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# **Comparison of Different Techniques: Ultrasonic, Laser, and** Traditional Liposuction with a Discussion on New Directions and the Future of Liposuction Techniques

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#### Abstract

Liposuction is one of the most commonly performed procedures in aesthetic surgery, with an increasing variety of available methods that enhance both the effectiveness and safety of this treatment. The aim of this paper is to analyze and compare three primary techniques: ultrasonic, laser, and traditional liposuction, as well as to highlight potential directions for the development of this procedure. Based on available literature and research findings, both the effectiveness and potential risks associated with each of these methods will be assessed, allowing for the identification of optimal solutions tailored to the individual needs of patients.

**Keywords:** liposuction, laser liposuction, ultrasonic liposuction, safety, effectiveness, surgical methods, body contouring, minimally invasive procedures, innovations in aesthetic surgery

#### 1. Introduction

Liposuction is one of the most frequently performed aesthetic procedures by certified plastic surgeons and has shown steadily increasing popularity. This procedure involves the removal of excess fat from specific areas of the body, improving body contour (1). Primarily a cosmetic treatment, liposuction commonly targets areas such as the torso, limbs, and submental regions (1). In recent years, due to rapid technological advancements, over 50 devices and techniques have been developed to support this procedure, making it more precise and reducing patient recovery time (2). In North America, liposuction ranks second among women's aesthetic procedures, following breast augmentation, and is one of the most frequently performed aesthetic surgeries worldwide, with approximately 300,000 procedures conducted annually in the United States. Furthermore, a 97% increase in the number of procedures was recorded between 1997 and 2015. Approximately 25% of patients who undergo liposuction choose the procedure as part of a weight-loss program, highlighting its growing popularity in the context of aesthetics and body contouring (3).

Selecting an appropriate liposuction method is crucial for both the procedure's effectiveness and patient safety. Different techniques vary in terms of tissue trauma minimization, fat removal efficiency, and recovery time. Choosing the right method helps reduce complication risks and increases patient satisfaction with the outcomes achieved (4). Some available studies on various liposuction techniques indicate differing levels of effectiveness and safety. Tumescent liposuction, regarded as the standard approach, shows favorable results in minimizing complications, while energy-assisted techniques, such as ultrasonic liposuction, demonstrate faster effects but may be associated with higher risks. Comparative analyses that consider different patient groups are also valuable, as they allow for better customization of techniques to individual needs.

The aim of this paper is to compare three liposuction methods in terms of their effectiveness, safety, and benefits for different patient groups based on available literature. Differences in clinical outcomes, complication risks, and patient satisfaction will be analyzed, contributing to a better understanding of which method may be most suitable for specific groups. The conclusions will be based on a review of scientific literature, which will help elevate surgical practice standards in the field of liposuction.

## 2. Overview of Methods

# I. Traditional Liposuction (Mechanical Liposuction)

## History of the Technique

Liposuction evolved from imprecise fat excision techniques. In 1929, French surgeon Charles Dujarrier performed the first fat contouring procedure on the thighs, inserting a sharp curette subcutaneously through a small incision (5). Unfortunately, the procedure resulted in hemorrhage, ultimately leading to amputation. Despite numerous attempts in the following decades to perform blind, sharp fat removal procedures with various instruments, all these methods were ultimately abandoned due to complications related to bleeding. In the late 1970s, Gerard Illouz from France developed the first modern liposuction technique. Unlike previous methods, Illouz used blunt-tipped suction cannulas and strong negative pressure to remove subcutaneous fat. His technique employed 10-millimeter cannulas and general endotracheal anesthesia, which led to significant blood loss, thereby limiting the scope of the procedure. This technique, known as dry liposuction, involved removing fat without injecting fluids. Over time, modifications were introduced, such as the injection of small amounts of saline solution, leading to the development of wet liposuction (1). The modern era of hemostatic liposuction techniques began in the mid-1980s. A key element of these methods was the introduction of large volumes of fluids with epinephrine into the targeted fat layers. In 1985, American dermatologist Jeffrey Klein introduced a local anesthesia technique known as tumescent liposuction (6). Klein's technique used lidocaine in higher volumes and total doses, along with smaller cannulas than those used previously, providing the best safety profile among liposuction methods. Another approach, superwet liposuction, introduced in the 1980s, employs general or regional anesthesia combined with lower volumes and concentrations of lidocaine than tumescent liposuction. Although it offers good hemostasis and postoperative analgesia, it carries anesthesia-related risks (1).

