cosmetics

MDPI

Review

Laser-Assisted Lipolysis Versus Surgical Fat Removal: A Review of Efficacy, Safety, and Patient Satisfaction

Kar Wai Alvin Lee [1], Lisa Kwin Wah Chan [1], Angela Wai Kay Lee [2], Cheuk Hung Lee [1], Jovian Wan [3] and Kyu-Ho Yi [4,5,*]

1 EverKeen Medical Centre, Hong Kong
2 The Skin Oracle, Hong Kong
3 Asia-Pacific Aesthetic Academy, Hong Kong
4 Division in Anatomy and Developmental Biology, Department of Oral Biology, Human Identification Research Institute, BK21 FOUR Project, College of Dentistry, Yonsei University, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea
5 Maylin Clinic (Apgujeong), Seoul 06005, Republic of Korea
* Correspondence: kyuho90@daum.net; Tel.: +82-2-2228-3047; Fax: +82-2-393-8076

Abstract: (1) Background: The demand for body-contouring procedures has surged, with lipolysis emerging as a common technique for excess fat removal. Laser-assisted lipolysis (LAL) has gained attention as a potential alternative to surgical fat removal (SFR), offering perceived advantages in safety and efficacy. However, the comparative benefits of LAL and SFR remain uncertain. (2) Objective: To conduct a review of the existing literature comparing the efficacy, safety, and patient satisfaction of LAL and SFR. (3) Methods: A comprehensive search of major electronic databases was conducted to identify studies comparing LAL and SFR for body-contouring procedures. Studies were included if they were published in English, involved human subjects, and reported outcomes for LAL and SFR. All studies were classified according to the Oxford Center for Evidence-Based Medicine evidence hierarchy (4) Results: LAL may not be a safer and more effective option than SFR. However, the evidence for these differences was limited by the quality of the studies and the heterogeneity of the results. (5) Conclusions: This review suggests that LAL may not be a safer and more effective option than SFR for body-contouring procedures because LAL is associated with higher risks of complications such as burns and scarring, whereas SFR offers a more established safety profile and consistent efficacy.

Keywords: body contouring; laser therapy; liposuction; treatment outcome; patient satisfaction

Citation: Lee, K.W.A.; Chan, L.K.W.; Lee, A.W.K.; Lee, C.H.; Wan, J.; Yi, K.-H. Laser-Assisted Lipolysis Versus Surgical Fat Removal: A Review of Efficacy, Safety, and Patient Satisfaction. *Cosmetics* **2024**, *11*, 164. https://doi.org/10.3390/cosmetics11050164

Academic Editors: Maria Manconi, Steven Paul Nisticò and Ester Del Duca

Received: 15 July 2024
Revised: 15 September 2024
Accepted: 25 September 2024
Published: 27 September 2024

1. Introduction

Body contouring has become an increasingly popular trend in the pursuit of a slimmer, more aesthetically pleasing physique. With the rise of minimally invasive procedures, patients are seeking out options that offer reduced downtime, minimal scarring, and effective results. Among the various methods available, lipolysis, a technique aimed at removing excess fat cells from the body, has emerged as a popular choice for individuals looking to achieve their desired body shape [1,2].

Surgical fat removal (SFR) has been the gold standard for body contouring procedures, involving the use of mechanical energy to disrupt and remove fat cells through suction or cannulae. However, this approach has its limitations, including potential risks such as bleeding, bruising, and swelling. Moreover, SFR often requires extensive downtime and may not provide optimal results for all patients [3,4].

In recent years, laser-assisted lipolysis (LAL) has gained popularity as a safer and more effective alternative to SFR. LAL uses laser energy to target and destroy fat cells, resulting in reduced postoperative discomfort, minimized bruising and swelling, and improved patient satisfaction [5,6]. There are other treatment modalities like ultrasound, cryotherapy,

injection, and shockwave to reduce fat cells [7–18], but we are not discussing them in this literature review. The introduction of LAL has raised questions about its efficacy and safety compared to SFR, sparking a debate among healthcare providers and patients alike.

Despite the growing popularity of LAL, there is a lack of consensus on its advantages and disadvantages compared to SFR. A comprehensive review of the current evidence is necessary to inform decision-making and guide patient selection for these procedures. This literature review aims to provide a thorough analysis of the existing research on LAL and SFR, examining the outcomes of each technique in terms of safety, efficacy, and patient satisfaction. By synthesizing the available evidence, this review aims to contribute to the ongoing discussion on the relative merits of LAL and TL and inform best practices in body contouring procedures. In this paper, we use several terms, distinguishing between procedures based on whether they involve the physical removal of fat, such as suction-assisted lipoplasty, or the use of lasers, which includes laser lipolysis and laser-assisted liposuction.

2. Materials and Methods

Keywords including "Liposuction", "lipoplasty", "Traditional lipolysis", "Laser lipolysis" "Lipectomy" "lasers", "laser assisted lipolysis", and "laser lipolysis versus traditional lipolysis" were searched in the MEDLINE, PubMed and Ovid databases for relevant studies published on clinical trials, diagnosis, and treatment. Some papers were further reviewed using a double-blinding approach, sample size, control usage, randomization usage and objective endpoint measurements. All studies were classified according to the Oxford Center for Evidence-Based Medicine evidence hierarchy [19].

3. Results

3.1. Postoperative Pain and Recovery

Llanos Olmedo et al. [20] compared postoperative pain between suction-assisted lipoplasty (SAL) and laser-assisted lipolysis (LAL) in 50 patients. Using a visual analog scale (VAS) at 0, 6, and 24 h postoperatively, the study found that LAL significantly reduced pain compared to SAL, with mean VAS scores of 3.4 versus 6.2 at 6 h, a difference that persisted at 24 h. The results indicated that patients who underwent LAL experienced significantly less postoperative pain compared to those who underwent SAL. Specifically, the mean VAS score was 3.4 in the LL group compared to 6.2 in the SAL group at 6 h postoperatively, with the difference in pain scores remaining significant at 24 h. The authors concluded that LAL is associated with reduced postoperative pain compared to SAL, likely due to the reduced trauma inflicted on the tissue by the laser energy (Level IIb).

Prado et al. [21] evaluated the efficacy and safety of LAL versus SAL in 60 patients, assessing pain, bruising, and satisfaction at 1 week, 1 month, and 3 months postoperatively. LAL was associated with significantly less pain and bruising, though no difference in complications or satisfaction was observed between groups (Level Ib).

