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ORIGINAL ARTICLE BODY CONTOURING

Safety and Efficacy of Third-Generation Ultrasound-Assisted Liposuction: A Series of 261 Cases

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Abstract

Background The introduction of third-generation ultrasound-assisted liposuction (3rd UAL) allows for a less invasive modality of both deep and superficial lipectomy while offering improved skin retraction and reduced rate of complications. This study examined the efficacy and safety profile of this technology over 15 years of clinical experience.

Methods A consecutive series of patients treated from 2005–2020 by the senior author were reviewed for demographic and anthropometric measurements, intraoperative settings, surgical outcomes, and complications via retrospective chart review. Body-Q survey was used to assess patient satisfaction.

Results A total of 261 patients underwent 3rd UAL in 783 areas. There were 238 female and 23 male patients with an average age of 43.5 years and BMI of 27.4 kg/m^2. The most frequently treated areas were the trunk and lower limbs. An average of 2840 mL of wetting solution was used with an average of 2284 mL of lipocrit aspirate. About 65% of the cases were done in conjunction with another procedure. Overall complication rate was 4.6%, contour irregularity (1.9%), seroma (0.8%), cellulitis (0.8%), pigmentation changes (0.4%), and electrolyte imbalance (0.4%), with a minimum follow-up of 6 months. 78% of patient would undergo the procedure again and 86% would recommend it.

Conclusion Third-generation ultrasound-assisted liposuction can be used effectively and safely, either alone, or in conjunction with other plastic surgery procedures. VASER liposuction allows surgeons to address superficial fat plane and enhanced skin tightening. Rate of complications are lower than that of traditional liposuction with equivalent or higher patient satisfaction.

Level of Evidence IV This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Liposuction · Suction assisted lipectomy (SAL) · Pneumatic assisted lipectomy (PAL) · Ultrasound-assisted lipectomy (UAL) · VASER · Body contouring · Lipoplasty · Liposculpting · Combined liposuction · Safety

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Background

Liposuction was the second most common plastic surgery procedure in the USA in 2019 [1]. The evolution of liposuction included the incorporation of various technologies to maximize aesthetic results while reducing complications and surgeon fatigue [2].

Though both standard-assisted liposuction (SAL) and pneumatic-assisted liposuction (PAL) provide satisfactory results, in order to avoid a contour irregularity, a superficial layer of adipose tissue is often spared [3, 4]. Moreover,

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these modalities do not satisfactorily address the skin laxity which often results from lipectomy, especially in large volume cases [3].

Ultrasound-assisted lipectomy (UAL) was first reported in the 1990s as a fat emulsification technique including the superficial adipose layer. This allowed for less invasive lipectomy as it specifically disrupted adipose tissues while avoiding trauma on blood vessels [5, 6]. While the addition of heat allows for superficial emulsification in the subdermal plane leading to subsequently enhanced skin retraction, it can also cause severe thermal injuries, skin necrosis, and other complications [3]. Multiple subsequent design improvements including lower pulsed power, smaller solid titanium probes, and avoidance of protective wetting solution during emulsification were made. These improvements have led to the third-generation UAL device, VASER (vibration amplification of sound energy at resonance) (Sound Surgical Technologies LLC, Louisville, CO) [5–7]. Such innovations make VASER a highly effective, less invasive, lipectomy modality with an acceptable safety profile.

Previous studies have been performed assessing the safety and efficacy of this modality of liposculpting [3, 5, 6, 8]. An early 2002 study of 77 patients had zero major complications, demonstrating the improved safety profile of VASER in comparison with earlier modalities [5]. In a later retrospective study of 306 VASER patients, only 20 experienced seroma, 9 port site burns and 5 prolonged edema [3]. A large study of 660 UAL patients yielded a complication rate of 1.9% with zero severe adverse events [8]. In addition to validation of safety and efficacy through outcome measurement, we aim to report patient reported outcomes via a validated survey module (Figs. 1, 2 and 3).