## **Description of the Technique**

Modern liposuction technique utilizes steel cannulas of varying diameters, ranging from 1 to 10 mm, with smaller cannulas allowing for greater control and larger ones enabling faster extraction. The process involves drawing fat tissue into the cannula openings through a forward and backward motion, during which suction pulls fat tissue into the lateral openings of the cannula. Small fragments of fat detach from the connective tissue, creating tunnels along the instrument's path. These tunnels collapse under the weight of the surrounding tissues, achieving a contouring effect. When the cannula is moved solely by the surgeon's hand, this technique is referred to as manual liposuction.

If the cannula's movement is mechanically driven via a motorized handle, this approach is known as power-assisted liposuction (PAL). Control over the cannula's direction is essential for ensuring patient safety and achieving a satisfactory aesthetic outcome. This method generally does not damage blood vessels or nerves, as these structures have greater resistance. Cannulas are designed to connect with a suction tube or syringes. The suction tube attaches to an aspirator pump, typically set to a maximum vacuum pressure of -100 kPa (or -750 mm Hg). Small incisions in the skin, usually made with a scalpel or specialized punches, are used to introduce the liposuction cannula. These incisions are often strategically placed in natural skin folds, bikini lines, scars, or tattoos to minimize the visibility of post-operative scars (1).

#### II. Ultrasonic Liposuction

Ultrasonic liposuction, using devices such as VASER, involves breaking down fat tissue before suctioning it out. It is distinguished by its precise targeting of fat cells, enabled by the use of ultrasonic energy. Ultrasound waves set to an amplitude of 70–80% are continuously transmitted, effectively disrupting the cohesiveness of fat tissue. This technique allows for the breakdown of fat without damaging surrounding structures such as nerves, blood vessels, and connective tissue. Due to this selectivity, the risk of unintended damage to surrounding tissues is minimized, enhancing safety and reducing complication risks. The procedure is performed prior to mechanical liposuction, which is ideally conducted in a crosshatch technique to achieve an even result. An example of this method's application is fat removal to improve the contour of the buttocks, representing a safer approach to buttock augmentation (7).

#### III. Laser Liposuction (Laser Lipolysis)

Laser-assisted liposuction is one of the techniques used to reduce localized fat deposits and improve skin tension (8-12). Numerous studies have demonstrated the beneficial effects of this laser on fat tissue as well as surrounding structures, such as the dermis, blood vessels, sweat glands, and sebaceous glands (13-17). The direct effects of an Nd:YAG laser with a wavelength of 1064 nm include fat cell breakdown and stimulation of new collagen production (18-21). During the procedure, energy is delivered to the subcutaneous tissue via a fiber optic cable with a diameter of 300 to 600 microns, attached to a stainless steel microcannula with a diameter of 1 to 1.4 mm and variable length. The total energy delivered is adjusted depending on the amount of fat and the need for dermal stimulation, leading to a skin-tightening effect. This value typically ranges between 5,040 J and 16,560 J. The laser's action results in cell lysis, causing the fat tissue to become a less dense solution. The resulting oily lysate, which contains cell fragments, oil, and infiltrative solution, is then removed from the treated areas. This process utilizes suction through a double-port cannula operating under negative pressure (22).

## IV. Comparison of the Three Techniques

A brief comparative analysis of the three methods is presented below, focusing on the technical aspects of each procedure to summarize the key information.

Liposuction Technique	Primary Mechanism of Procedure	Tools Used	Procedure
Mechanical Liposuction	Cannula movement back and forth with suction	Cannulas of various diameters	Manual removal of fat tissue
Ultrasonic Liposuction	Fat cell disruption through ultrasound	Ultrasonic device (VASER)	Use of ultrasound waves to break down fat cells
Laser Liposuction	Cell lysis via Nd laser energy	Nd laser, microcannula	Application of laser energy to break down fat cells and stimulate collagen

## **3. Efficacy and Safety of Liposuction Procedures**

## I. Mechanical Liposuction

The final outcome of liposuction varies and depends on patient preferences, fat and skin tissue structure, muscle anatomy, and the goal of achieving symmetry. For example, more fat may be intentionally left in the thigh area to preserve natural curves, whereas in the abdominal region, a greater fat reduction is typically pursued to accentuate muscle lines. Complete removal of subcutaneous fat is not the objective, as this could lead to skin damage. A thin layer of fat (around 5 mm) is recommended to protect subcutaneous blood vessels and minimize skin wrinkling.

There is no scientifically established upper limit for the volume of fat that can be safely removed in a single liposuction session, though regulations exist in various North American states. In California, for instance, outpatient procedures are restricted to 5,000 ml of aspirate (SB 450, 1999), and in Florida, the limit is 4,000 ml for tumescent liposuction in clinics (64B89–9.009, 2000). These restrictions are due to the lidocaine dose used in tumescent liposuction. However, the volume of fat removed does not yield uniform results for different body sizes or multiple treatment areas (1).

