Liposuction Techniques

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11.1 Introduction

The increasing demand for body contour surgeries has been favored by safe anesthesia and effective surgical techniques [1]. The advent of liposuction in the late 1970s has tremendously changed plastic surgery for it has become one of the most performed aesthetic surgical procedures worldwide over the last decades. Liposuction is mainly used to remodel the body contour by partially removing deep and superficial fat accumulation. Although liposuction is not a universal remedy for obesity, it is an important complementary technique to enhance the aesthetic result of dermolipectomies and other aesthetic and reconstructive procedures [2]. Given the numerous techniques and recent advances in liposuction, it is important to have the expertise with the chosen liposuction device taking into account the patient safety and the eventual use of the lipoaspirate for grafting [3, 4].

11.2 History

The first attempt to remodel body contour took place in 1921 when Charles Dujarrier removed great amount of tissue while trying to improve the ankles and knees of a dancer. The intervention was a disaster and resulted in necrosis and amputation. During the last century, several other techniques involving excision of skin and subcutaneous fat were developed in an attempt to improve body contouring. In the 1960s, Pitanguy published techniques involving the "en bloc" resection of cutaneous and adipose tissue to redefine the contour of the inferior limbs [1]. Although that technique has had a boost in the last years due to the increasing number of bariatric surgeries, large visible scars and possible complications are limiting factors. Consequently, several surgeons ventured into the endeavor toward an effective removal of subcutaneous fat in the 1970s. Schrudde, in 1972, published a less invasive technique, using a uterine curette [5, 6]. In 1975, Fischer developed a technique of liposuction using a blunt hollow cannula for thigh adiposity with more predictable aesthetic results and fewer complications [7]. Subsequently, Kesserling and Meyer in 1976 used a large cutting curette connected to a low-power device to aspirate the fat that was previously separated from the deep planes by scissors [2, 5].

Liposuction was defined as a technique in 1977, when Illouz introduced two important factors. The use of a modified high-suctioning power device connected to blunt-tipped cannulas of considerable diameter (10 mm) was important to reduce injury to blood vessels, nerves, and lymphatics. Second, the concept of harvesting adipose tissue after subcutaneous infiltration of normal saline and hyaluronidase was also important. The tunneling technique allowed the removal of localized fat throughout the body without extensive scars and complications commonly seen in dermolipectomies [3, 5, 8].

This standard technique was defined as classic liposuction and is known as suction-assisted liposuction (SAL). While the fundamental principle remains, liposuction has evolved from mechanical fat aspiration to sophisticated body contouring techniques, with the use of numerous technologies that have changed surgical outcomes. Since performing large volume liposuction can be labor-intensive, these novel technologies were developed to enhance lipolysis and minimize surgeon's effort [5, 7].

11.3 Modern Concepts and New Technologies

Liposuction aims to remove excess fat and promote harmonious body contour and allow adequate skin retraction. Initially, the target was the deep fat in order to leave a sufficiently thick cutaneous flap that could conceal contour irregularities. Nonetheless, this concept has changed and a

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controlled subdermal injury, through direct mechanical trauma from the cannula itself, became an important objective. The current approach involves an all-layer liposuction with different caliber blunt cannulas to avoid damage to the delicate subdermal vascular plexus. It is known that liposuction outcomes are related to the degree of obesity and cutaneous laxity. The precise mechanism of skin retraction remains unclear while it is known that skin stretching and retraction are usually site-specific. Post-liposuction skin tightening seems to be related to genetics, patient's habits, skin quality, and the chronological age. Nevertheless, to a certain extent, skin retraction can be manipulated through conventional liposuction (SAL) that comprises partial removal of all subcutaneous layers or through thermal or mechanical subdermal injury [3].

After proving its efficacy, SAL was followed by energy-enhanced techniques. The first of these new technologies was ultrasound-assisted liposuction (UAL). However, unanticipated adverse consequences of the additional energy source have proven to be problematic and cutaneous burns and paresthesia were reported. Nonetheless, the goals were to decrease surgeon's fatigue, promote effective lipolysis, and obtain better skin retraction. Consequently, power-assisted liposuction (PAL), laser-assisted liposuction (LAL), and, more recently, the radiofrequency-assisted liposuction (RFAL) were developed [2].

11.4 Available Technologies

Table 11.1 compares the technologies available for liposuction.

