

Sensory Changes after Traditional and Ultrasound-Assisted Liposuction Using Computer-Assisted Analysis

[Cosmetic]

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It should be noted that none of the authors have proprietary interest in the company that manufactures the Pressure Specified Sensory Device.

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Postoperative sensory changes (i.e., hypesthesias) that occur after suction-assisted lipoplasty (SAL) are expected clinical sequelae. These disturbances usually return to normal within several weeks to months postoperatively. The presumed mechanism of injury is direct trauma to the peripheral nerves from the suction cannula. In addition, the potential for demyelination of peripheral nerves secondary to cavitation during ultrasound-assisted liposuction (UAL) is well known. Quantitative data describing hypesthesia after both procedures are limited. The purpose of this study was to objectively evaluate the severity and duration of postoperative hypesthesia after liposuction to better educate patients preoperatively. Furthermore, the authors use the three-stage UAL technique and wanted to determine whether a clinical difference in sensory return existed between suction- and ultrasound-treated areas.

A total of 21 patients underwent liposuction performed by the senior author (R.J.R.). The abdomen, flanks, thighs, and medial knees were tested for objective sensation with the Pressure Specified Sensory Device preoperatively and at 2, 6, and 10 weeks postoperatively. A total of 102 sites were tested. On average, the SAL-treated areas improved to normal sensation by 6 weeks, whereas the UAL-treated areas took, on average, 10 weeks to recover. The severity of the hypesthesia was not correlated with larger aspiration volumes or longer UAL exposure time per site. At 10 weeks, 90 percent of UAL-treated patients and 89 percent of liposuction patients overall had recovered normal sensation. This study provides the body-contouring surgeon with good, objective data with which to educate patients regarding sensory return after liposuction.

Postoperative hypesthesia is a well-known sequela of traditional suction-assisted lipoplasty (SAL).^{1,2} Although permanent sensory changes are rare, hypesthesia is common.³ The incidence is reportedly as high as 18 percent, and cases have been known to persist for up to 6 years.⁴ Despite the frequency of this phenomenon, objective data are lacking because of the variability of measurements and the inherent difficulty of obtaining objective measurements of sensation in areas such as the abdomen and thighs.⁵ Previous reports have often been subjective in their descriptions of the degree and duration of sensory change. To date, the analysis by Courtiss and Donelan⁵ is the only prospective study that specifically addressed the issue of postoperative sensory changes. The authors concluded that return of sensory function was complete at 1 year and that suction lipectomy does not seem to cause permanent nerve damage.⁵ However, sensation was measured as an all-or-none response to painful stimulation, and the study did expose subtle differences. Therefore, many questions regarding the actual severity and duration of the hypesthesia remain unanswered.

Sensory loss after SAL is likely caused by mechanical trauma of the nerves from the liposuction cannula. In theory, when SAL is performed using a "tunneling" technique in the deep subcutaneous layer in conjunction with infiltration, it spares vessels, nerves, and other structures passing between the muscle fascia and skin.³ However, in vivo postoperative histologic studies of adipose tissue and liposuction aspirate provide evidence of nerve avulsion.^{6,7} The acceptance among body-contouring surgeons of ultrasound-assisted liposuction (UAL) as an excellent adjunct technique, especially in fibrous areas, opens the possibility of other causes for sensory disturbances. The mechanism of action of UAL is selective destruction of low-density adipose tissue through cavitation. This theoretically spares vascular, nervous, and connective tissue.⁸ However, both in vitro and in vivo studies have demonstrated that ultrasound exposure can cause temporary functional and histologic nerve damage.⁹⁻¹⁵ Demyelination of peripheral nerves has been demonstrated with direct exposure of the nerves to ultrasound energy.¹⁰⁻¹⁵

We use a three-stage UAL technique in conjunction with SAL¹⁶ (Table I). On the basis of our previous experience, we believed that an objective evaluation of postoperative sensory changes would provide beneficial data for preoperative patient education. To our knowledge, no such study has yet been conducted.

Stage	Treatment
I	Subcutaneous infiltration
II	Ultrasound treatment
III	Excisional/traditional treatment

TABLE I Three-Stage Ultrasound-Assisted Liposuction Technique

The purpose of this study was twofold. First, we wanted to evaluate objectively the severity and duration of postoperative sensory changes after our three-stage UAL procedure. We were specifically interested in

identifying existing correlations between the degree of hypesthesia and the volume aspirated, area treated, and total time of ultrasound exposure. Second, we wanted to compare these changes to those seen after traditional SAL and to determine if any significant differences exist between these two techniques.