The objective of this study is to assess the efficacy, safety profile and patient satisfaction of this approach to liposuction utilizing data from 15 years of clinical practice. In our experience, appropriate patient selection is the key to success. Our findings demonstrate VASER lipectomy to be efficacious in addressing both deep plane and superficial plane fat, allow for enhanced skin retraction, and most importantly exhibit an excellent safety profile.

Patients and Methods

Patient Selection

Candidates for VASER liposuction are those with good skin tone, localized fat, and most importantly realistic expectations. Patients with severe muscle laxity, striae distensae, and hanging skin are excluded. All patients were screened with a thorough history and physical exam to detect any serious underlying contraindications such as abdominal hernia, severe diastasis recti, as well as cardiovascular, renal, hepatic, and thyroid disease. Current or recent tobacco use was generally a contraindication for this procedure (Figs. 4, 5 and 6).

Surgical Techniques

All cases were done by senior author (M.A.) between 2005 and 2020, under general anesthesia at an accredited surgical facility. Patients were instructed to take Vitamin K for 5 days prior to surgery and Arnica tablets for 2 days prior to surgery. Aspirin and anticoagulation products were to be stopped for 2 weeks prior to surgery. Patients who were prone to bruising may also require tranexamic acid [9]. The targeted treatment areas were marked the day before surgery in both standing and sitting positions. A three-color coding system was used: (1) blue circles marked areas of lipodystrophy to be suctioned while blue lines indicated areas of tapering, (2) red lines designated areas of depression, creases, and lines that may need to be released, and (3) green markings signify areas to be fat grafted with blue circles. Infiltration of both deep and superficial levels was performed with a solution of 1000 mL lactated ringer with 20 mL of 1% lidocaine and 2 mL of 1/1000 epinephrine using super-wet technique. Skin protectors was applied to each access point. The skin surface was covered with folded wet towels to avoid exposure to the vibrating probe. Targeted areas were approached from both above and below entry points (Tables 1, 2 and 3).

Pre-tunneling was performed with a 4.6-mm or 3.7-mm blunt cannula to mix the wetting solution and allow time for epinephrine to take effect. Deep plane emulsification was first performed with a 3.7-mm 2 groove probe at 80% power in continuous mode at a duration of 1 min per each 100 mL infiltration. The superficial layer was then targeted with a 3.7-mm 3 groove probe at 70% power in VASER mode. During emulsification, a fanning technique with gentle, smooth, long strokes, was used to cover the entire region. Room temperature saline was applied frequently during emulsification to keep the area cool and moist. Loss of resistance while passing the probe served as a signifier of therapy completion in that area. Areas of fat that were not emulsified would be broken down with a 5.2-mm Mercedes cannula off suction. Following emulsification, evacuation is performed with a collection of 4.6-mm, 3.7-mm, and 3.0-mm cannulas to ensure the treated surface has uniform thickness. A pinch test was performed at the conclusion of the case to ensure a uniform 2 cm thickness taken into consideration the residual infiltrated fluid. Furthermore, it is important not to remove all the fat layers as it can result in scarring of the dermis. Stab incisions were

