ORIGINAL ARTICLE

Effect of Ultrasonic Liposuction Energy Levels on Acute Adipocyte Viability in Patients Undergoing Liposuction

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Background: Vibration amplification of sound energy at resonance (VASER) devices are increasingly being used to address undesirable body proportions. The typical energy level used for fat suction is approximately 80% to 90%. However, there is currently no data on the survival rate of adipocytes at this energy level.

Objective: To investigate the effects of energy levels from the VASER device on adipocyte viability in individuals undergoing fat suction.

Materials and Methods: The present study used a single-center quasi-experimental design to collect data on the survivability of adipocytes obtained after liposuction from individuals underwent cosmetic surgery at the Faculty of Medicine, Vajira Hospital. Data was collected between August 1, 2022, and December 31, 2023.

Results: Thirty-three adipose tissue specimens were obtained from liposuction procedures and categorized into three groups according to the VASER energy applied, 60% for 10, 80% for 11, and 90% for 12. The mean percentages of viable adipocytes in the 60%, 80%, and 90% energy groups were 98.05%, 98.57%, and 97.84%, respectively. Comparison among the three groups demonstrated no statistically significant difference in adipocyte viability (p=0.957).

Conclusion: The findings of the present study indicate that VASER-assisted liposuction maintains high adipocyte viability across various energy levels at 60%, 80%, and 90%, demonstrating its safety and efficacy for fat removal and grafting. These results provide surgeons with flexibility in energy settings without compromising adipocyte quality and should enhance clinical outcomes and support the broader adoption of VASER technology in cosmetic and reconstructive surgery.

Keywords: VASER liposuction; Ultrasonic liposuction; Adipocyte viability; Fat grafting; Energy levels

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Autologous fat grafting is a surgical procedure used to correct abnormalities caused by adipose tissue loss and to address aesthetic concerns. Adipocyte viability depends on fat harvesting, preparation, and injection methods. Techniques have been developed to minimize fat resorption after grafting based on fat harvesting, processing, and injection techniques[1]. However, the position of fat harvesting and use of specific anesthesia were not significantly related to the survival of adipocytes, with no significant difference between syringe aspiration and liposuction pump aspiration[2].

Currently, several methods are available for fat suction, including syringe aspiration, suction-assisted liposuction, power-assisted liposuction, ultrasound-assisted liposuction, and laser-assisted liposuction. Ultrasound-assisted liposuction[3] is superior to suction-assisted liposuction in terms of reducing blood loss during surgery and tightening the skin postoperatively[4].

The Division of Plastic and Reconstructive Surgery at the Faculty of Medicine, Vajira Hospital, Navamindradhiraj University, offers treatment for patients seeking to correct undesirable body proportions using the vibration amplification of sound energy at resonance (VASER) (VASER Lipo System, Solta Medical, USA) suction technique. VASER is a third-generation ultrasound-assisted liposuction device that has gained popularity owing to its ability to reduce blood loss, postoperative pain, and swelling,

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and improve postoperative skin tightening[5]. A study conducted using a VASER liposuction machine with 60% energy in the pulse mode found that adipocyte viability was between 85% and 88%[1]. Standard energy levels for fat removal are 80% and 90%[6]. However, the fat quality at different energy levels and its survival rate after liposuction are poorly understood. Further research is required to investigate these factors.

The optimal energy level of the VASER device for Thai individuals with viable adipocytes is recommended to maximize adipocyte preservation during lipofilling procedures and facilitate further clinical research.

Objective

Primary objective

To investigate the effect of VASER energy levels on adipocyte survival in individuals undergoing liposuction.

Secondary objective

Comparing the average adipocyte viability percentage between genders and fat locations.

Analyzing the correlation between fat viability percentage and procedure duration.

Materials and Methods

Research methodology

The present study was a single-center quasi-experimental study that collected data on the survival of adipocytes obtained after liposuction in individuals undergoing cosmetic surgery at the Faculty of Medicine, Vajira Hospital. It was conducted in accordance with the Helsinki Declaration of Human Rights and approved by the Research Ethics Committee of the Faculty of Medicine, Vajira Hospital, Navamindradhiraj University, Thailand (study code 103/65 FB). The present study was registered in the Thai Clinical Trials Registry (TCTR), number TCTR20230621005.