Patients and Methods [TOP](#)

This prospective study examined 21 consecutive healthy patients who underwent liposuction at the University of Texas Southwestern Medical Center over a 5-month period from September of 1997 through February of 1998. Patients with significant medical problems or morbid obesity were not candidates for liposuction and were not offered surgery. The following areas were studied for sensory changes after treatment: abdomen, flanks, outer thighs, and medial knees. If a patient had prior liposuction or other surgery in a particular area, this area was not tested. The objectives of the study were explained to the patient during the preoperative evaluation. All patients were voluntary participants in the study. This study was approved by the University of Texas Southwestern Medical Center Institutional Review Board for human clinical studies.

All liposuction was performed under general anesthesia. Liposuction of the abdomen, outer thighs, and flanks was accomplished with our three-stage UAL technique. Stage I consists of uniform subcutaneous infiltration of wetting solution in a 1:1, or superwet,[17](#) ratio of infiltrate to aspirate. Stage II involves the performance of UAL in an intermediate to deep plane with a Lysonix 2000 ultrasound generator (maximum output 130 W) (Lysonix, Inc., Carpinteria, Calif.) operating at 23 kHz, with 50 to 60 percent of maximum power. This translates to an average of 60 to 70 W. A 5-mm, hollow, "square end" or "round end" titanium cannula and a standard surgical aspirator (Wells-Johnson, Tucson, Ariz.) operating at 0.5 atm were used. Stage III consists of evacuation and final contouring using traditional blunt-suction lipectomy with 3.0- or 3.7-mm cannulas.

Liposuction of the knees was performed with superwet infiltration and SAL only. This area served as a comparison for those treated by UAL.

Standard intraoperative data sheets were used to record UAL and SAL time (in minutes), volumes of wetting solution infiltrated, and total fat aspirated (in cc) for each area treated.

Objective preoperative and postoperative measurements of sensory function were taken on the medial abdomen, flanks, outer thighs, and medial knees ([Fig. 1](#)). The measurements were performed using the Pressure Specified Sensory Device (PSSD) (Sensory Management Services, Lutherville, Md.). This device consists of two prongs mounted on a computer-linked force transducer. Each of the prongs has a hemispherical end approximately 0.9 mm in diameter. The interprong distance may be adjusted by the examiner to a range of 2.5 to 20 mm, so that either one- or two-point discrimination may be tested. Division of the force of application by the cross-sectional area of the prong specifies the force applied in g/mm^2 . The examiner lowers the prong until it touches the patient's skin and continues to slowly increase the pressure; at the patient's first perception of the pressure, the patient pushes a button connected to the computer, which registers the force applied (in g/mm^2). The equipment has the capability of testing the threshold for pressure perception of both static (a measure of slowly adapting nerve fiber function) and moving (a measure of quickly adapting nerve fiber function) one- and two-point sensation.[18](#)



Fig. 1. Sites tested (photograph).

In all patients, the treated areas were tested for one-point static sensation preoperatively and at 2, 6, and 10 weeks postoperatively. For purposes of data analysis, the measurements of the left and right sites (i.e., left abdomen and right abdomen) were averaged to give a final value for the area (i.e., abdomen) tested in each patient. The intrinsic variability of a patient's response was controlled through preoperative and postoperative testing of an untreated area on the forearm. By averaging the variability of these two measurements in each individual patient, we created a window of normal variability. For part of the data analysis, this window was added to each preoperative measurement to generate a high normal measurement to which postoperative measurements could be compared.

Testing was performed in a quiet, distraction-free environment, with the patient positioned supine on an examining table. The patient was unable to see the computer screen during testing. Ten trials were performed on each area and averaged by the computer to generate a final value.

Patients were also evaluated for subjective sensory changes at each follow-up. Hypesthesia, dysesthesia (unpleasant, nonpainful, "pins and needles" sensation), hyperalgesia (heightened painful sensation to light touch), and neuromas were distinguished from one another.¹⁹

Statistical techniques used to analyze the data included paired *t* tests, Fisher's exact tests, Pearson's correlation, and Kendall's τ - β correlation. As our sample sizes were smaller than the 30 areas tested per group, an α of 0.1 was chosen, and all *p* values less than this number were considered significant. All statistical analysis was performed by the University of Texas Southwestern Medical Center Academic Computing Center.