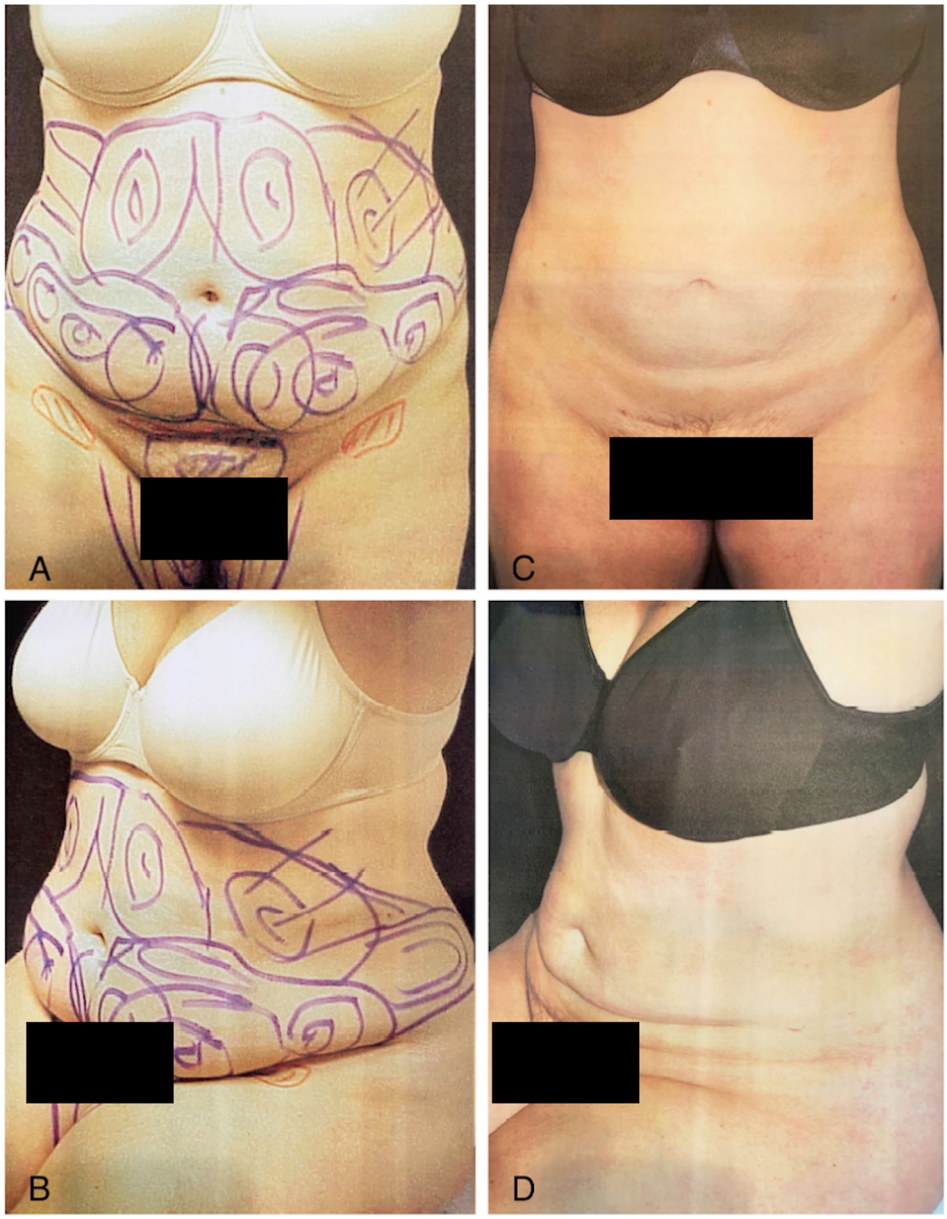

Fig. 1 Four months after VASER liposuction. 25-year-old woman, height 5'4", weight 150 pounds, BMI 26. Four months after reduction mammoplasty and VASER liposuction of abdomen, flanks, back, lateral chest walls. **a**, **b**—Before; **c**, **d**—after

then closed with 5-0 nylon sutures, and the patient was fitted with a compression girdle while still under general anesthesia. The amount of intravenous fluid plus infiltration was just enough to prevent thermal injuries

Patient continued wearing compression girdle with Epifoam (Biodermis, Henderson, NV) padding during recovery. Rehydration was encouraged including electrolytic fluids. We did not use any venous thromboembolism (VTE) chemoprophylaxis, but rather sequential compression devices, frequent lower extremity passive range of motion, and mandatory early ambulation on postoperative day zero. Oral antibiotics were prescribed for four days after surgery. Short courses of oxycodone-acetaminophen or acetaminophen-codeine phosphate were used for pain control. No endermologie for 5–6 weeks until the patient was completely healed.