Population

The target population comprised individuals who underwent liposuction in the Division of Plastic and Reconstructive Surgery, Faculty of Medicine, Vajira Hospital, between August 1, 2022, and December 31, 2023.

Inclusion criteria:

Individuals who underwent liposuction procedures on the forearm, thigh, abdomen, back, or waist at the Division of Plastic and Reconstructive Surgery, Faculty of Medicine, Vajira Hospital, between August 1, 2022, and December 31, 2023. Age was 20 to 50 years with a BMI of 30 or less.

Exclusion criteria:

Patients with diabetes mellitus or with immune disorders, those receiving chemotherapy or immunosuppressive drugs, and those taking steroids continuously for more than 30 days pre-surgery. Pregnant patients as well as patients at risk of abnormal bleeding, such as those taking anticoagulants or antiplatelet medications were excluded. Finally, patients who did not voluntarily participate, smokers, psychiatric patients, prisoners, and patients with hernias were also excluded.

Sample size calculation

Owing to the small sample, which is five to six patients annually, data from all patients who met the selection criteria were used, with an expected total sample of 10 cases.

Definitions

1. The VASER machine uses electrical signals converted into high-frequency sound wave energy to separate adipose tissue.

2. The energy level used can be adjusted from 10% to 100%, and is used to generate ultrasonic sound waves for separating adipose tissue.

3. The ultrasound mode is a form of vibration that encompasses two modes simultaneously:

• C-mode (continuous mode): Ultrasonic sound waves are emitted continuously, suitable for targeting deep fat

• Pulse mode or V-mode (specifically the VASER mode): Ultrasonic waves are generated periodically, appropriate for shallow fat deposits.

4. The superwetting solution was a solution composed of Ringer's lactate solution of 1,000 mL, 1% lidocaine without adrenaline of 20 mL, and adrenaline with a ratio of 1:1,000 for 1.5 mL, was used to reduce blood loss, alleviate pain, and decrease the heat generated from VASER. The tumescence technique is used in a ratio of one-to-one[7].

5. The VASER process involves three primary steps.

• Injecting a liquid solution into the layer of tissue beneath the skin.

• Using the VASER probe to separate fat tissue in the subcutaneous layer[8-10].

• Using a low-pressure suction technique with a small suction needle to extract isolated adipocytes, minimizing harm to blood vessels, nerves, and surrounding tissues[10-12].

7. The ultrasound probe application time was defined as the duration of using the VASER probe to separate subcutaneous fat tissue.

7. The surgical endpoints were the maximum time that the VASER probe can be used, as recommended by the company, which is one minute per 100 mL of wetting solution[13].

8. The adipocyte viability was the adipocyte survival after various fat extraction methods, assessed using the trypan blue dye staining method, where adipocytes that do not take up the blue dye are considered alive[14,15].

9. The percentage of fat viability was the adipocyte survival rate calculated as a percentage of the number of surviving adipocytes to the total number of adipocytes.

$$\text{Fat viability (\%)} = \frac{\text{Adipocyte viability}}{\text{Total adipocyte}} \times 100$$

10. The time to cell count was the duration from the extraction of fat body to the initiation of the process of measuring the survival of adipocytes.

11. The lipofilling was the transfer of fat by suctioning it from one area and injecting it into the desired area.

Study flow

- The researchers coordinated with the Department of Clinical Pathology, Faculty of Medicine, Vajira Hospital, to assist in analyzing viable adipocytes. WC was responsible for overseeing and analyzing the data.
- After obtaining ethics committee approval, the researchers collected data from patients who provided written consent for participation. These patients were evaluated by plastic surgeons to determine the appropriate areas for fat suction, including the abdomen, hips, arms, waist, and back. The assessment considered the patients' desired areas and the presence of excess fat. However, certain areas, including the distal iliotibial tract, gluteal crease, lateral gluteal depression, middle medial thigh, and distal posterior thigh, were avoided to prevent postoperative contour deformities[7].
- The day before surgery, the researchers notified WC to prepare for the analysis and counting of adipocytes.
- During the surgical procedure, volunteer surgeons were assigned specific areas for fat suction. These areas were divided into sections for fat suction using the VASER machine at energy levels of 60%, 80%, and 90% in the pulse mode (Figure 1). The entire process of marking the areas for fat suction and performing the fat suction procedure was performed by knowledgeable and experienced instructors using the VASER machine.