Although serious complications from liposuction are rare (below 1%), ensuring adequate treatment and preventive measures is crucial to minimize risks (23, 24). The mortality rate associated with liposuction is approximately 0.02%, primarily due to thromboembolic venous disease (23, 25, 26). A multivariate analysis conducted by Kaoutzanis et al. found that patients undergoing multi-area liposuction, combined procedures, and obese individuals are at an increased risk of complications (23). The most common complication of liposuction is contour irregularities, which occur in about 20% of cases (27, 28, 29).

Skin, major blood vessel, and internal organ injuries from the cannula can result from inadequate preoperative assessment, excessive suctioning, and insufficient palpation of the cannula tip during the procedure.

Postoperative cellulitis or soft tissue infections should be treated aggressively with appropriate antibiotics. Other potential complications include paresthesias, which usually resolve spontaneously within 2–3 months (30). Postoperative skin hyperpigmentation may be caused by factors such as skin trauma and sun exposure (31).

Seroma is another complication that may occur both early and later after surgery, likely resulting from excessive manipulation that exposes the fascia and damages lymphatic vessels (30).

## II. Laser Liposuction

Internal lasers aiding traditional liposuction were first described in 1992, suggesting that their use could result in reduced blood loss, bruising, and tissue reorganization through coagulation of blood vessels, collagen, and adipocytes (1). First-generation devices, utilizing a neodymium-doped yttrium aluminum garnet (Nd:YAG) laser with a wavelength of 1065 nm, gained popularity in South and North America. However, clinical trials, including randomized studies, did not demonstrate significant differences in cosmetic outcomes or recovery times (32). A multicenter study in the United States involving about fifty patients undergoing laser-assisted liposuction found no clear benefits or supportive effects of this technique (33, 34).

Nevertheless, a report on Nd:YAG laser-assisted liposuction indicated that this method could provide improved skin tightening compared to traditional liposuction. Goldman et al. observed that the use of the Nd:YAG laser with a wavelength of 1064 nm in subcutaneous liposuction produced better results in this regard (35). However, these findings should be approached with caution, as the evaluation method relied on subjective criteria, such as photo comparisons, which could introduce bias. The case selection process should also be considered carefully, as improved outcomes may be due to selective patient choice. Moreover, numerous earlier reports did not demonstrate significant advantages of laser use in liposuction (33, 36).

Cost analysis should also be considered across various liposuction methods. Nd:YAG laserassisted liposuction undeniably involves higher unit costs, which may render it a less costeffective approach compared to other techniques. Nonetheless, the liposuction market continues to introduce various lasers promoting "innovative" wavelength and power combinations, promising better cosmetic results, though supported mostly by anecdotal evidence from a few surgeons. In 2005, water-assisted liposuction was introduced in Europe, claimed to cause less tissue damage by using a cannula delivering a pulsating fluid flow while simultaneously aspirating it. However, the available data are insufficient to substantiate these claims (37, 38, 39).

# III. Ultrasound-Assisted Liposuctio

Ultrasound technology in liposuction, introduced by Zocchi in 1992, was regarded as a significant advancement. It requires operation in a wet environment, the use of a titanium probe emitting ultrasound, and manual modeling or supplementation with aspiration to remove adipocytes. Zocchi noted its advantages, such as the selective destruction of fat cells, although this has been questioned by others. Additionally, the skin tightening effect remains disputed, and while the procedure reduces surgeon fatigue, it requires caution due to the risk of burns (40, 41, 42). Burns continue to pose a significant issue with this method, as ultrasound energy tends to convert into thermal energy.

For example, the commonly used harmonic scalpel operates on the same principles, utilizing thermal effects, which underscores the risks associated with using ultrasound (1).

One of the subsequent and key advantages of ultrasound-assisted liposuction is its precision and selectivity in eliminating fat cells.

By utilizing ultrasound energy, this method effectively destroys fat cells while preserving nearby structures such as nerves, blood vessels, and connective tissue. Such precision significantly reduces the risk of accidental damage to surrounding tissues, enhancing the safety of the procedure (7). Currently, ultrasound liposuction is valued for reducing the physical effort required by the surgeon, especially when working on areas with high fat density, such as the back or upper abdomen. However, it should be noted that this method may cause greater blood loss compared to traditional liposuction.