3.2. Efficacy in Fat Removal and Skin Tightening

DiBernardo et al. [22] investigated the comparative effects of LAL and SFR on skin shrinkage and tightening. The study aimed to evaluate the efficacy of LAL in enhancing skin texture and reducing sagging relative to SFR. Twenty patients were divided into two groups, with one group undergoing LAL and the other undergoing SFR. A split-abdomen model was utilized, with one side treated with LAL and the other with SFR. At 3 months postoperatively, patients were evaluated using standardized measurements of skin thickness, elasticity, and texture. The results demonstrated that the LAL group exhibited significantly greater skin shrinkage and improvements in skin texture compared to the SFR group. Specifically, mean skin thickness decreased by 34% on the LAL side compared to 17% on the SFR side. Additionally, the LAL side showed enhanced skin elasticity and texture. The study concluded that LAL is effective in promoting skin

shrinkage and tightening, likely due to the thermal energy delivered during the procedure, which stimulates collagen production and enhances skin texture (Level IIa).

Brañas et al. [23] assessed the effectiveness and safety of using a 924 and 975 nm laser diode for LAL in the lower extremities. The study involved 20 patients who underwent laser lipolysis treatment on their lower extremities using the specified laser diodes. The treatment protocol included a single session of laser lipolysis with multiple passes of the laser over the treatment area. Patients were evaluated at 1, 3, and 6 months post-treatment using standardized measures of skin thickness, elasticity, and texture. Significant improvements in skin thickness, elasticity, and texture were observed at all time points compared to pre-treatment values. The study also reported a high patient satisfaction rate, with 90% of patients reporting good or excellent results. The authors concluded that the combination of 924 and 975 nm laser diodes is effective in promoting skin tightening and improving skin texture in the lower extremities, with minimal risk of complications (Level IV).

Wolfenson et al. [24] evaluated the efficacy of diode laser treatment in promoting skin tightening during lipoplasty procedures. The study involved 30 patients who underwent lipoplasty with the addition of diode laser treatment on one side of the body and traditional lipoplasty on the other side. The diode laser targeted the deeper layers of the skin, stimulating collagen production and enhancing skin texture and elasticity. Results showed significant improvements in skin thickness, elasticity, and texture on the laser-treated side compared to the control side. The study also reported a high patient satisfaction rate, with 87% of patients reporting good or excellent results. The authors concluded that a diode laser can be safely and effectively used in combination with lipoplasty to promote skin tightening and improve overall aesthetic outcomes (Level IIa).

Valizadeh et al. [25] conducted a comparative study to evaluate the safety and efficacy of 980 nm diode laser-assisted lipolysis versus traditional liposuction for submental rejuvenation. Thirty patients were randomly assigned to receive either laser-assisted lipolysis or traditional liposuction. Both treatments resulted in significant improvements in skin tightness, fat reduction, and patient satisfaction. However, the laser-assisted lipolysis group experienced significantly less postoperative pain, bruising, and swelling compared to the traditional liposuction group. The authors concluded that laser-assisted lipolysis is a safe and effective alternative to traditional liposuction for submental rejuvenation, offering potential benefits such as reduced postoperative morbidity (Level IIa).

3.3. Complication Rates and Safety Concerns

Jecan et al. [26] conducted a histological analysis comparing the aspirates obtained during LAL and SAL. The study aimed to explore differences in the composition of the aspirates and their potential effects on tissue structure. Thirty patients underwent either LAL or SAL, and tissue samples were collected for histological examination. Results revealed that LAL aspirates contained a higher proportion of fat cells, less fibrotic tissue, and more blood vessels compared to SAL aspirates. Conversely, SAL aspirates exhibited a higher proportion of connective tissue and more inflammatory cells. The authors concluded that LAL may be more effective in removing excess fat while preserving tissue integrity, whereas SAL may be more effective in removing fibrotic tissue (Level IV).

Goldman et al. [27] compared the efficacy of subdermal Nd LAL with SFR for tissue tightening in a study involving 30 patients. The study aimed to evaluate the effectiveness of LAL in improving skin elasticity and firmness compared to SFR. The results demonstrated that both treatments led to significant improvements in skin tightening; however, the LAL group showed greater improvements in skin elasticity and firmness. The authors attributed the superior results of LAL to the additional thermal effects of the laser on dermal tissue, concluding that LAL is more effective than SFR for tissue tightening (Level IIa).

Pereira-Netto et al. [28] conducted a comprehensive review comparing the effectiveness and safety of LAL with SFR. The authors performed a systematic search of electronic databases and included 14 studies that met the inclusion criteria. The review findings

indicated that LAL may offer advantages over SFR, including reduced bleeding, pain, and enhanced skin tightening. However, the quality of evidence was generally low to moderate due to heterogeneity among studies, small sample sizes, and lack of protocol standardization. The authors concluded that while LAL appears to be a promising technique, further high-quality studies are needed to establish its effectiveness and safety definitively (Level IIIa).

Mordon et al. [3] reviewed the effectiveness and safety of LAL compared to SFR for fat removal. The authors discussed the benefits and limitations of each technique, highlighting the potential advantages of LAL, such as reduced bleeding, pain, and scarring. The review cited studies demonstrating the efficacy and safety of LAL for fat removal while also discussing the associated risks and complications, including contour irregularities, infection, and seroma (Level IIc).

Abdelaal et al. [4] compared blood loss between LAL and SFR in a prospective randomized controlled trial involving 40 patients. The study aimed to quantify and compare the amount of blood loss during and after the procedures. The findings indicated that LAL was associated with significantly less blood loss compared to SFR, with average blood loss measuring 23.5 mL in the LAL group versus 114.5 mL in the SFR group. The study also found that blood loss was significantly lower in the LAL group during the procedure itself, though not after the procedure (Level IIa).

Swanson et al. [29] reviewed existing literature on the effectiveness of LAL in reducing blood loss during and after liposuction. The authors discussed potential benefits of LAL, including reduced bleeding, pain, and scarring, while summarizing several studies that investigated the relationship between LAL and blood loss. The studies reviewed produced mixed results, with some showing LAL reduces blood loss, while others found no significant difference. The authors concluded that the evidence is not strong enough to definitively support LAL's effectiveness in reducing blood loss (Level V).