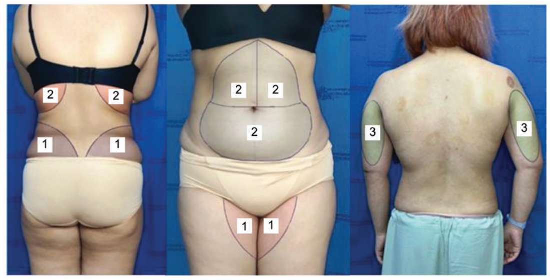

Figure 1. Illustration of the positions for various energy levels of the VASER device division technique. The first position represents the utilization of VASER at a 60% energy level, the second one at an energy level of 80%, and the third one at an energy level of 90%.

- After marking the desired areas, liposuction was performed sequentially, one area at a time. The initial step involved injecting a superwetting solution into the subcutaneous layer beneath the skin using an infusion pump at a speed of 250 mL/minute if general anesthesia was administered or 150 mL/minute if general anesthesia was not administered. The amount injected depended on the patient's existing amount of fat, and the total amount used should not exceed 35 mg/kg lidocaine to avoid the side effects of anesthesia.
- After injecting the wetting solution, a VASER head with a diameter of 3.7 mm, two rings, and a length of 26 cm, as specified in the machine's manual, was employed. The probe was operated at energy levels of 60%, 80%, and 90%, targeting areas numbered 1, 2, and 3, respectively. The duration of VASER probe usage to dissolve the adipose tissue in each numbered area was as follows: Super wetting solution (mL)/100 = Duration of VASER probe application or each number (minutes).
- The first fat suction began at a designated time, starting sequentially at positions 1, 2, and 3. A pump with a suction force of –27 inHg, per the manufacturer's recommendations, was used. At each position (Figure 1), 20 mL of fat was suctioned and placed in a sterile container. Once obtained, all three samples were immediately sent to the clinical pathology laboratory for further analysis.
- The second fat suction commenced using the same pump with a suction pressure of –27 inHg to extract fat from positions 1, 2, and 3. This process was repeated until proportional and appropriate

consistency was achieved. Postoperative care was the same for patients treated with standard fat suction procedures.

The obtained fat samples were labeled with random letters to blind the interpreter to the energy levels used for fat extraction. The fat samples were placed in 15 mL centrifuge tubes (Corning®, NY, USA) with a volume of 10 mL and centrifuged at 3,000 rpm for three minutes[16]. The fat in the central part of the tube was selected for analysis.

For analysis, 1 g of centrifuged fat was subjected to a non-adipocyte substance degradation process using 1 mL of 0.1% collagenase (Sigma-Aldrich, St. Louis, MO, USA; ≥125 CDU), 20 mM 4-(2-hydroxyethyl)-1-piperazine ethanesulfonic acid buffer (Sigma-Aldrich), and Dulbecco's Modified Eagle's medium (Sigma-Aldrich). The sample was incubated at 37°C for 30 minutes. Subsequently, each fat sample was mixed with 7.6 mL of 10% formalin to prolong cell viability during the measurement process. The fat was then digested and stained with 0.4% trypan blue dye solution at a ratio of 15:1.

Measurement

Adipocyte viability was assessed by examining cell morphology using the trypan blue dye dilution method in a hemocytometer (BOECO™) with standard glass coverslips on both sides. The hemocytometer was positioned at approximately 45° with the pipette tip touching the glass coverslip, and the index finger was used to control the release of the solution from the pipette onto the hemocytometer. After allowing the solution to settle for two minutes, the hemocytometer was left undisturbed to ensure cell stability.

To count the total number of adipocytes, a low-magnification microscope lens (10x) was used, focusing on the four corners of the hemocytometer grid in the W-table (Figure 2). Both stained (non-viable) and unstained (viable) adipocytes were counted within the small 16-grid squares of the W-table. Only adipocytes within the square or intersected by the top and left lines of each square were counted. Adipocytes intersected by the bottom and right lines were not counted to avoid confusion or double counting (Figure 2).

After counting all four squares, the total number of cells and viable adipocytes was added. The percentage of viable adipocytes was calculated using the following formula: Percentage of adipocyte viability = (Total adipocyte viability/Total adipocytes) × 100.