Outcomes

Patient demographic and anthropometric information were collected. Intraoperative settings as well as infusate and lipocrit volumes were also documented. Postoperative complications were noted with a minimum follow-up period of 6 months.

Fig. 2 Ten months after VASER liposuction. 36-year-old woman, height 5'2", weight 140 pounds, BMI 26. Had prior liposuction and breast augmentation with a different surgeon. Here is 10 months after VASER liposuction of abdomen, flanks, back, arms. **a**, **b**—Before; **c**, **d**—after

Skin Retraction Measurement

A skin retraction test was performed in 20 patients in which a 10 cm × 10 cm square was marked on treated area with nylon sutures and permanent marking pens. The square was then measured immediately after VASER liposuction intraoperatively and subsequently at every follow-up visit until the nylon sutures were removed. The authors report no commercial associations or study funding with VASER industry.

Body-Q Survey

Body-Q survey was also conducted during the postoperative period to generate a better understanding of patient satisfaction after the procedure [10]. Survey questions focused largely on the patient's sentiment towards the aesthetic appearance of their body as well as their interactions with the plastic surgery team and office staff. Lastly, patients were asked the likelihood of undergoing this same procedure and if they would recommend this procedure to a friend.

Results

A total of 261 patients underwent VASER liposuction in 783 areas. There were 238 female and 23 male patients with an average age of 43.5 years and BMI of 27.4 kg/m^2.

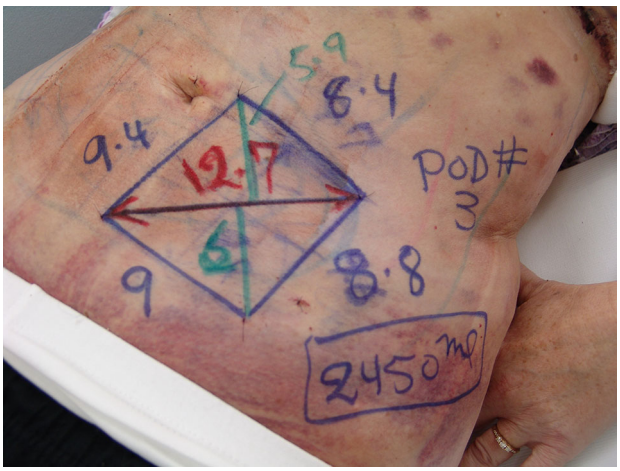

Fig. 3 Skin retraction test. Image demonstrating technique utilized to perform skin retraction test. Nylon sutures indicate a square measuring 10 cm × 10 cm. The area measured is the sum of the two triangles displayed. In this image, the area measured is [12.7 × (6+5.9)/2) = 75.565 cm^2]. Area of skin retraction is calculated as the difference between the two [100 cm^2–75.6 cm^2 = 24.4 cm^2 or 24.4%]

Treatment areas were divided into trunk, extremity, and other. Among areas of the trunk, the flank (199, 25.42%), abdomen (149, 19.03%) and back (116, 14.81%) were the most commonly treated areas. The lateral chest comprised a smaller amount (35, 4.47%). The lower extremity (216, 27.59%) was treated more frequently than the upper extremity (34, 4.34%). Other treatment sites comprised a small minority of overall treatments and included the pubic area (20, 2.55%), neck (9, 1.15%), sacral (0.51%), and submental (1, 0.13%). An average of 2840 mL of wetting solution/infusate was used with a returned 2284 mL of lipocrit. About 65% of the cases were done in conjunction with at least another procedure such as reduction mammoplasty, augmentation mammoplasty, and fat grafting to buttocks. There were 44 cases (16.9%) of large volume liposuction (> 4 L). Incidence of a complication was 4.6% and was composed of contour irregularity (n = 5, 1.9%), seroma (n = 2, 0.8%), cellulitis (n = 2, 0.8%), pigmentation changes (n = 1, 0.4%), electrolyte imbalance (n = 1, 0.4%) with a minimum follow-up of 6 months. There were no major complications involving thermal injuries, skin necrosis, or solid organ injuries. There was also no incidence of deep venous thrombosis or venous