Aboelatta et al. [30] compared the efficacy of LAL and traditional liposuction (SFR) in combination with endoscopic surgical excision for treating grade II gynecomastia. The study included 30 patients who underwent either LAL or SFR combined with endoscopic excision of gynecomastia tissue. Results showed that both LAL and SFR achieved comparable outcomes in terms of breast shape and contour, with significant improvements in both groups. However, the LAL group experienced less blood loss and pain compared to the SFR group.

3.4. Complications and Long-Term Outcomes

Senra et al. [31] conducted a retrospective analysis over a 10-year period, reviewing the outcomes of 766 patients who underwent laser-assisted lipolysis (LAL) for various indications, including body contouring, fat reduction, and skin tightening. The study reported an overall success rate of 85%, with a complication rate of 2.6%. The most frequently observed complications were paresthesia, hyperemia, and mild pain. The findings also indicated that LAL was more effective in treating areas with larger fat deposits, while its efficacy was diminished in areas with smaller deposits (Level IV).

Apfelberg et al. [32] presented a multicenter study involving 1100 patients who underwent LAL across 12 different centers, with a mean follow-up period of 6 months. The study evaluated the safety and efficacy of LAL in various body regions, including the abdomen, thighs, knees, arms, and neck. The results demonstrated significant improvements in body contour and fat reduction, with an average fat volume reduction of 70%. The study also reported a low complication rate of 2.4%, with seromas and hematomas being the most common complications. LAL was found to be particularly effective in areas with larger fat deposits (Level IIa).

Przylipiak et al. [33] compared the effects of internal LAL and conventional liposuction (CL) on postoperative laboratory values in a study of 80 patients. Participants were divided into two groups, with 40 patients receiving LAL and 40 undergoing CL for body contouring and fat reduction. The study also examined the impact of anesthesia type, comparing

propofol and fentanyl with sevoflurane and sufentanil. The findings revealed similar changes in laboratory values, such as decreased levels of triglycerides, cholesterol, and creatinine, and increased white blood cell counts for both LAL and CL. However, LAL was associated with faster recovery and reduced postoperative pain. The anesthesia type had no significant effect on postoperative laboratory outcomes (Level IIIb).

Nagy et al. [34] conducted a randomized controlled trial comparing the efficacy and safety of VASER-assisted lipoplasty (VAL) with SAL in 150 patients undergoing body contouring and fat reduction. The study measured primary outcomes such as patient satisfaction, pain, and bruising. Both VAL and SAL achieved significant improvements in body contour and fat reduction, though VAL was associated with less bruising and a faster recovery time. Patient satisfaction levels were similar between the two groups, with VAL showing a lower incidence of hematoma and seroma compared to SAL (Level Ib).

Oh et al. [35] investigated the effectiveness of a combined non-invasive and minimally invasive laser lipolysis system for fat reduction in a study involving 20 patients treated for facial fat reduction. The novel system, which integrates non-invasive laser energy with minimally invasive lipolysis, was evaluated for its impact on fat thickness. Results indicated a significant reduction in facial fat thickness, averaging 35.6%. The treatment was well-tolerated, with minimal adverse effects reported. A control group receiving only non-invasive laser treatment demonstrated a smaller reduction in fat thickness, suggesting that the addition of minimally invasive lipolysis enhanced the treatment's efficacy (Level IV).

Yildiz et al. [36] conducted a histopathological analysis comparing the effects of LAL and SAL on fat cells. The study assessed the morphological and structural changes in fat cells harvested from patients undergoing LAL or SAL procedures. The results demonstrated that LAL induced more pronounced changes in fat cell morphology, leading to a higher degree of lipolysis, inflammation, and fibrosis compared to SAL. LAL-treated fat cells exhibited a higher concentration of inflammatory cells and a lower concentration of adipocytes compared to those treated with SAL (Level IIIb).

Levenberg et al. [37] compared the effects of LAL and mechanical liposuction (ML) on cell viability and sample quality in a study involving 30 patients undergoing procedures for autologous fat grafting. The results showed that LAL significantly improved cell viability and sample quality compared to ML. LAL-treated fat tissue demonstrated higher cell survival rates, reduced cell damage, and better tissue integrity. Additionally, LAL samples exhibited improved fatty acid content, collagen density, and vascularization compared to ML samples (Level IIb).

Chia et al. [38] provided an overview of the current evidence on liposuction techniques, including LAL and traditional suction-assisted liposuction (SAL). The authors concluded that LAL offers no significant advantages over SAL in terms of fat removal, skin tightening, or patient satisfaction. Furthermore, LAL may be associated with an increased risk of complications such as burns and scarring. The article highlighted that LAL's use of laser energy to heat fat tissue prior to suctioning may result in more extensive tissue damage and inflammation, leading to longer recovery times, increased pain, and a higher risk of complications. In contrast, SAL is presented as a more established technique with a lower likelihood of causing such adverse effects (Level IV).

Žgaljardić et al. [39] provided an overview of current techniques and applications of laser-assisted body contouring in cosmetic surgery. The chapter discussed the principles of laser technology, including the types of lasers used, their mechanisms of action, and their benefits and limitations. The authors described various laser-assisted body contouring procedures, such as laser lipolysis, laser-assisted lipectomy, and laser skin tightening. They also discussed indications, contraindications, and potential complications and risks associated with these procedures (Level V).

Machado et al. [40] examined various liposuction techniques, with a particular focus on gluteal fat augmentation. The authors emphasized the critical role of proper liposuction techniques in achieving successful outcomes, especially in gluteal augmentation proce-

dures. The chapter covered different types of liposuction, including traditional SAL, LAL, and power-assisted liposuction (PAL). The authors highlighted the importance of patient selection, pre-operative planning, and post-operative care in achieving optimal results. The chapter also discussed the role of tumescent anesthesia in liposuction, detailing its benefits and limitations. Additionally, practical tips and techniques for optimizing liposuction outcomes, such as multiple passes, careful tissue handling, and precise aspiration methods, were provided (Level V).

3.5. Safety and Technique Comparisons

Halk et al. [41] aimed to evaluate the safety of LAL and SFR by conducting a systematic review of existing literature. The authors searched multiple databases and identified 34 studies that reported safety outcomes for LAL and SFR. The outcomes assessed included adverse events, complications, and patient satisfaction. The results showed that both LAL and SFR were generally safe, with similar rates of minor complications such as bruising, swelling, and numbness. However, LAL was associated with a higher risk of more severe complications, including burns, skin necrosis, and scarring (Level Ia).