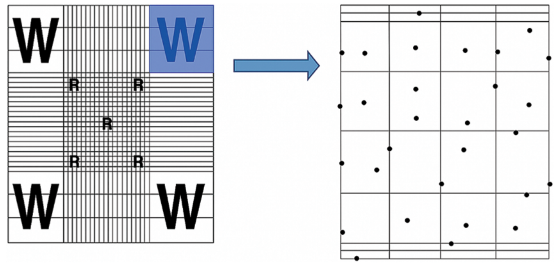

Figure 2. Channels in the hemocytometer plate and W sub-table of the hemocytometer plate.

Data collection

Data was recorded in a case record form (CRF) before being transferred to the database. To prevent the disclosure of personal information, the recorded data did not include patients' names, surnames, or hospital numbers (HNs). The collected data included age, gender, body mass index (BMI), wetting solution volume, ultrasound probe application time, surgical endpoint, duration from fat aspiration to cell examination, percentage adipocyte viability, and fat aspiration site. The CRF documents were stored in a secure locker with a robust lock. The database was stored on an encrypted computer. All data will be destroyed within five years of publication.

Statistical analysis

Descriptive statistics were used to present the general characteristics of the sample, including counts, percentages, means, standard deviations, medians, and maximum and minimum values. The relationship or comparison of proportions between categorical data, such as sex and area, among the three VASER power groups were analyzed using the chi-squared test or Fisher's exact test. The average values of continuous quantitative data, such as age, BMI, percentage of fat viability, and time to cell count, were compared among the three VASER power groups using one-way analysis of variance (ANOVA) for normally distributed data. For non-normally distributed data, the Kruskal-Wallis test was used, followed by pairwise post-hoc tests using the least significant difference (LSD) method. The average values of the percentage of fat viability between the genders were compared using an independent t-test for normally distributed data. For non-normally distributed data, the Mann-Whitney U test was used. The correlation coefficient (r) was used to analyze the relationship between the percentage of fat viability and the duration of various processes. Pearson's correlation coefficient was used for

Table 1. Demographic and clinical characteristics of the subjects (n=33 specimens)

Characteristics	Total (n=33)	VASER power			p-value
		60% (n=10)	80% (n=11)	90% (n=12)	
Sex; n (%)					0.160
Male	5 (15.2)	2 (20.0)	3 (27.3)	0 (0.0)	
Female	28 (84.8)	8 (80.0)	8 (72.7)	12 (100)	
Age (years); mean±SD	38.00±7.74	40.40±8.76	35.64±7.98	38.17±6.53	0.414
BMI (kg/m²); mean±SD	27.01±1.72	27.68±2.05	26.82±1.15	26.62±1.82	0.623
Area; n (%)					0.098
Abdomen	15 (45.5)	2 (20.0)	7 (63.6)	6 (50.0)	
Arm	4 (12.1)	0 (0.0)	2 (18.2)	2 (16.7)	
Back	2 (6.1)	2 (20.0)	0 (0.0)	0 (0.0)	
Thigh	2 (6.1)	2 (20.0)	0 (0.0)	0 (0.0)	
Waist	10 (30.3)	4 (40.0)	2 (18.2)	4 (33.3)	

VASER=vibration amplification of sound energy at resonance; BMI=body mass index; SD=standard deviation
p-values for mean data were calculated with the use of the Kruskal-Wallis test; for percentages, Fisher's exact test was used.

Table 2. Liposuction (n=33 specimens)

Characteristics	Total (n=33)	VASER power; mean±SD			p-value
		60% (n=10)	80% (n=11)	90% (n=12)	
Percentage of fat cell viability	98.15±2.72	98.05±3.16	98.57±1.86	97.84±3.16	0.957
Time to cell count (minutes)	156.21±49.88	159.90±14.97^{AB}	177.55±54.94^{A}	133.58±57.31^{B}	0.031*
Super wetting solution	342.73±182.11	470.30±225.00^{A}	291.55±107.1^{B}	283.33±152.7^{B}	0.046*
Ultrasound probe application time (minutes)	3.44±1.81	4.70±2.25^{A}	2.96±1.04^{B}	2.83±1.53^{B}	0.043*
Surgical endpoint (minutes)	3.43±1.82	4.70±2.25^{A}	2.92±1.07^{B}	2.83±1.53^{B}	0.047*

VASER=vibration amplification of sound energy at resonance; SD=standard deviation
p-value from Kruskal-Wallis test, * Significant at p<0.05
The letters A and B indicate that if the letters are different, their average values are different.

normally distributed data, and Spearman's correlation coefficient was used for non-normally distributed data. Statistical significance was set at p-value less than 0.05.