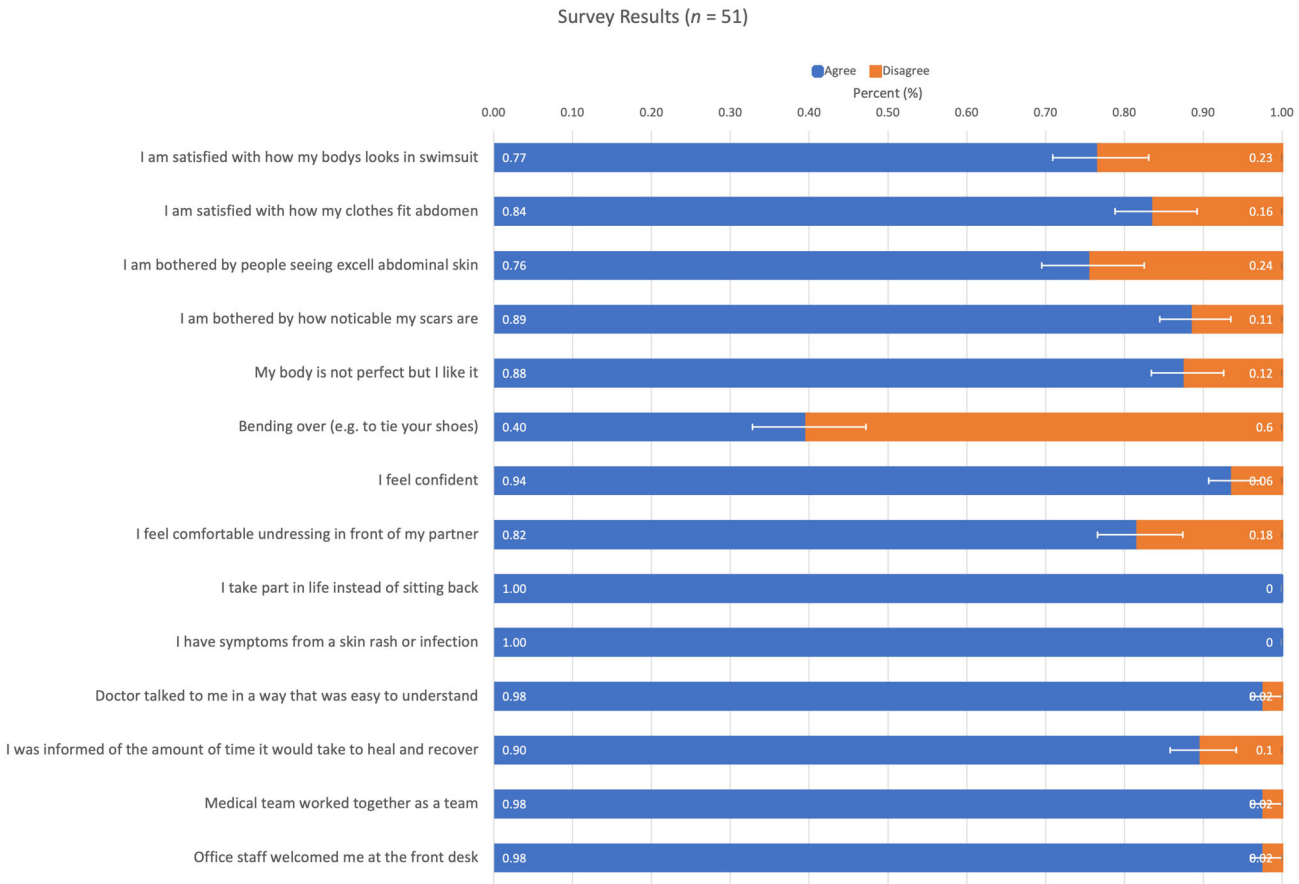

Fig. 4 Overall survey results. Results of the overall patient survey assessing satisfaction utilizing the BODY-Q questionnaire