Results [TOP](#)

Demographics [TOP](#)

A total of 21 healthy patients underwent liposuction, which included at least one of the following areas: medial abdomen, flank, outer thigh, or medial knee. Five of the patients were men, and 16 were women. The average age was 42 years (range, 30 to 57 years), with a standard deviation of 8.86 years. Average patient weight was 76.2 kg (range, 57 to 109 kg), with a standard deviation of 14.5 kg. A total of 102 sites (51 areas) were tested for static one-point sensation with the PSSD preoperatively ([Table II](#)). There were three predetermined postoperative follow-up periods (1, 2, and 3). The average time to follow-up 1 was 14 days (2 weeks), with a range of 9 to 21 days and a standard deviation of 3.6. The average time to follow-up 2 was 45 days (6.4 weeks), with a range of 39 to 51 days and a standard deviation of 4.3. The average time to follow-up 3 was 71 days (10.1 weeks), with a range of 40 to 90 days and a standard deviation of 16.5. Fifty-one areas (102 sites) in 21 patients were tested at follow-up 1. Forty-three areas (86 sites) in 16 patients were tested at follow-up 2. Forty-four areas (88 sites) in 16 patients were tested at follow-up 3 ([Table III](#)). One patient was lost to follow-up after the first check, one patient was lost to follow-up after the second check, and two patients missed follow-up 2 (although they were examined at follow-up 3). If a patient had both normal subjective and objective sensation of an area before follow-up 3, then testing of that area was discontinued. One patient had normal sensation in all areas tested at follow-up 1, and three patients had normal sensation at follow-up 2.

	Sites Tested (Left or Right)	Patients (Areas) Tested
Abdomen	34	17
Flank	28	14
Thigh	24	12
Knee	16	8
Total	102	51

TABLE II Sites and Areas Tested

Follow-Up	Average Time to Follow-Up	Number of Areas Tested ^a
1	14 ± 3.6 days	51 in 21 patients
2	45 ± 4.3 days	43 in 16 patients
3	71 ± 16.5 days	44 in 16 patients

TABLE III Follow-Up Information

^a An average of two areas was tested per patient.

The average number of sites tested per patient was four (average number of areas was two), with a range of two to eight (range of areas, one to four). The average total volume aspirated per patient was 4313 cc (range, 450 to 10,850 cc). The average total volume aspirated per site was 521 cc (range, 100 to 1163 cc). A summary of the volumes aspirated for each procedure and total volumes aspirated from each site can be seen in [Table IV](#). Average UAL aspiration time per site was 4.0 minutes (range, 0 to 11 minutes). Aspiration times for each site using each procedure are listed in [Table V](#).

Site Treated (Left or Right)	Average (range) Volume Aspirated (cc)		
	Total	SAL	UAL
Abdomen	522 (150-1100)	401 (125-775)	147 (25-490)
Flank	419 (115-990)	305 (85-750)	109 (35-225)
Thigh	536 (220-1140)	425 (150-880)	127 (50-225)
Knee	303 (130-520)	303 (130-520)	0

TABLE IV Average Volume Aspirated per Site

Site Treated (Left or Right)	Average (range) Time of Aspiration (min)		
	Total	SAL	UAL
Abdomen	10.5 (5.5-15.5)	10.5 (5.5-15.5)	10.5 (5.5-15.5)
Flank	10.5 (5.5-15.5)	10.5 (5.5-15.5)	10.5 (5.5-15.5)
Thigh	10.5 (5.5-15.5)	10.5 (5.5-15.5)	10.5 (5.5-15.5)
Knee	10.5 (5.5-15.5)	10.5 (5.5-15.5)	10.5 (5.5-15.5)

TABLE V Average Time of Aspiration per Site

Objective Hypesthesia [TOP](#)

The average overall preoperative threshold for pressure perception was 5.4 g/mm². Averages for individual areas are listed in [Table VI](#). They were not significantly different ($p > 0.1$ using a paired t test).