Urbonas et al. [42] compared the effectiveness of LAL and SFR in terms of adipocyte viability and surgeon efficiency. The study involved 30 patients who underwent either LAL or SFR for the removal of excess fat from the abdomen, thighs, and arms. The results showed that LAL resulted in significantly higher adipocyte viability compared to SFR ($p < 0.05$), with a mean difference of 12.5% (95% CI 6.8–18.2%). Additionally, surgeons performing LAL reported improved work efficiency, with a mean reduction in procedure time of 23.1 min (95% CI 12.5–33.7 min). The authors concluded that LAL may be associated with higher adipocyte viability and improved surgeon efficiency compared to SFR. However, further studies are required to confirm these findings and to evaluate the long-term effects of LAL on patient outcomes (Level IIb).

Venkataram et al. [43] provided a comprehensive overview of liposuction techniques, including LAL and SFR. The authors discussed the principles, techniques, and outcomes of each method, highlighting the advantages and disadvantages. The article noted that LAL facilitates fat removal using laser energy, resulting in less bleeding and trauma to surrounding tissue, which can lead to improved patient comfort and faster recovery times. However, LAL is also associated with higher costs and may require more complex equipment. In contrast, SFR is a more traditional method that uses suction alone to remove fat but can result in greater bleeding and trauma. SFR is generally less expensive and can be performed with simpler equipment. The authors concluded that while both LAL and SFR are effective, LAL may offer advantages in terms of patient comfort and recovery time. However, additional research is necessary to confirm these findings and to establish the long-term effects of LAL on patient outcomes (Level V).

Rassam et al. [44] provided an overview of various techniques used in body-contouring surgery, including LAL and SFR. The authors emphasized the importance of selecting the appropriate technique for each patient, discussing the respective advantages and disadvantages. The article noted that LAL is a minimally invasive technique that uses laser energy to dissolve fat cells before suctioning, which reduces trauma to surrounding tissues and leads to less bleeding, swelling, and scarring. However, LAL is also more expensive and may require specialized equipment. In contrast, SFR, a more traditional method, relies solely on suction to remove fat, which may cause more bleeding and trauma. SFR is generally less costly and can be performed with simpler equipment (Level V).

Theodorou et al. [45] discussed the advantages of LAL compared to SFR. The authors highlighted the use of laser energy in LAL to break down fat cells before suctioning, which results in reduced bleeding, bruising, and recovery time. LAL was noted to be particularly beneficial for patients with fibrotic or septated fat, as the laser energy can help break down these tissues, facilitating fat removal. Additionally, LAL may lead to improved skin retraction and contouring due to the stimulation of collagen production. However, the authors also cautioned that LAL may not be suitable for all patients, particularly those with

significant excess skin or poor skin elasticity, as the laser's ability to stimulate collagen may be insufficient in these cases (Level IV).

Beidas et al. [46] provided an extensive overview of the current state of liposuction techniques, including LAL. The authors emphasized the importance of selecting the appropriate technique based on individual patient factors such as body type, skin quality, and patient expectations. The article highlighted that LAL is a minimally invasive technique that uses laser energy to break down fat cells before suctioning, resulting in less bleeding, bruising, and scarring compared to traditional methods. However, the authors also noted that LAL may not be ideal for all patients, particularly those with significant skin laxity. They also discussed the benefits of power-assisted liposuction (PAL), which uses a motorized device to assist in fat removal and can be particularly beneficial for patients with dense or fibrotic fat (Level V).

Chittoria et al. [47] provided a comprehensive overview of the indications, techniques, and safety considerations for liposuction surgery. The authors emphasized the critical importance of proper patient selection, thorough preoperative evaluation, and meticulous postoperative care to achieve optimal outcomes. The article discussed various liposuction techniques, including traditional liposuction, PAL, ultrasound-assisted liposuction (UAL), and LAL. Each technique was described in detail, highlighting its advantages and disadvantages. The authors also underscored the importance of safety considerations, including the selection of appropriate anesthesia, wound closure techniques, and the management of potential complications. The emphasis was placed on individualized treatment planning and patient-specific approaches to minimize risks and ensure successful outcomes (Level V).

4. Discussion

Among the various methods available, lipolysis, a minimally invasive technique aimed at removing excess fat cells from the body, has emerged as a popular choice for individuals seeking to achieve their desired body shape [48–50]. Traditional SFR utilizes mechanical energy to disrupt and remove fat cells through suction or cannulae, whereas LAL employs laser energy to specifically target and destroy fat cells. The introduction of LAL has sparked debate regarding its efficacy and safety compared to SFR. The summarized table is as below (Table 1).

Table 1. Comparison of Postoperative Pain, Efficacy, and Safety in Various Liposuction Techniques.

Study	Liposuction Technique	Sample Size	Primary Outcome Measures	Key Findings	Level of Evidence
Llanos Olmedo et al. [20]	Suction-Assisted Lipoplasty (SAL) vs. Laser Lipolysis (LL)	50	Postoperative Pain (VAS)	LL showed significantly less pain compared to SAL (VAS score: 3.4 vs. 6.2 at 6 h)	IIb
Prado et al. [21]	Laser-Assisted Lipoplasty (LAL) vs. Suction-Assisted Lipoplasty (SAL)	60	Pain, Bruising, Patient Satisfaction	LAL had less pain and bruising compared to SAL; similar patient satisfaction	Ib
DiBernardo et al. [22]	Laser-Assisted Liposuction (LAL) vs. Traditional Liposuction (TL)	20	Skin Shrinkage, Texture	LAL showed greater skin shrinkage and improved texture compared to TL	IIa
Brañas et al. [23]	924- and 975-nm Laser Diode	20	Skin Thickness, Elasticity, Texture	Significant improvements in all measures; high patient satisfaction	IV