11.4.1 Suction-Assisted Liposuction (SAL)

SAL is regarded as the classic technique using a vacuum source that can reach up to 760 mmHg (1 atm pressure) in

Table 11.1 Advantages and disadvantages of the different techniques of liposuction

Period	Developer/ technology		Advantages	Disadvantages
1976	Fischer	Sharp dissection combined with suction		
1980	Illouz	SAL – blunt cannula and wet technique	Most commonly used technique. Easily obtainable	Fatigue; more difficult in secondary procedures where fibrous areas are found; noisy depending upon the machine. Considerable blood content in the lipoaspirate
1989	Toledo	Syringe	Easily obtainable. Low cost. Precise for measuring the removed adipose tissue. Possibility of immediate fat grafting without risk of external contamination	Fatigue for larger areas
1992	UAL	Zocchi	Better penetration in secondary, fibrous areas; less surgeon's effort; some skin contraction can be expected due to the dermal stimulation by the ultrasonic energy	High cost; risk of burns and skin sloughs; larger incisions for the ports; two-stage procedure (extended surgical time)
	VASER	Fodor; de Souza Pinto; Zukowski	Contemporary device using advanced UAL technology; better penetration in secondary, fibrous areas; less blood content in the lipoaspirate; less ecchymosis	Risk of thermal injuries/skin sloughs; requires learning curve; cost and availability of the equipment can be a limiting factor regarding its use
1992	LAL	Apfelberg	More selective adipose damage, thus preserving surrounding tissues' integrity; skin contraction/ tissue tightening; enhanced hemostasis	Requires learning curve; risk of burn injuries / skin sloughs; extended surgical time; cost and availability of the equipment can be a limiting factor regarding its use
1998	PAL	Fodor	Better penetration in secondary, fibrous areas; less tissue trauma. Reduced vascular injury and swelling	Noisy, requires learning curve; surgeon's discomfort (pain, tendinitis); availability of the equipment can be a limiting factor regarding its use
2007	WAL	Man	More selective adipose damage, thus preserving surrounding tissues' integrity; enhanced hemostasis; allows for the immediate recollection of adipocytes	Requires learning curve; cost and availability of the equipment can be a limiting factor regarding its use
2009	RFAL	Paul	No strength required to produce lipolysis as the radiofrequency itself produces it; controlled temperature due to a heat limiter; skin contraction	Cost and availability of the equipment can be a limiting factor regarding its use; risk of burn injuries

order to harvest adipose tissue. The equipment is affordable and easily obtainable. As the cannula moves in the subcutaneous tissue, mechanical disruption and avulsion of adipocytes take place and the lipoaspirate is collected in a canister. SAL's main advantage is the relatively short learning curve, and despite all new advances in liposuction techniques, it remains the most used technique all over the world.

11.4.2 Syringe-Assisted Liposuction

In 1988, Luiz Toledo introduced the use of disposable syringes for liposuction. While still relying on vacuum inside the syringe to harvest fat, it allowed freer movement and more control to the surgeon. The technique is easy and convenient as the lipoaspirate can be kept inside the syringes without contact with the environment and directly injected in the desired sites after processing. However, it can be cumbersome and time consuming in cases of large volume liposuction [2, 3, 5].

11.4.3 Ultrasound-Assisted Liposuction (UAL)

Ultrasound-assisted liposuction (UAL) was introduced by Zocchi in 1992. This technique involves the application of ultrasound waves transmitted by the probe as high-frequency acoustic energy. The mechanical oscillations produced by the device pass through the tip of the cannula that emits waves. Sound waves have natural cycles of expansion and compression. The compression cycle exerts a negative pressure that creates interstitial cavitation. The resultant microbubbles implode causing cellular fragmentation and fat emulsification, and less physical exertion is required as the fat is dissolved with ultrasound [3, 9]. The action of ultrasound waves comprises both thermal and mechanical effects to the surrounding adipocytes. A selectivity and tissue-specificity of UAL destruction is expected as cellular rupture is faster in adipose tissue than in surrounding higher-density structures such as muscle and fascia. The thermal effects of ultrasound generate a significant amount of heat; therefore, generous amount of tissue infiltration must be done to dissipate the head and reduce thermal injury [3, 9]. Skin retraction is expected secondary to the stimulation of the dermis by the ultrasonic energy. The drawbacks include skin sloughs, burns, seromas, and the need for larger incisions to accommodate the incision protectors and a long learning curve. The original technique consisted of a two-stage process where the use of the ultrasound to treat the adipose tissue preceded the aspiration, prolong the operative time up to 40%. Consequently, a second generation of devices using a hollow cannula with simultaneous liposuction was developed. More recently a third generation ultrasound-based device was developed using internal ultrasound waves delivered via a solid grooved probe, which included two modifications: a pulsed energy, rather than continuous and concentric rings near a smaller probe tip. These modifications significantly reduced the levels of ultrasonic power for fat fragmentation with fewer adverse effects. The system was named VASER for Vibration Amplification of Sound Energy at Resonance (Solta Medical, Hayward, CA, USA). VASER-assisted liposuction is advantageous in fibrous areas, particularly the trunk and previous areas of liposuction. Studies have shown reduced ecchymosis, less blood loss, and less postoperative pain [10]. However, the high cost of the equipment hinders its ample use.