Area	Preoperative Sensation (Threshold for Pressure Perception in g/mm ²)	
	Average	Range (SD)
Abdomen	6.8	1.4-19.8 (5.4)
Flank	6.09	1.7-27.2 (9.5)
Thigh	5.9	1.8-15.2 (4.1)
Knee	5.0	2.3-10.0 (3.1)
Overall	5.4	1.4-27.2 (4.5)

TABLE VI Preoperative Sensation for Each Area

The trend of objective sensory measurement values over time is depicted in [Figure 2](#). At all follow-ups, the average threshold for pressure perception was lower for the SAL-treated areas (knees) than for the UAL-treated areas (thigh, flank, and abdomen). As calculated by paired t tests, these differences in sensation were statistically significant between the abdomen and knee at follow-up 1 ($p = 0.048$) and follow-up 3 ($p = 0.042$), between the thigh and knee at follow-up 1 ($p = 0.084$) and at follow-up 3 ($p = 0.006$), and between the flank and knee at follow-up 2 ($p = 0.025$) and at follow-up 3 ($p = 0.075$). Of all other collective permutations, the only other significant difference in sensation was between the abdomen and the thigh at follow-up 1 ($p = 0.026$). A comparison of all p values for an assessment of relative significance is given in [Table VII](#).

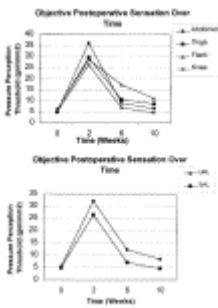


Fig. 2. (Above) Objective sensory measurement over time: specific areas. (Below) Objective sensory measurement over time: ultrasound-assisted (UAL) versus suction-assisted (SAL) liposuction.

Sites Compared	p Values* at Follow-Up		
	2 weeks	6 weeks	10 weeks
Abdomen versus thigh	0.02†	0.34	0.27
Abdomen versus flank	0.34	0.25	0.01
Abdomen versus knee	0.05†	0.15	0.04†
Thigh versus flank	0.96	0.17	0.75
Thigh versus knee	0.08†	0.17	0.006†
Flank versus knee	0.79	0.02†	0.08†

TABLE VII Correlations between Areas

Similarly, when all UAL-treated areas (abdomen, flanks, thighs) were compared as a group to SAL only-treated areas (knees), the SAL only-treated areas had consistently better sensation (lower pressure perception thresholds; [Fig. 2, below](#)), which was significantly better at 6 and 10 weeks ($p = 0.13, 0.03,$ and 0.03 for follow-ups 1, 2, and 3, respectively, using a paired t test).

The average of the variability of the control measurements for each individual was 5 g/mm². Therefore, 5 was considered a normal window; this value was added to the patient's preoperative value for the specific area tested to give a high normal value. Using this definition of normal sensation, the initial incidence of hypesthesia at 2 weeks was 79 percent in patients treated with UAL and 65 percent in those treated with SAL only. By 10 weeks, 90 percent of patients treated with UAL and 83 percent of those treated with SAL only had normal sensation; 89 percent of *all patients* treated by liposuction had normal sensation by 10 weeks.

A comparison of the volume removed and degree of sensory change revealed only three measurements that did seem to be significantly correlated: the abdomen at follow-up 1 (Pearson correlation coefficient = 0.47, $p = 0.055$), the thigh at follow-up 3 (Pearson correlation coefficient = 0.71, $p = 0.03$), and the knee at follow-up 3 (Pearson correlation coefficient = 0.79, $p = 0.1$). Overall, there was not a strongly positive correlation between the total volume aspirated from a site and the degree of postoperative objective hypesthesia.

Subjective Hypesthesia [TOP](#)

Patients were evaluated for subjective hypesthesia, the incidence of which is depicted in [Figure 3](#). Although for the first two follow-ups a consistently smaller percentage of patients reported numbness of the knees, because of the small number of patients, the incidence of subjective hypesthesia of the knee was not significantly less than that of the abdomen, flank, or thigh at any follow-up ($p > 0.1$ using Fisher's exact test, 2-tailed).

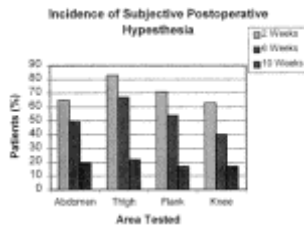


Fig. 3. Incidence of subjective hypesthesia.

The flank was the only area tested where increased UAL aspiration time and total volume aspirated worsened postoperative subjective hypesthesia. At follow-up 1, subjective hypesthesia of the flank was significantly correlated with UAL time (Kendall τ - β correlation coefficient = 0.349, $p = 0.092$) and total volume aspirated (Kendall τ - β correlation coefficient = 0.45, $p = 0.034$).