Results

The effect of the ultrasound-assisted liposuction (VASER) energy level on adipocyte survival was investigated in 33 fat tissue specimens. The samples were divided into three groups according to the VASER energy applied with 60% for 10, 80% for 11, and 90% for 12 specimens.

Baseline demographic and clinical data, including gender, age, BMI, and anatomical site of fat aspiration, were analyzed across the three groups. Statistical evaluation using the Kruskal-Wallis and Fisher's exact tests revealed no significant differences in these baseline characteristics among the energy-level groups (p>0.05).

These findings indicate that the groups were comparable in general characteristics, ensuring that subsequent differences in adipocyte viability could be attributed primarily to the variations in ultrasound energy levels rather than to demographic or anatomical factors (Table 1).

Significant differences were observed among the three VASER energy-level groups, 60%, 80%, and 90%, in the time to cell count, volume of wetting solution used, duration of VASER probe application, and maximum duration of VASER probe use, which is the surgical endpoint (p<0.05).

In contrast, comparison of the average adipocyte survival rate, expressed as the percentage of viable adipocytes relative to the total cell count for percentage adipocyte viability, showed no statistically significant difference among the three VASER energy levels (p=0.957) (Table 2).

The percentage of adipocyte viability did not correlate with gender or the position of fat suction (Table 3).

The time from fat aspiration to cell count showed a weak inverse relationship (r=–0.352) with the percentage of living adipocytes as percentage of adipocyte viability (Figure 3).

Table 3. Comparison of the percentage of adipocyte viability between sexes and liposuction location (n=33 specimens)

Characteristics	n	Percentage of fat cell viability mean±SD	p-value
Sex			0.959
Male	5	99.42±0.10	
Female	28	97.92±2.90	
Area			0.267
Abdomen	15	98.50±1.69	
Waist	10	99.38±0.84	
Other (arm, back, thigh)	8	95.95±4.38	
Area			0.0505
Abdomen	15	98.50±1.69	
Waist	10	99.38±0.84	
Arm	4	95.69±4.85	
Back	2	100.00±0.00	
Thigh	2	92.41±2.42	

SD=standard deviation
p-value from Kruskal-Wallis test or Mann-Whitney U test

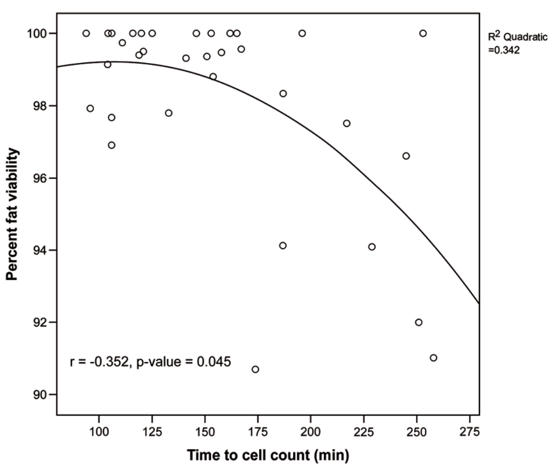

Figure 3. Relationship between the percentage of viable adipocytes and the time required for cell counting.

The dose of anesthetic used, duration of VASER probe application, and maximum duration for the surgical endpoint showed no significant relationship with the percentage of adipocyte viability (Table 4).

Discussion

Liposuction is currently the most popular cosmetic procedure, and its popularity continues to increase[17]. Some patients also desire lipofilling, which involves injecting adipocytes to address aesthetic concerns, in conjunction with liposuction. The selection of a method for fat aspiration is crucial for determining adipocyte viability, which is essential for the persistence of adipocytes after transplantation.

Table 4. Correlation between the percentage of fat viability and the duration of the process (n=33 specimens)

Duration of the process		Fat cell viability (%)
Time to cell count (minutes)	r	−0.352
	p-value	0.045*
Wetting solution	r	−0.301
	p-value	0.088
Ultrasound probe application time (minutes)	r	−0.302
	p-value	0.088
Surgical endpoint (minutes)	r	−0.302
	p-value	0.088

p-value from Spearman's correlation coefficient, * Correlation is significant

VASER is a fat removal method that uses ultrasonic sound waves for fragmentation and emulsification[18]. It has gained popularity because of its ability to reduce blood loss during surgery, alleviate postoperative pain, minimize swelling, and promote skin tightening. The energy level typically used for general fat suction is 80% to 90%. Currently, there is no available data on the survival rate of adipocytes at this energy level.