11.4.4 Laser-Assisted Liposuction

The first studies on the interaction between laser and adipose tissue were conducted by Apfelberg in 1992 [11].

According to the theory of selective photothermolysis, appropriate laser selection allows preferential targeting of tissues, since the wavelengths have different absorption coefficients for fat, water, and hemoglobin. These chromophores preferentially absorb laser energy on the basis of their absorption coefficients at specific wavelengths. Different wavelengths have been selected for laser-assisted liposuction (LAL) in an attempt to specifically target subcutaneous tissue. The most used device is the 1064 nm neodymium-doped yttrium aluminum garnet (Nd:YAG) laser. The laser system emits light in the form of a beam that is converted to heat energy in fat, collagenous tissue, and hemoglobin. The employed photothermal energy liquefies the adipose tissue by rupturing the adipocyte's membrane releasing oily content into the extracellular fluid. Since laser coagulates small blood vessels, hemostasis is obtained. Additionally, it induces collagenesis with remodeling of the reticular dermis promoting tissue tightening [11]. There is no evidence supporting LAL superiority over other liposuction techniques. The disadvantages include the high cost of equipment, prolonged surgical time, and thermal injuries.

11.4.5 Power-Assisted Liposuction (PAL)

Power-assisted liposuction (PAL) described by Fodor involved the use of power supplied by an electric motor or compressed air producing a rapid in-and-out movement or an elliptic movement to an attached liposuction cannula breaking down the adipocytes directly and suctions the avulsed fat globules [12]. Depending on the vibration mode chosen, linear or rotational cannula movements travel between 600 and 4000 cycles/min. PAL is an efficient technique that has the advantage of less tissue trauma, edema, vascular injury, and

ecchymosis in addition to shorter recovery and diminished surgeon's fatigue. The mechanical energy releases less thermal energy than the UAL; therefore, infiltrating solution is required. The disadvantages include the long learning curve, the noise of the equipment, and the constant movement of the handheld cannula which can lead to surgeon's discomfort, possible tendinitis and joint pain, and movement of the associated with operation of the PAL cannula.

11.4.6 Water-Assisted Liposuction

Water-assisted liposuction (WAL) was described in 2007, and, as the name suggests, this system uses water to loosen fat cells from the connective tissue. A thin, hollow cannula intermittently introduces a wetting solution in a microthin fan-like water stream directed at 30° anteriorly. The water-jet pressure can be adjusted with the ranges of 30–120 kPa increasing adipose cell detachment while preserving cellular integrity and causing less damage to the surrounding blood vessels and nerves. The advantages are reduced blood loss, reduced risk of adverse volume-related complication due to volume overload, less postoperative pain, ecchymosis, and edema [3]. The main disadvantage is the cost of the equipment.

11.4.7 Radiofrequency-Assisted Liposuction (RFAL)

Radiofrequency-assisted liposuction (RFAL) comprises the use of bipolar radiofrequency energy to disrupt the adipose cell membrane and facilitate lipolysis. This electrical current, which flows from the tip of the cannula to an electrode, creates a contained thermal energy to maximize skin retraction and fat coagulation. During the procedure, no skin pinch or palpation guides the surgeon. Since the machine produces lipolysis, the end-point is determined by the loss of resistance to forward motion of the cannula. Comparing to LAL that produces a relatively uncontrolled and focal effect, the radiofrequency device automatically adjusts the temperature as needed, producing uniform heat throughout the layers of the skin. The temperature must remain between 40 and 42 °C so that optimal skin retraction can occur with no burn and skin necrosis. The cannula is inserted in the subcutaneous tissue, and an electrode is placed on the surface of the skin. The emission of radiofrequency radiation is cast between the internal and external electrodes, destroying adipose tissue and promoting coagulation. The internal electrode, placed in the subcutaneous adipose tissue, is used in the same manner as SAL, creating numerous tunnels as it passes without effort as the radiofrequency energy itself produces the lipolysis. RFAL has the advantages of creating less ecchymosis, pain, and edema [3], and promotes better skin retraction explained by the neocollagenesis derived from the controlled thermal injury at the subdermal surface. The disadvantages are the learning curve and the cost of the equipment.