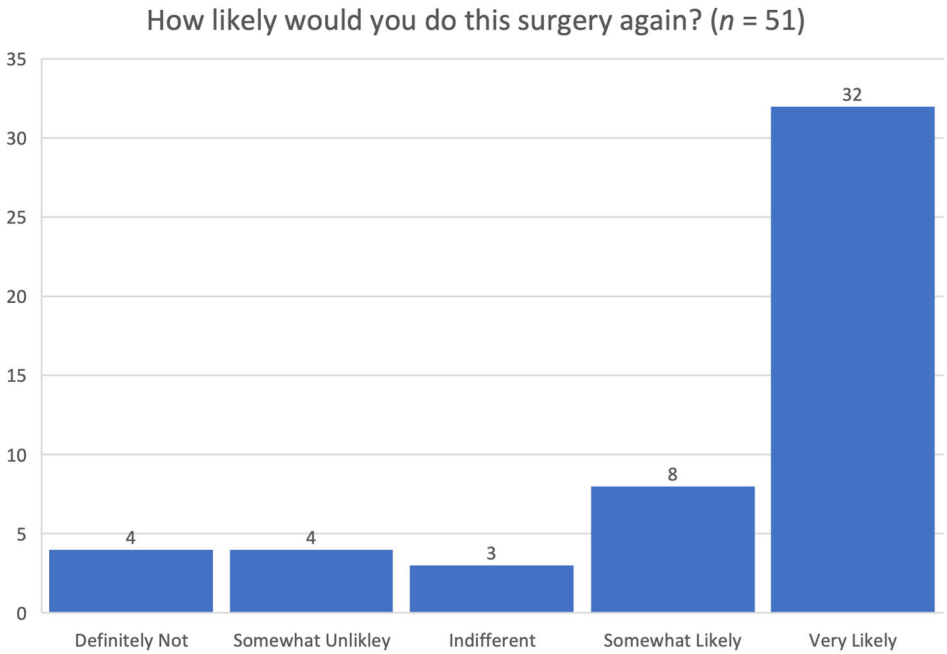

Fig. 5 Repeat procedure survey results. Results of patient survey assessing willingness to undergo the same procedure

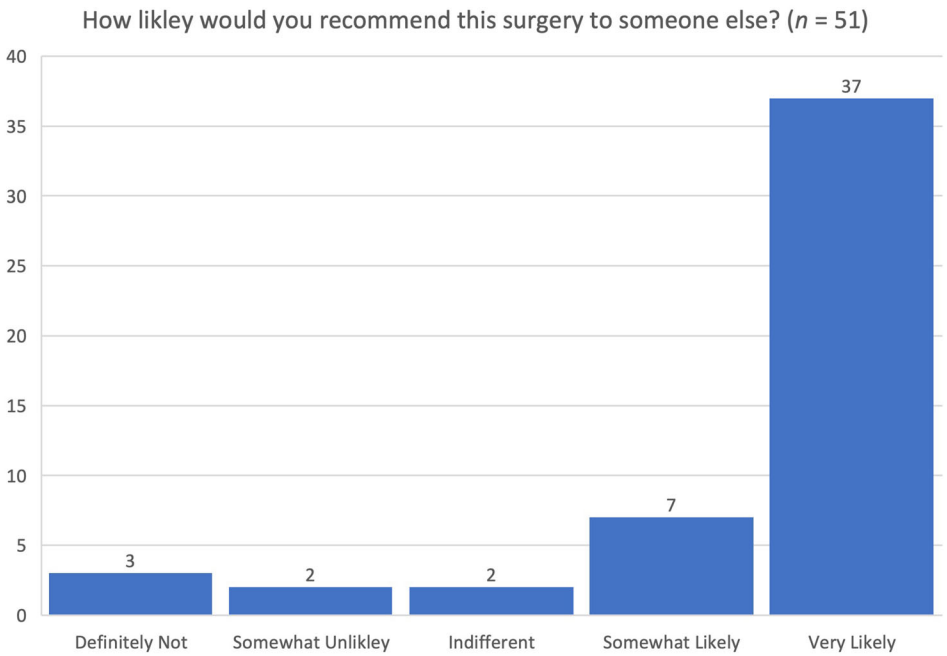

Fig. 6 Recommend procedure survey results. Results of patient survey assessing willingness to recommend the procedure to others