No patients developed neuromas. Two patients developed paresthesias of the abdomen; one resolved within 10 weeks and one resolved at 12 weeks. Another patient had hyperalgesia of the flank, which resolved at 12 weeks.

Discussion [TOP](#)

Postoperative hypesthesia, usually temporary, although in some cases persistent,²⁰ has clearly been documented as a common sequelae of SAL.^{1,3,20} It has been suggested that UAL may be associated with more prolonged or severe sensory changes.²¹ However, to date, there has been no objective study measuring the actual severity and duration of postoperative hypesthesia. One reason for this paucity of data is the lack of convenient objective sensory testing techniques. The method used in this study, computer-assisted quantitative sensory testing, is more sensitive in the diagnosis of peripheral nerve entrapment than electrodiagnostic testing, as shown by testing for carpal and tarsal tunnel syndrome.²² The PSSD specifically tests A- β nerve fibers, the large diameter fibers that innervate pressure-detecting skin organs.²³ Earlier studies by Dellon et al.¹⁸ established a normal pressure threshold for the fingertip of 1 g/mm². Although it has been used principally for evaluating sensibility in the hand and foot, the device is capable of measuring pressure perception for any body surface.²² In this study, we used the PSSD to generate an average normal pressure threshold for the nonglabrous hairy skin of the abdomen, flanks, thighs, and knees of 5.4 g/mm.²

Mechanism of Nerve Injury [TOP](#)

There are two possible mechanisms for the pathologic reactions of peripheral nerves after liposuction.

Axonal degeneration and regeneration (Wallerian degeneration). This is the presumed mechanism of nerve damage resulting from SAL. It seems that the cannula causes direct trauma to the axons. The presence of nerve fragments in the aspirated fat has been documented.⁶ When an axon in a peripheral nerve is injured—because of direct trauma, ischemia, or entrapment—the distal aspect undergoes Wallerian degeneration. Regeneration occurs from the proximal stump, with growth toward the sensory end organ at a rate of 1 to

2.5 mm/day.²⁴ Carpaneda⁷ demonstrated, with an in vivo study, that although partial preservation of nerves is present, extensive tissue irregularity and scar formation also occur. These latter conditions could potentially alter the anatomical pathway and impede the success of nerve regeneration. He suggests that changes in sensation postoperatively may not only be caused by direct nerve damage, but also by involvement of the nerves in the healing process, or formation of neuromas.⁷

Demyelination and remyelination. Demyelination may be caused by interference with Schwann cell metabolism (macrophages are involved in the destruction of myelin debris) or an immunologic attack on the peripheral nerve myelin by lymphocytes and macrophages. With the exception of severe demyelinating neuropathies, the axon remains intact, and remyelination is rapid (well-advanced by 2 weeks) with restoration of nerve function.²⁴ The cavitation effect of ultrasound-assisted liposuction is targeted at low density adipocytes.⁸ However, some peripheral nerves are insulated by myelin, which is 75 percent lipid, and demyelination has been implicated as a cause of hypesthesia after UAL.²¹ Disruption of the myelin sheath has been demonstrated in neonatal rats exposed to diagnostic levels of ultrasound.¹⁰

The Cavitron ultrasonic surgical aspirator (CUSA), introduced in 1976,²⁵ has been used successfully as a surgical dissecting instrument in general, neurologic, and urologic surgery.²⁵⁻²⁸ Like current UAL equipment, it is a high-frequency ultrasound device, which oscillates longitudinally at 23 kHz and destroys tissue through cavitation.⁹ This device's effects on nerve structures have been extensively studied in both laboratory and clinical settings.^{9,11-14} In an initial study by Flamm⁹ in the cat model, placement of the CUSA probe tip 2 to 3 mm from the spinal cord for 30 minutes resulted in histologic alterations, including hemorrhage, edema, and glial scarring. For most of the animals, recovery to walking took at least 6 weeks, and three animals remained paraplegic. However, the authors admitted that this protocol represented an unrealistically extreme situation of prolonged, uninterrupted application of the CUSA to nerve structures. The authors concluded that although the potential for damage is present, it is unlikely to occur when the instrument is used in the clinical setting. A later study by Young et al.¹¹ demonstrated edema and disruption of nerve fibers in a 100- μ m transition zone from the probe tip after rat sciatic nerves were exposed to the CUSA probe tip. If the probe tip even momentarily touched a nerve with a diameter of 0.5 mm or less, the nerve would be destroyed. However, loss of the action potential required direct contact with the probe tip. Gleeson and Felix¹² documented disruption of the perineurium, diffuse hemorrhage, edema, and disruption of the myelin sheaths when a rat facial nerve was dissected using the CUSA at 30 percent of maximum power (approximately 21 W). These degenerative changes were even more severe in those nerves exposed to both ultrasound and suction. Despite these histologic findings, facial nerve function was normal by postoperative day 1 in those rats treated by ultrasound alone. Seventy-five percent of rats treated with both suction and ultrasound had normal function by 2 weeks. At 11 to 17 days, postoperatively harvested nerves showed evidence of active remyelination. A clinical study by this same group on the human greater auricular nerve documented similar histologic changes, with damage limited to 1.5 mm from the probe tip.¹³