The present study investigated the effect of VASER device energy levels on the viability of adipocytes in individuals undergoing liposuction. After examining the characteristics of the three energy groups, including gender, age, BMI, and fat suction position, no statistically significant differences were found among the VASER energy levels.

The assessment included the amount of superwetting solution used, duration of VASER probe application, and maximum surgical endpoint time for VASER probe usage. Statistically significant differences were observed in these three variables among the three patient groups ($p<0.05$).

The researchers found that the average survival rate of adipocytes did not significantly differ between the VASER energy levels of 60%, 80%, and 90%. This finding is consistent with previous observation of no differences in adipocyte survival rates when using fourth-generation ultrasound-assisted liposuction with Heus equipment at energy levels of 40% and 70%[19].

The present study also examined the relationship between the time from fat aspiration to cell counting and the percentage of adipocyte viability. These two variables were significantly, negatively correlated ($r=-0.352$, $p=0.045$). The present study finding is consistent with a previous report[14], of a 21% decrease in adipocyte survival rate within four hours. Additionally, the use of formalin during the cell counting process helps maintain the viability of adipocytes during the 4-hour waiting period.

The quantity of superwetting solution was not significantly associated with the percentage of adipocyte viability. This is consistent with a previous study on the effects of lidocaine and adrenaline on the survival of human adipocyte stem cells that revealed that neither lidocaine nor adrenaline affected the viability of human adipocytes[20].

The duration of VASER probe application for subcutaneous fat tissue separation or ultrasound probe application time, and the maximum duration of the surgical endpoint were not significantly associated with the percentage of adipocyte viability. This is consistent with consensus-based recommendations for VASER liposuction, which concluded that VASER liposuction does not compromise the structure and growth potential of adipocytes[21].

The present study provides valuable insights into the effects of different VASER energy levels on adipocyte viability, contributing to the extant knowledge of cosmetic surgery. One strength of the present study is its quasi-experimental design, which allows the control of variables that might influence the results. However, the present study has limitations. The sample was small with 33 specimens. The study was conducted at a single center, which may limit the generalizability of the findings. The quasi-experimental methodology was employed owing to ethical constraints inherent in the research. The absence of an investigation into long-term survival rates after fat grafting is another notable limitation. Future research with larger samples and multicenter designs is needed to confirm these results and explore additional factors that might affect adipocyte viability.

Conclusion

The present study indicates that VASER energy levels of 60%, 80%, and 90% do not significantly affect the viability of adipocytes in individuals undergoing liposuction. These findings suggest that surgeons have flexibility in choosing VASER energy settings without compromising the quality of harvested fat, thereby supporting the use of VASER technology for effective and safe fat removal and grafting. Further research is warranted to explore the long-term outcomes of fat grafting using VASER-harvested adipocytes and to compare VASER with other liposuction techniques.

What is already known about this topic?

Ultrasound-assisted liposuction, particularly using the VASER device, has become a widely used technique for body contouring due to its advantages in reducing blood loss, minimizing postoperative pain, and improving skin tightening. Previous research has shown that adipocyte viability can be preserved using lower VASER energy levels such as 60% in pulse mode, but the effects of higher energy levels, such as the standard 80% to 90% used in clinical practice, on adipocyte survival remain unclear.

What does this study add?

This study demonstrates that adipocyte viability remains consistently high across VASER energy levels of 60%, 80%, and 90%, with no significant differences in survival rates. These findings suggest that surgeons can safely utilize higher VASER energy settings without compromising adipocyte quality, thereby supporting the use of this technology for fat grafting and liposuction. The study also highlights that factors such as sex, fat suction location, and anesthesia dosage do not significantly influence adipocyte viability, further reinforcing the flexibility of VASER-assisted liposuction in clinical applications.

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Authors' contributions

WL collected the data, revised critically, and drafted the manuscript. SU collected the data and drafted the manuscript. WC collected the data and made critical revisions. PS drafted the manuscript and made critical revisions. All authors designed the study and analyzed, interpreted, read, and approved the final manuscript.

Conflicts of interest

The authors declare that they have no disclosures.

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