Table 1. *Cont.*

Study	Liposuction Technique	Sample Size	Primary Outcome Measures	Key Findings	Level of Evidence
Wolfenson et al. [24]	Diode Laser during Lipoplasty	30	Skin Thickness, Elasticity, Texture	Significant improvements on laser-treated side; high patient satisfaction	IIa
Valizadeh et al. [25]	980-nm Diode Laser-Assisted Lipolysis vs. Traditional Liposuction	30	Safety, Efficacy, Pain, Bruising, Swelling	Less pain, bruising, and swelling in laser group	IIa
Jecan et al. [26]	Laser-Assisted Lipolysis (LAL) vs. Suction-Assisted Lipoplasty (SAL)	30	Histological Analysis of Aspirates	LAL aspirates had more fat cells, fewer fibrotic tissues, and more blood vessels compared to SAL	IV
Goldman et al. [27]	Subdermal Nd Laser-Assisted Liposuction (LAL) vs. Traditional Liposuction (TL)	30	Tissue Tightening	Greater improvement in skin elasticity and firmness with LAL	IIa
Pereira-Netto et al. [28]	Laser-Assisted Liposuction (LAL) vs. Traditional Liposuction (TL)	14 studies	Comprehensive Review	LAL associated with less bleeding, pain, and improved skin tightening	IIIa
Mordon et al. [3]	Laser-Assisted Lipolysis (LAL) vs. Traditional Liposuction (TL)	Literature Review	Effectiveness, Safety	LAL potentially offers reduced bleeding, pain, and scarring	IIc
Abdelaal et al. [4]	Laser-Assisted Lipolysis (LAL) vs. Traditional Liposuction (TL)	40	Blood Loss	LAL had significantly less blood loss compared to TL	IIa
Swanson et al. [29]	Review of LAL	Literature Review	Blood Loss	Mixed results on LAL's effectiveness in reducing blood loss	V
Aboelatta et al. [30]	Laser-Assisted Liposuction (LAL) vs. Traditional Liposuction (TL) for Gynecomastia	30	Breast Shape, Pain, Recovery	LAL group had less blood loss, less pain, and faster recovery	IIb
Senra et al. [31]	Laser Lipolysis (LL)	766	Complication Rate, Success Rate	High success rate (85%); low complication rate (2.6%)	IV
Apfelberg et al. [32]	Laser-Assisted Liposuction (LAL)	1100	Body Contour, Fat Reduction	Significant improvements in body contour and fat reduction; low complication rate (2.4%)	IIa
Przylipiak et al. [33]	Internal Laser-Assisted Liposuction (IAL) vs. Conventional Liposuction (CL)	80	Postoperative Laboratory Values	IAL associated with faster recovery and reduced postoperative pain	IIIb

Table 1. *Cont.*

Study	Liposuction Technique	Sample Size	Primary Outcome Measures	Key Findings	Level of Evidence
Nagy et al. [34]	VASER-Assisted Lipoplasty (VAL) vs. Suction-Assisted Lipoplasty (SAL)	150	Patient Satisfaction, Pain, Bruising	VAL had less bruising and faster recovery; similar patient satisfaction	Ib
Oh et al. [35]	Combined Non-Invasive and Minimally Invasive Laser Lipolysis	20	Facial Fat Reduction	Significant fat reduction; minimal adverse effects	IV
Yildiz et al. [36]	Laser-Assisted Liposuction (LAL) vs. Suction-Assisted Liposuction (SAL)	Histopathological Study	Fat Cell Changes	LAL induced more significant changes in fat cell morphology and structure	IIIb
Levenberg et al. [37]	Laser-Assisted Liposuction (LAL) vs. Mechanical Liposuction (ML)	30	Cell Viability, Sample Quality	LAL improved cell viability and sample quality compared to ML	IIb
Chia et al. [38]	Review of LAL vs. SAL	Literature Review	Fat Removal, Skin Tightening, Patient Satisfaction	LAL has no significant advantages over SAL; may have increased risk of complications	IV
Žgaljardić et al. [39]	Overview of Laser-Assisted Body Contouring	Literature Review	Techniques, Applications	Discusses principles, benefits, limitations of laser-assisted body contouring	V
Machado et al. [40]	Liposuction Techniques	Literature Review	Gluteal Fat Augmentation	Emphasizes importance of technique, patient selection, pre- and post-operative care	V
Halk et al. [41]	Review of LAL vs. TL Safety	Literature Review	Safety Outcomes	Both LAL and TL are generally safe; LAL associated with higher risk of severe complications	Ia
Urbonas et al. [42]	Laser-Assisted Liposuction (LAL) vs. Traditional Liposuction (TL)	30	Adipocyte Viability, Work Efficiency	LAL had higher adipocyte viability and improved surgeons' work efficiency	IIb
Venkataram et al. [43]	Review of Liposuction Techniques	Literature Review	Efficacy, Safety, Patient Comfort	LAL may offer advantages in patient comfort and recovery time; TL more traditional and less costly	V
Rassam et al. [44]	Review of Body Contouring Techniques	Literature Review	Techniques, Advantages, Disadvantages	Highlights importance of selecting appropriate technique for each patient	V
Theodorou et al. [45]	Overview of Laser-Assisted Liposuction (LAL)	Literature Review	Principles, Advantages	LAL beneficial for fibrotic or septated fat; may improve skin retraction and contouring	IV

Table 1. *Cont.*

Study	Liposuction Technique	Sample Size	Primary Outcome Measures	Key Findings	Level of Evidence
Beidas et al. [46]	Review of Liposuction Techniques	Literature Review	Technique Selection, Patient Considerations	LAL uses laser energy to break down fat cells; emphasizes importance of selecting appropriate technique	V
Chittoria et al. [47]	Overview of Liposuction Techniques	Literature Review	Indications, Techniques, Safety	Detailed description of various techniques; highlights importance of patient selection and safety	V

Note: VAS = Visual Analog Scale; LAL = Laser-Assisted Liposuction; SAL = Suction-Assisted Lipoplasty; TL = Traditional Liposuction; VAL = VASER-Assisted Lipoplasty; LL = Laser Lipolysis; IAL = Internal Laser-Assisted Liposuction; ML = Mechanical Liposuction.

Early studies on LAL often highlighted its advantages over traditional liposuction, suggesting benefits such as reduced postoperative pain, bruising, and swelling. For instance, a study published in 2007 found that patients who underwent LAL experienced significantly less postoperative pain compared to those who underwent traditional liposuction [20]. Similarly, a 2010 study reported that LAL was associated with less bruising and swelling [21].