thromboembolism (VTE) in our series. A skin retraction test measured a range of 15–35% reduction

A total of 51 patients completed the survey in its entirety. Of note, 77% of patients stated that they felt comfortable wearing a swimsuit, 84% of patients were satisfied with how clothes fit their abdomen and 94% described themselves as feeling confident about their bodies. Only 24% stated they were bothered by people seeing excess abdominal skin, and 11% stated that they were unhappy with the appearance of their scars. 78% of patients stated that they would undergo this procedure again (62.7% very likely, 15.7% somewhat likely) and 86% of patients would recommend this procedure to a friend (72.5% very likely, 13.7% somewhat likely).

Table 1 Patient demographics

Number of patients	261
Number of treated areas	783
Average age (years)	43.5
Sex (female/male)	238/23
Body mass index, BMI (kg/m^2)	27.4

Discussion

In our series of 261 cases of third-generation UAL with VASER liposuction, we encountered small number of minor complications despite a large number of treated areas and volume of lipocrit aspirate. Further, our series documented a significant percentage of skin retraction even in early stages of recovery.

Liposuction is often combined with other procedures and has been reported to increase primary operation complication rates, specifically hematoma (0.15% → 0.6%), surgical site infection (0.1% → 0.7%), pulmonary complications (0.1% → 0.2%), and VTE (0.19% → 0.6%) [11]. We did not notice such trend in our series despite a significant number of combined cases (n = 170, 65%). We had two cases of puncture site cellulitis (0.8%) but no cases of hematoma or VTE. We specifically do not use chemoprophylaxis but utilize a strict mechanical prophylaxis (sequential compression device, q1 hour passive range of motion of lower extremity intraoperatively) and early ambulation for VTE prevention. Without the use of chemoprophylaxis and the addition of tranexamic acid, we have recorded no VTE, a significant reduction in blood loss and hematoma formation.

Third-generation UAL devices such as VASER allow for a greater fragmentation of adipocytes by using pulsed rather than continuous energy, at lower settings, resulting in lower rate of thermal complications [3, 12]. The VASER probes are variable with 1–5 groove tips, providing greater versatility and precision [6, 13, 14]. In general, more grooves provide greater emulsification efficacy whereas fewer grooves provide better performance at sites with more fibrous tissue. Additionally, the VASER System offers a choice of continuous or pulsating mode, enabling the surgeon to tailor the approach according to the extent of fibrosis [3, 5, 6, 12, 15–21]. Continuous mode is appropriate for general use (more fibrous tissue) and higher speed fragmentation. The pulsating mode is appropriate for softer tissues and applications in which finer sculpting is required. Furthermore, VASER liposuction employs ultrasonic energy to deliver a highly selective tissue lipolysis [6, 13].

Cavitation formation of air bubbles in tumescent fluid results in a crow-bar effect of streaming fat cells and adipocyte-derived stem cells which can be used subsequently for fat grafting [22]. This cavitation effect also helps decrease blood loss and operative time while providing less ecchymosis and discomfort, as well as improved contour in rather fibrous areas such as back and chest [22]. Prior studies have noted decreased blood loss, more lipoextraction,