Is it worth pursuing this method? The advancement of technology, particularly in new suctionassisting motors, seems to be shifting the paradigm. Modern devices are more precise and result in fewer complications when working on the same anatomical areas, both deep and superficial (34). Some researchers have conducted ultrasound-assisted percutaneous aspirations using conventional ultrasound devices. External ultrasound probe-assisted liposuction, introduced by Silberg in 1998, gained popularity due to its ease of use and greater penetration ability, particularly in combination with superficial liposuction. However, the results and their analysis presented in existing studies remain generally unconvincing (43).

## IV. Comparison of Effectiveness and Safety of Three Techniques

The table below outlines the differences between the three liposuction techniques, focusing on their effectiveness and safety.

Type of Liposuction	Effectiveness	Safety
Mechanical Liposuction	The final result varies and depends on patient preferences and tissue structure. It is recommended to leave a thin layer of fat (5 mm) to protect the vessels.	Serious complications are rare (<1%). The mortality rate is approximately 0.02%. The most common complications include contour irregularities (20%).
Laser-Assisted Liposuction	Studies have not shown significant benefits compared to traditional liposuction. There is potential for improved skin tightening.	Concerns regarding subjective assessment methods. Previous reports have not confirmed significant benefits from laser use.
Ultrasound- Assisted Liposuction	Considered a technological advancement; selectively destroys fat cells. Limited effectiveness regarding skin tightening.	Greater blood loss compared to traditional liposuction. Risk of burns. Helps reduce surgeon fatigue.

#### 4. New Directions and the Future of Liposuction Techniques

The variety of available techniques, types of anesthesia, and the possibility of combining procedures offer diverse perspectives for the future of sculpting liposuction. Currently, the techniques in use are already advanced, and their optimal application is crucial. By integrating superficial, intermediate, and deep aspirations, we can effectively shape body contours and improve skin texture, which forms the foundation of effective sculpting liposuction.

Research directions should include more precise semiological analyses to better assess fat tissue density and skin elasticity. Furthermore, it is essential to enhance postoperative patient comfort through scientifically documented therapies that can reduce swelling, bruising, sensory disturbances, and pain. It is desirable for lymphatic drainage and pressotherapy to become more effective and less restrictive (24).

The contribution of micropharmacology to adipocyte metabolism is one of the key challenges for the coming years. The objective is to achieve adipolysis through intracellular diffusion, which would allow for even more precise sculpting during aspiration (44, 45). We can envision the introduction of external skin tightening techniques using a new generation of lasers, which would combine the effects of internal retraction induced by superficial liposuction with the external retraction resulting from laser action. Such synergy could bring us closer to the goal of every plastic surgeon: to perform operations without scars or to minimize them as much as possible (24).

#### 5. Summary and Conclusions

In summarizing the comparison of the efficacy and safety of three liposuction methods, it has been observed that classical, laser, and ultrasonic liposuction differ in both aesthetic outcomes and safety profiles according to various sources, necessitating further research in this field. Current studies on liposuction indicate the need for a deeper analysis of the efficacy and safety of different methods, particularly concerning long-term outcomes, as well as clarification of the discrepancies in findings from various studies. As of today, based on a review of the literature on this topic, no technology appears to provide better results than conventional methods. Classical liposuction remains the gold standard; however, key findings suggest that individualization of the method selection may be necessary, depending on the patient's specifics and the area to be treated. The choice of technique should be discussed with an experienced plastic surgeon.

Regarding the future of sculpting liposuction, it relies on the advancement of techniques and their optimal utilization. It is crucial to integrate different aspiration methods and improve patient comfort post-operation. Further research is required in semiology, supportive therapies, and new technologies, such as laser skin tightening, to minimize scarring. The contribution of micropharmacology to adipolysis and the synergy of techniques could revolutionize the approach to liposuction, bringing surgeons closer to the goal of performing scar-free operations.

## DISLOCURE

## Author's contribution:

Conceptualization, Mariusz Zimonczyk, Agnieszka Nowotarska and Gustaw Błaszczyński; Methodology: Monika Zawół; Software: Gustaw Błaszczyński, Agnieszka Nowotarska Check,: Paweł Nojek, Wiktoria Pawlik, Monika Zawół; Formal analysis: Wiktoria Pawlik and Mariusz Zimonczyk Investigation: Paweł Nojek and Gustaw Błaszczyński Resources: Paweł Nojek Data curation: Wiktoria Pawlik, Agnieszka Nowotarska Writing-rough preparation: Mariusz Zimonczyk and Monika Zawół; Writing review and editing: Paweł Nojek and Gustaw Błaszczyński; Visualization: Wiktoria Pawlik, Agnieszka Nowotarska and Monika Zawół Project administration: Paweł Nojek and Mariusz Zimonczyk; Receiving funding-no specific funding.

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The authors deny any conflict of interest

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