Three months after dissection of a rat femoral nerve with the CUSA, Fischer et al.¹⁴ found histologic changes (scarring, loss of nerve substance, and disruption of the myelin sheath) and persistence of nerve conduction delay. However, clinical assessment of nerve function was not performed.

In a recent study at our own institution, we evaluated both the histologic and functional effects of UAL on peripheral nerves in a rat model.¹⁵ The UAL cannula was directly applied to the rat sciatic nerve with the ultrasound generator set at varying amplitudes and with varying passes. Immediate gross changes, including focal areas of epineural sheath hemorrhage, fat destruction, and muscle tissue contraction, were limited to within 1 mm of the treated nerve and occurred only in groups exposed to amplitudes above clinical use. Significantly, by 11 weeks, all groups had returned to normal or near-normal function. Histologically, there was evidence of disrupted architecture and massive infiltration of foamy histiocytes only in the most severely injured group. This picture of chronic inflammation is consistent with a regenerative process, implying demyelination and remyelination. A direct correlation between the amplitude/number of passes and the extent of nerve injury (as measured by the sciatic function index) was established.¹⁵

Overall, a number of studies have shown that cavitating ultrasound energy has the potential to cause both functional and histologic nerve damage. However, the clinical correlation of most of these studies is unclear and cannot be directly applied to the use of UAL. Of note, the only experiments performed with a UAL probe itself produced reversible damage only in settings above clinical applicability.

In addition to demyelination, it has been suggested that UAL might cause tissue destruction by generating high subcutaneous temperatures. Ultrasound energy-induced hyperthermia reportedly caused damage to

the endothelium of blood vessels in a pig model.²⁹ However, Ablaza et al.³⁰ showed that the thermal effects of ultrasound can be nearly eliminated by the use of cool tumescent fluid at operating room temperatures (21°C) and constant movement of the probe tip. Additionally, UAL treatment times have decreased since the treatment was first introduced, and subcutaneous thermal buildup is less likely.¹⁶

Clinical Applications [TOP](#)

Data regarding postoperative sensory changes after UAL are limited, because reports of the clinical use of UAL in the United States are only now being published. Rohrich et al.,¹⁶ in a series of 114 patients treated with UAL over a 13-month period, reported only two patients who had painful dysesthesias. Both of these complaints resolved within 8 weeks. There were no motor disturbances. Maxwell and Gingrass³¹ reported only one dysesthesia (which resolved within 2 weeks) in a series of 250 patients. In their recent series of 100 patients, Fodor and Watson³² found no difference in postoperative sensory changes between ultrasound- or suction-treated areas. However, Sheflan and Tazi,²¹ using longer treatment times, reported a 6 percent incidence of sensory alteration and prolonged paresthesias and dysesthesias after UAL use when compared with SAL.

The results of our study are comparable, but they are more quantitative than those previously published. We found that, with the use of our three-stage UAL technique, most patients (79 percent) will have hypesthesia. This sensory disturbance peaks at approximately 2 weeks postoperatively, but it follows an overall trend to normal sensation (90 percent of patients) by 10 weeks. In contrast, Courtiss and Donelan⁵ reported a return to normal sensation in 6 to 8 months. Additionally, unlike Courtiss and Donelan, we did not find a strong correlation between larger aspiration volumes and severity of sensory change. This difference may arise because the sensory loss from SAL is caused by direct mechanical trauma to the nerve from a cannula, whereas the focal effects of the ultrasound do not extend more than 1 to 2 mm from the probe tip and may not build up a diffuse cumulative effect.