However, a comprehensive review by Halk et al. [41], published in 2019, provided a more nuanced perspective by assessing the safety of various liposuction procedures, including LAL and SFR. The authors categorized complications into four levels: minor, moderate, major, and rare. They found that while both LAL and SFR generally exhibited similar rates of minor complications such as bruising, swelling, and numbness, LAL was associated with a higher incidence of severe complications, including burns, skin necrosis, and scarring. The study also identified several risk factors that could increase the likelihood of complications, such as high-volume liposuction, large treatment areas, comorbidities like hypertension and diabetes, a history of bleeding disorders, and the use of general anesthesia. To mitigate these risks, the authors recommended preoperative screening, careful patient selection, the use of tumescent anesthesia, strict sterile techniques, and vigilant postoperative monitoring.

In examining specific body regions and outcomes, various studies have compared LAL and SFR. Llanos Olmedo et al. [20] and Prado et al. [21] both found that LAL resulted in significantly less postoperative pain, as measured by the Visual Analog Scale, with lower scores indicating less pain in LAL patients. The reduced pain was attributed to the precision of the laser in targeting fat cells, thereby minimizing trauma to surrounding tissues.

DiBernardo et al. [22] and Goldman et al. [27] focused on the efficacy of LAL in fat removal and skin tightening, utilizing methods like split-abdomen studies to assess outcomes such as skin shrinkage, elasticity, and texture improvements. LAL demonstrated superior results in skin tightening and texture enhancement, likely due to the thermal energy promoting collagen production. Valizadeh et al. [25] further noted that LAL was associated with less bruising and swelling postoperatively, suggesting a gentler impact on body tissues.

Research has also targeted specific body regions treated with LAL. For instance, Branas et al. [23] assessed the use of LAL in the lower extremities, focusing on areas like the thighs and calves, while Aboelatta et al. [30] examined the combination of LAL and SFR for treating gynecomastia in men. Oh et al. [35] explored the efficacy of a combined non-invasive and minimally invasive laser lipolysis system for facial fat reduction, demonstrating LAL's versatility across different body regions.

Regarding safety and complication rates, Halk et al. [41] and Swanson et al. [29] confirmed that both LAL and SFR are generally safe, though LAL was linked to a higher

risk of severe complications, such as burns and skin necrosis, likely due to laser-induced thermal damage. Chia et al. [38] emphasized that proper technique and careful patient selection are crucial in mitigating these risks.

Histological and cellular analyses, as conducted by Jecan et al. [26] and Yildiz et al. [36], revealed that LAL preserved a higher proportion of fat cells while reducing fibrotic tissue, indicating more effective fat removal. LAL-treated areas also exhibited greater inflammation, suggesting a more active fat breakdown process. Levenberg et al. [37] explored cell viability post-procedure, finding that LAL-treated fat tissue had higher cell survival rates and better quality, making it potentially more suitable for subsequent fat grafting.

Despite these findings, many studies, including those by Prado et al. [21] and Valizadeh et al. [25], acknowledged limitations such as small sample sizes and short follow-up periods, which could affect the reliability and generalizability of the results. The need for standardized outcome measures and larger, well-designed randomized controlled trials was emphasized to provide more definitive conclusions. Pereira-Netto et al. [28] and Rassam et al. [44] suggested that future research should focus on long-term outcomes, patient satisfaction, and comparisons across different patient demographics and body areas to better understand the nuances of each technique.

The evidence indicates that LAL may not necessarily be a safer or more effective option than SFR. However, several limitations must be considered when interpreting these findings. Notably, the relatively small sample sizes in some studies may constrain the generalizability of the results. Additionally, the short follow-up periods in certain studies may not adequately capture long-term outcomes. The absence of well-designed control groups further complicates the robustness of the conclusions. Therefore, there is a clear need for more rigorous research, with larger sample sizes and better-controlled conditions, to provide more definitive insights in future studies.

5. Conclusions

The ongoing debate over LAL and SFR has persisted for several years, with both techniques offering distinct advantages and disadvantages. This literature review aimed to provide a comprehensive evaluation of the current evidence regarding the efficacy and safety of LAL compared to SFR. The findings from this review suggest that LAL may not necessarily be a safer or more effective option than SFR for body-contouring procedures. Although limitations such as small sample sizes and short follow-up periods must be considered, the overall evidence indicates that LAL is a viable alternative to SFR. However, it is important to acknowledge that LAL carries its own set of risks and complications, including the potential for burns, scarring, and hyperpigmentation. Given these findings, it is evident that both LAL and SFR have their own unique benefits and drawbacks. Patients considering body-contouring procedures should be thoroughly counseled on the advantages and risks associated with each technique. Collaborative decision-making between the patient and healthcare provider is essential to determine the most appropriate treatment plan tailored to the patient's individual needs.

As the field of body contouring continues to advance, new technologies and techniques will likely emerge. Healthcare providers must remain informed about the latest evidence-based practices and patient preferences to ensure the delivery of optimal care. Future research should prioritize studies with larger sample sizes, extended follow-up periods, and comparisons between different LAL technologies to enhance decision-making in this area.

Ultimately, the decision between LAL and SFR should be guided by a comprehensive evaluation of the patient's specific needs and preferences. By carefully weighing the benefits and risks of each technique, patients can make informed choices about their treatment options and achieve their desired aesthetic outcomes.

Author Contributions: Conceptualization, L.K.W.C., K.W.A.L., C.H.L. and A.W.K.L.; Writing—Original Draft Preparation, K.W.A.L., L.K.W.C. and A.W.K.L.; Writing—Review and Editing, L.K.W.C., K.W.A.L., J.W. and K.-H.Y.; Supervision, K.-H.Y. All authors have read and agreed to the published version of the manuscript.

Funding: There is no financial disclosure to report.

Conflicts of Interest: I acknowledge that I have considered the conflict-of-interest statement included in the "Author Guidelines". I hereby certify that, to the best of my knowledge, no aspect of my current personal or professional situation might reasonably be expected to significantly affect my views on the subject I am presenting.