Table 2 Intraoperative details

Treatment areas	Number	Percentage
Trunk		
Flank	199	25.42%
Abdomen	149	19.03%
Back	116	14.81%
Lateral Chest	35	4.47%
Extremity		
Upper	34	4.34%
Lower	216	27.59%
Other		
Pubic	20	2.55%
Neck	9	1.15%
Sacral	4	0.51%
Submental	1	0.13%
Total	783	100%
Average lipocrit volume (mL)	2284	
Average infusate volume (mL)	2840	
Average intravenous fluid	2951	
Number of combined cases	169	64.7%
Number of cases with > 4 L of lipocrit aspirate	44	16.9%

Table 3 Complications (incidence/Total number of patients)

Complication	Number	Percentage
Contour irregularities	5	1.9%
Seroma	2	0.8%
Cellulitis/infections	2	0.8%
Pigmentation changes	1	0.4%
Electrolyte imbalance	1	0.4%
Puncture site skin retraction	1	0.4%
Thermal injuries	0	0.0%
Skin necrosis	0	0.0%
Dysesthesia	0	0.0%
Prolonged edema	0	0.0%
Visceral organ injury	0	0.0%
VTE	0	0.0%
Overall complications	12	4.6%

enhanced contour definition and skin retraction, faster and less painful recovery, and an overall higher rate of patient satisfaction compared to other modalities [3, 5–7, 12, 14–19, 21, 23–27].

The complication rate among patients undergoing third-generation UAL in this study was 4.6%. This is significantly lower than the rate among larger studies assessing complication rate among all forms of liposuction. A 2010 study comprising 2,398 liposuction patients demonstrated a complication rate of 8.6% [28]. Contour irregularity and seroma formation were the most common complications among our patient population. However, the rate of occurrence was significantly lower than that seen in many other studies of liposuction [29]. Furthermore, our study reported zero cases of hematoma or VTE, which are rare but significant complications of liposuction. A prospective cohort study found that these complications occurred at rates of 0.15% and 0.6%, respectively, in patients undergoing liposuction [11].

For patient with contour irregularities, we encourage early massages and only proceed with correction with lipofilling at a year. Two patients with seroma were successfully treated with in-office aspiration and compression. Incision site cellulitis was treated with oral antibiotics and close observation until symptoms resolved. One patient with entry site pigmentation changes was treated with laser with good result. One patient had symptomatic hyponatremia after large volume liposuction circumferentially. She was admitted overnight and was treated successfully with intravenous hydration. It has become our practice to keep large volume liposuction patients (defined as > 5 L of lipoaspirate) overnight for intravenous resuscitation and electrolyte monitoring.

Regarding patient satisfaction, third-generation UAL patients experienced equivalent or greater satisfaction rates as compared to liposuction patients as a whole. There is limited data available on the satisfaction rates of patients undergoing first or second-generation ultrasound-assisted liposuction, making comparison among generations difficult. A similar postoperative questionnaire collection of liposuction patients found that 79.7% of patients would have the procedure done again and 86% would recommend to family and friends [30]. This is nearly equivalent to the results demonstrated by our study. A study assessing patient reviews placed on Realself.com, a plastic surgery social media site where verified patients are able to leave reviews of their surgical experiences, found the overall satisfaction rate of liposuction to be 66% [31]. Satisfaction rates appear to be similar for third-generation UAL patients and patients undergoing all forms of liposuction.

Conclusion

This study documents the senior author's 15-year experience of 261 cases with VASER lipectomy in body contouring, the majority of which were done safely and concurrently with other procedures. Third-generation ultrasound-assisted VASER liposuction is a safe and effective modality for body contouring, allowing surgeons to better address the superficial fat plane and enhance skin tightening. Rates of complications are lower than that of liposuction overall while still demonstrating equivalent or higher levels of patient satisfaction. Thoughtful patient selection is the key to success in this procedure. As we continue to "push the envelope" of body contouring, emerging technologies such as ultrasound-assisted liposuction become powerful tools in our expanding repertoire.

Acknowledgement The authors declare that they have no conflict of interest.

Declaration

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained for patient image display. Further informed consent was not required due to the retrospective nature of the study.

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