative weight was 161.4 lb., and the average postoperative weight was 157.2 lb. The average change in weight was 4.2 lb., which was not statistically significant ($p > 0.05$). Preoperative and postoperative region-specific fat content was calculated for all patients with DEXA. The average change in region-specific fat content for all patients was then recorded (Table). There was a consistent reduction in fat content for each region except the abdomen. For patients 1 and 3 the actual amount of abdominal fat after surgery increased slightly, which is consistent with previous reports of inaccuracy in measuring the fat content of the abdomen. Currently our technique for measuring the fat content of the abdomen is being modified in an attempt to improve the accuracy of densitometry in the abdomen. The amount of fat aspirated from each region was determined by subtracting 40% from the total regional volume aspirated, which represented infiltration solution, blood, and serum. The average amount of fat aspirated for all patients from each region was compared with the change in fat demonstrated by preoperative and postoperative densitometer scans (Figure 3). The amount of fat aspirated (adjusted for the 40% of emulsion representing infiltration solution, blood, and serum) was consistently less than the fat reduction calculated by DEXA. The fat reduction as mea-

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**Table**

**Region-specific Change in Fat Content (in Grams) Calculated by DEXA for Each Patient**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Right Thigh</th>
<th>Left Thigh</th>
<th>Right Hip</th>
<th>Left Hip</th>
<th>Abdomen</th>
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Figure 5. Preoperative photos for patient 1: (A) frontal, (B) lateral, and (C) rear. Postoperative photos 5 months after ultrasound-assisted lipoplasty: (D) frontal, (E) lateral, and (F) rear.

Discussion

One of the advantages of DEXA scanning is that region-specific changes in fat can be calculated. For example, in patient 1 the lateral thigh and hip were examined as a unit (Figure 4). Before surgery the fat content was 2098 gm and 2348 gm on the right and left sides, respectively. The fat content after surgery was reduced by 30% and 25% for the right and left sides, respectively. The preoperative and postoperative photographs afford subjective comparison (Figure 5). In patient 2 the hips, abdomen,
Figure 6. Scans and analysis before and 5 months after surgery. A, Preoperative DEXA scan for patient 2 demonstrates 11,975 gm and 11,675 gm of fat for the right and left hip, abdomen, and medial and lateral thighs, respectively. B, After surgery the fat content was reduced to 7140 gm and 7006 gm for the right and left sides, respectively.

Figure 7. Preoperative photographs for patient 2: (A) frontal and (B) lateral. Postoperative photographs: (C) frontal and (D) lateral.

Figure 8. A merged three-dimensional image captured by the Virtuoso® shape camera, which is comparable to the photograph in Figure 5E.
versibly injured by heat generated by the ultrasound probe.

A Lunar DEXA scanner costs $150,000 and has only recently been approved for measuring fat content. The Cardiac Rehabilitation Center at the University of Pittsburgh charges us $80 for each scan. A more practical means of measuring regional volume and contour changes after body contouring surgery is the recently developed Virtuoso® shape camera (Visual Interface, Inc., Pittsburgh, PA), which digitally captures accurate shape and color information from eight different views (frontal, right oblique, right lateral, etc.). Acquired within milliseconds, each image is then anatomically registered and merged into a complete three-dimensional model. Similar to a reformatted computed tomography scan, but with color video lifelike quality, the model can be rotated on the video screen and segmented at will for regional volume measurements. The printout of the right lateral monitor view of Figure 5E is seen in Figure 8.

Figure 9 shows the superimposition of the preoperative and postoperative lateral views of this same patient. The shape camera calculation of the change in total volume between the costal margin and pubis is 2013 ml, which compares with a 1753 ml difference of the two DEXA scans. The 250 ml difference is related to an inability to precisely register the two images.

As technology advances and new techniques are introduced for body contouring, it is important to have objective methods of assessing results. DEXA can be used to assess objectively and quantitatively the results of ultrasound-assisted lipoplasty. The accuracy of measuring fat content for the lower extremity has been shown to be highly accurate. Although the accuracy of measuring abdominal fat content by DEXA at present is inconsistent, we are currently modifying our technique for this region. In our opinion body composition densitometry (DEXA) more accurately reflects region-specific changes in fat content than current outcome measures. Furthermore, it reflects not only the amount of fat aspirated at the time of surgery, but also subsequent loss of fat resulting from fat necrosis or resorption of emulsion. The reliability of the Virtuoso® shape camera for regional volume measurements is being studied.

References