References

1. Illouz, Y.G. Body contouring by lipolysis: A 5-year experience with over 3000 cases. *Plast. Reconstr. Surg.* **1983**, *72*, 591–597. [CrossRef] [PubMed]
2. Wolska, J.; Hassan, H. Noninvasive lipolysis modalities in aesthetic medicine. *J. Cosmet. Dermatol.* **2023**, *22*, 2635–2649. [CrossRef] [PubMed]
3. Mordon, S.; Plot, E. Laser lipolysis versus traditional liposuction for fat removal. *Expert Rev. Med. Devices* **2009**, *6*, 677–688. [CrossRef] [PubMed]
4. Abdelaal, M.M.; Aboelatta, Y.A. Comparison of blood loss in laser lipolysis vs. traditional liposuction. *Aesthetic Surg. J.* **2014**, *34*, 907–912. [CrossRef]
5. Fakhouri, T.M.; El Tal, A.K.; Abrou, A.E.; Mehregan, D.A.; Barone, F. Laser-assisted lipolysis: A review. *Dermatol. Surg.* **2012**, *38 Pt 1*, 155–169. [CrossRef]
6. Weiss, R.A. Laser lipolysis and laser-assisted liposuction. In *Fat Removal: Invasive and Non-Invasive Body Contouring*; Wiley-Blackwell: Hoboken, NJ, USA, 2015; pp. 120–136.
7. Sklar, L.R.; El Tal, A.K.; Kerwin, L.Y. Use of transcutaneous ultrasound for lipolysis and skin tightening: A review. *Aesthetic Plast. Surg.* **2014**, *38*, 429–441. [CrossRef]
8. Otto, M.J. The safety and efficacy of thermal lipolysis of adipose tissue via ultrasound for circumference reduction: An open label, single-arm exploratory study. *Lasers Surg. Med.* **2016**, *48*, 734–741. [CrossRef]
9. Jewell, M.L.; Solish, N.J.; Desilets, C.S. Noninvasive body sculpting technologies with an emphasis on high-intensity focused ultrasound. *Aesthetic Plast. Surg.* **2011**, *35*, 901–912. [CrossRef]
10. Ortiz, A.E.; Avram, M.M. Noninvasive body contouring: Cryolipolysis and ultrasound. *Semin. Cutan. Med. Surg.* **2015**, *34*, 129–133. [CrossRef]
11. Pinto, H. Cryolipolysis. In *Cosmetic Medicine and Surgery*; CRC Press: Boca Raton, FL, USA, 2017; pp. 551–560.
12. Duncan, D.I.; Chubaty, R. Clinical safety data and standards of practice for injection lipolysis: A retrospective study. *Aesthetic Surg. J.* **2006**, *26*, 575–585. [CrossRef]
13. Duncan, D. Injection lipolysis for body contouring. In *Body Contouring: Art, Science, and Clinical Practice*; Springer: Berlin/Heidelberg, Germany, 2010; pp. 59–70.
14. Thomas, M.K.; D'Silva, J.A.; Borole, A.J. Injection lipolysis: A systematic review of literature and our experience with a combination of phosphatidylcholine and deoxycholate over a period of 14 years in 1269 patients of Indian and South East Asian origin. *J. Cutan. Aesthetic Surg.* **2018**, *11*, 222–228. [CrossRef] [PubMed]
15. Jegasothy, S.M. Deoxycholic acid injections for bra-line lipolysis. *Dermatol. Surg.* **2018**, *44*, 757–760. [CrossRef] [PubMed]
16. Modena, D.A.O.; da Silva, C.N.; Grecco, C.; Guidi, R.M.; Moreira, R.G.; Coelho, A.A.; Sant'Ana, E.; de Souza, J.R. Extracorporeal shockwave: Mechanisms of action and physiological aspects for cellulite, body shaping, and localized fat—Systematic review. *J. Cosmet. Laser Ther.* **2017**, *19*, 314–319. [CrossRef]
17. Steinert, S.; Steinert, M. Body Contouring with Cryolipolysis and Shock Wave. In *Energy for the Skin: Effects and Side-Effects of Lasers, Flash Lamps and Other Sources of Energy*; Springer International Publishing: Cham, Switzerland, 2022; pp. 345–349.
18. Guidi, R.M.; Soares, C.D.; Cazzo, E.; Chaim, E.A. Electromagnetic shock wave therapy in dermatology: Microscopic analysis of its interaction with the possible reduction of adipose tissue in obese individuals. *Surg. Cosmet. Dermatol.* **2020**, *12*, 352–358.
19. Centre for Evidence-Based Medicine. Oxford Centre for Evidence-Based Medicine: Levels of Evidence (March 2009). Available online: https://www.cebm.ox.ac.uk/resources/levels-of-evidence/oxford-centre-for-evidence-based-medicine-levels-of-evidence-march-2009 (accessed on 5 February 2023).
20. Llanos Olmedo, S.; Danilla Enei, S.; Cavada, G.; Searle, S.; Ponce, D.; Navarrete, L.; Calderón Ortega, W. Postoperative pain in suction assited lipoplasty versus laser lipolisis. Comparative prospective study Comparación del dolor secundario a lipoaspiración tradicional versus lipolisis láser. Estudio prospectivo. *Cir. Plast. Ibero-Latinoam.* **2007**, *33*, 221–231.
21. Prado, A.; Andrades, P.; Danilla, S.; Leniz, P.; Castillo, P.; Gaete, F. A prospective, randomized, double-blind, controlled clinical trial comparing laser-assisted lipoplasty with suction-assisted lipoplasty. *Plast. Reconstr. Surg.* **2006**, *118*, 1032–1045. [CrossRef]
22. DiBernardo, B.E. Randomized, blinded split abdomen study evaluating skin shrinkage and skin tightening in laser-assisted liposuction versus liposuction control. *Aesthetic Surg. J.* **2010**, *30*, 593–602. [CrossRef]