There was no correlation of increased sensory loss with longer UAL treatment time using our current UAL treatment parameters. Gleeson et al.¹³ previously reported that the extent of nerve damage did not seem to be proportional to either the duration of CUSA contact or the power output setting of the probe. This may be because of the localized effects of both cannula-induced trauma and ultrasound.

One significant finding is the prolonged recovery time of UAL-treated areas compared with SAL-only treated areas. At follow-up 1, the average pressure threshold for one-point static sensation in the SAL-treated sites was 26.4 g/mm², whereas in the UAL-treated sites, it was 32.5 g/mm². This difference was not statistically significant ($p = 0.13$ using the paired t test). These values demonstrate an obvious abnormality of sensation—approximately a five- to sixfold hypesthesia. By 6 weeks, sensation was significantly different; the pressure thresholds were 12.2 g/mm² in UAL-treated sites and 7.0 g/mm² in SAL only-treated sites ($p = 0.03$ using the paired t test.) If the window of normal variation (5 g/mm²) is applied to the average normal preoperative value (5.4 g/mm²), then the upper limit of normal sensation is 10.4 g/mm². Therefore, sensation at 6 weeks of SAL only-treated sites (7.0 g/mm²) but not of UAL-treated sites falls in the range of normal sensation. At 10 weeks, sensation was still significantly better in the SAL only-treated sites (4.6 versus 10.0 g/mm² in the UAL-treated sites; $p = 0.03$ using a two-tailed t test), but both treatments had values within the normal range. Therefore, it seems that, on average, sites treated with SAL only tend to improve to normal within 6 weeks, whereas those treated with both UAL and SAL improve by 10 weeks. Although the recovery time to normal sensation may be prolonged with the use of UAL, the overall clinical outcome is comparable to that of SAL. Therefore, any additional peripheral nerve damage incurred by ultrasound, as clinically assessed postoperatively in the setting of UAL, seems to be temporary and minor.

The smaller percentage of SAL only-treated sites with normal sensation at 10 weeks is misleading and is probably caused by the smaller sample size (16 SAL-treated versus 86 UAL-treated sites).

There were no significant differences in the subjective sensation of UAL-treated sites when compared with SAL-treated sites. The differences detected by the PSSD proved that it was more sensitive than the patient's subjective assessment. The minor added effect the ultrasound has on hypesthesia was not noticeable to the patient. Therefore, it may be clinically insignificant.

Of course, these conclusions can only be applied to the range of volumes aspirated (100 to 1100 cc) and UAL-treatment times (2 minutes, 18 seconds to 11 minutes) used per site in this study. It should be

emphasized that site refers to left or right area; for the entire abdomen, the maximum total volume removed was 2200 cc, and the maximum UAL treatment time was 22 minutes. It is important that the surgeon using UAL is experienced enough to use the equipment efficiently and, thereby, limit treatment times and energy. Since our earliest series of UAL patients, we have decreased our UAL treatment times significantly.[16](#)

We can safely say that, when UAL is performed by experienced surgeons, the incidence of painful neurologic sequelae is rare. In 86 UAL-treated sites, our incidence of neuromas was 0, our incidence of hyperalgesia was 1.2 percent ($n = 1$), and our incidence of dysesthesias was 2.3 percent ($n = 2$). Theoretically, in liposuction, scar formation in the subcutaneous tissue might prevent regenerating nerve fibers from making appropriate distal connections, resulting in painful neuromas. On the basis of our data, this does not seem to be common. The one patient who developed hyperalgesia of the flank was a police officer who wore a holster with a gun constantly pressing against the operative site. Dysesthesias may be experienced while the distal nerve fibers are regenerating.[19](#)

In conclusion, this study has enabled us to answer questions about sensory changes that occur with liposuction in our preoperative patient counseling. We can tell our patients that, although the majority of those who undergo UAL will experience some degree of postoperative hypesthesia, on average, 83 percent of patients treated with SAL-only and 90 percent of patients treated with UAL will have normal sensation within 10 weeks, regardless of volume removed. Furthermore, although UAL-treated areas may have a slightly prolonged recovery time, the difference between UAL-and SAL-treated areas is clinically undetectable. Finally, we can assure our patients that painful nerve sequelae are rare using either technique.

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