23. Brañas, E.B.; Moraga, J.M. Laser lipolysis using a 924-and 975-nm laser diode in the lower extremities. *Aesthetic Plast. Surg.* **2013**, *37*, 246–253. [CrossRef]
24. Wolfenson, M.; Hochman, B.; Ferreira, L.M. Laser lipolysis: Skin tightening in lipoplasty using a diode laser. *Plast. Reconstr. Surg.* **2015**, *135*, 1369–1377. [CrossRef]
25. Valizadeh, N.; Jalaly, N.Y.; Zarghampour, M.; Barikbin, B.; Haghighatkhah, H.R. Evaluation of safety and efficacy of 980-nm diode laser-assisted lipolysis versus traditional liposuction for submental rejuvenation: A randomized clinical trial. *J. Cosmet. Laser Ther.* **2016**, *18*, 41–45. [CrossRef]
26. Jecan, C.R.; Hernic, A.D.; Tianu, E.C.; Florescu, I.P.; Lascar, I. Histological differences between laser-assisted and suction-as-sisted lipoplasty aspirates—A comparative study. *Rom. J. Morphol. Embryol.* **2015**, *56* (Suppl. 2), S797–S801.
27. Goldman, A.; Wollina, U.; de Mundstock, E.C. Evaluation of tissue tightening by the subdermal Nd: YAG laser-assisted liposuction versus liposuction alone. *J. Cutan. Aesthetic Surg.* **2011**, *4*, 122–128. [CrossRef] [PubMed]
28. Pereira-Netto, D.; Montano-Pedroso, J.C.; Aidar, A.L.E.S.; Marson, W.L.; Ferreira, L.M. Laser-assisted liposuction (LAL) versus traditional liposuction: Systematic review. *Aesthetic Plast. Surg.* **2018**, *42*, 376–383. [CrossRef] [PubMed]
29. Swanson, E. Does laser assistance reduce blood loss after liposuction? *Aesthetic Surg. J.* **2015**, *35*, NP38–NP39. [CrossRef]
30. Aboelatta, Y.A.; Abdelaal, M.M. Comparison of laser-assisted liposuction and traditional liposuction combined with endoscopic surgical excision of grade II gynecomastia. *Eur. J. Plast. Surg.* **2017**, *40*, 541–548. [CrossRef]
31. Senra, A. Evaluation of laser lipolysis: 10 years of experience with 766 patients. *Rev. Bras. Cir. Plástica* **2001**, *28*, 389–397.
32. Apfelberg, D.B. Results of multicenter study of laser-assisted liposuction. *Clin. Plast. Surg.* **1996**, *23*, 713–719. [CrossRef]
33. Przylipiak, A.F.; Galicka, E.; Donejko, M.; Niczyporuk, M.; Przylipiak, J. A comparative study of internal laser-assisted and conventional liposuction: A look at the influence of drugs and major surgery on laboratory postoperative values. *Drug Des. Dev. Ther.* **2013**, *7*, 1195–1200. [CrossRef]
34. Nagy, M.W.; Vanek, P.F., Jr. A multicenter, prospective, randomized, single-blind, controlled clinical trial comparing VASER-assisted lipoplasty and suction-assisted lipoplasty. *Plast. Reconstr. Surg.* **2012**, *129*, 681e–689e. [CrossRef]
35. Oh, S.W.; Lee, J.Y.; Ryu, H.Y.; Seo, Y.S. A comparison of fat reduction efficacy using combined non-invasive and minimally invasive laser lipolysis system. In *Design and Quality for Biomedical Technologies XIII, Proceedings of the SPIE BiOS 2020, San Francisco, CA, USA, 1–6 February 2020*; SPIE: Bellingham, WA, USA, 2020; Volume 11231, pp. 79–82.
36. Yildiz, K.; Tasli, P.N.; Sahin, F.; Güneren, E. Comparison of cellular alterations in fat cells harvested with laser-assisted liposuction and suction-assisted liposuction. *J. Craniofac. Surg.* **2016**, *27*, 631–635. [CrossRef]
37. Levenberg, A.; Scheinowitz, M.; Sharabani-Yosef, O. Higher cell viability and enhanced sample quality following laser-assisted liposuction versus mechanical liposuction. *J. Cosmet. Dermatol. Sci. Appl.* **2015**, *5*, 238. [CrossRef]
38. Chia, C.T.; Neinstein, R.M.; Theodorou, S.J. Evidence-based medicine: Liposuction. *Plast. Reconstr. Surg.* **2017**, *139*, 267e–274e. [CrossRef]
39. Žgaljardić, Z.; Žgaljardić, I. Laser Assisted Body Contouring. In *Manual of Cosmetic Surgery and Medicine: Volume 1—Body Contouring Procedures*; Springer Nature: Singapore, 2023; pp. 267–285.
40. Machado, B.H.B. Liposuction Techniques. In *Gluteal Fat Augmentation: Best Practices in Brazilian Butt Lift*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 73–77.
41. Halk, A.B.; Habbema, L.; Genders, R.E.; Hanke, C.W. Safety studies in the field of liposuction: A systematic review. *Dermatol. Surg.* **2019**, *45*, 171–182. [CrossRef] [PubMed]
42. Urbonas, T.; Kievišas, M.; Petrikaitė, V.; Gibieža, P.; Baranauskas, G.; Mištautas, T.; Jasukaitiene, A. Assessing adipocyte viability and surgeons' work efficiency by comparing different liposuction methods. *Plast. Reconstr. Surg.–Glob. Open* **2023**, *11*, e5190. [CrossRef]
43. Venkataram, J.; Mysore, V. Liposuction-principles, techniques, outcomes. *Dermatol. Rev.* **2021**, *2*, 170–179. [CrossRef]
44. Rassam, M.; Davoudi, B. Techniques in Body-Contouring Surgery. *Evolution* **2024**, *3*, 731–744.
45. Theodorou, S.J.; Chia, C.T.; Dayan, E. Laser-Assisted Liposuction. In *Male Aesthetic Plastic Surgery*; Thieme: Stuttgart, Germany, 2020.
46. Beidas, O.E.; Gusenoff, J.A. Update on liposuction: What all plastic surgeons should know. *Plast. Reconstr. Surg.* **2021**, *147*, 658e–668e. [CrossRef]
47. Chittoria, R.K.; Singh, P.B.K. Indications and techniques of liposuction. *Cosmoderma* **2022**, *2*, 109. [CrossRef]
48. Duncan, R.E.; Ahmadian, M.; Jaworski, K.; Sarkadi-Nagy, E.; Sul, H.S. Regulation of lipolysis in adipocytes. *Annu. Rev. Nutr.* **2007**, *27*, 79–101. [CrossRef]
49. Ahmadian, M.; Wang, Y.; Sul, H.S. Lipolysis in adipocytes. *Int. J. Biochem. Cell Biol.* **2010**, *42*, 555–559. [CrossRef]
50. Lafontan, M.; Langin, D. Lipolysis and lipid mobilization in human adipose tissue. *Prog. Lipid Res.* **2009**, *48*, 275–297. [CrossRef]