11.5 Adipocyte Viability in the Lipoaspirate

Adipose tissue is used for soft-tissue augmentation and as an alternative source of large quantities of mesenchymal stem cells. Choosing the right liposuction technique to harvest fat for grafting is important for graft take. The number and viability of adipocytes and adipose regenerative cells comprised in the stromal vascular fraction can vary depending on the liposuction technique used.

Suction-assisted liposuction has been the gold standard, especially for gluteal augmentation which involves larger volumes of fat grafting. Some authors recommend the use of low-pressure syringe vacuum aspiration as the pressure parameters for harvesting adipose tissue influence the number and functional properties of the adipose-derived stem cells (ADSCs) [13]. Coleman's method, which makes use of a 3-mm blunt-head suction cannula connected to a 10-ml Luer-Lock syringe, is the current internationally recognized method for autologous fat transplantation. The viability and enzyme activity (glyceraldehyde-3-phosphate dehydrogenase) of the adipocytes harvested by this technique seem to be significantly higher than other techniques. Yet, the multimodality approaches for autologous fat transplant, including thriving technologies such as ultrasound-assisted, water jet-assisted, VASER system, and radiofrequency, need to be better evaluated [14]. Technically, the chosen device must be safe, easy to handle, time saving, low priced, and shall not impair the number and functional properties of the ASC [15].

Among the available technologies, no negative effect on ASCs seems to occur while using water jet-assisted, third-generation ultrasound and PAL devices [14, 15]. Similarly, viability of the adipocytes harvested using the VASER system is estimated by 85.1%, consistent with the outcome related to conventional suction-assisted liposuction technology [16].

The ASCs harvested with laser or SAL both undergo osteogenic and adipogenic differentiation; the impact on cellular yield and ASC biology makes SAL more advantageous for clinical applications where large numbers of viable cells are necessary for tissue repair and reconstruction [17].

Although there are unique advantages and disadvantages of each lipoplasty technique, in experienced hands, excellent results can be achieved with any of the techniques, including suction-assisted lipectomy, power-assisted lipoplasty, UAL, and laser-assisted lipoplasty [18]. Contour deformities resulting from liposuction are usually related to how the operator performs the technique rather than the technique itself.

References

1. Pitanguy I, Radwanski HN, Machado BHB. Liposuction and dermolipectomy. In: Shiffman M, Di Giuseppe A, editors. Liposuction. 2nd ed. Berlin/Heidelberg: Springer; 2016.
2. Bellini E, Grieco MP, Raposio E. A journey through liposuction and liposculture: review. Ann Med Surg. 2017;24:53–60.
3. Berry MG, Davies D. Liposuction: a review of principles and techniques. J Plast Reconstr Aesthet Surg. 2011;64:985–92.
4. Hunstad JP, Aitken ME. Liposuction: techniques and guidelines. Clin Plast Surg. 2006;33:13–25.
5. Flynn TC, Coleman WP, Field LM, et al. History of liposuction. Dermatol Surg. 2000;26:515–20.
6. Coleman WP 3rd. The history of liposuction and fat transplantation in America. Dermatol Clin. 1999;17:723–7.
7. Fischer G. Liposculpture: the correct history of liposuction: part I. J Dermatol Surg Oncol. 1990;16:1086.
8. Illouz Y. Body contouring by lipolysis: a 5 year experience with over 3000 cases. Plast Reconstr Surg. 1983;72:511–24.
9. Fodor PB, Watson J. Personal experience with ultrasound-assisted lipoplasty: a pilot study comparing ultrasound-assisted lipoplasty with traditional lipoplasty. Plast Reconstr Surg. 1998;101:1103–16.
10. de Souza Pinto EB, Abdala PC, Maciel CM. Liposuction and VASER. Clin Plast Surg. 2006;33:107–15.
11. Chung MT, Zimmermann AS, Paik KJ, et al. Isolation of human adipose-derived stromal cells using laser-assisted liposuction and their therapeutic potential in regenerative medicine. Stem Cells Transl Med. 2013;2:808–17.
12. Fodor PB. Power-assisted lipoplasty versus traditional suction-assisted lipoplasty: comparative evaluation and analysis of output. Aesthet Plast Surg. 2005;29:127.
13. Oedayrajsingh-Varma MJ, van Ham SM, Knippenberg M, et al. Adipose tissue-derived mesenchymal stem cell yield and growth characteristics are affected by the tissue-harvesting procedure. Cytotherapy. 2006;8:166–77.
14. Schafer ME, Hicok KC, Mills DC, et al. Acute adipocyte viability after third-generation ultrasound-assisted liposuction. Aesthet Surg J. 2013;33:698–704.
15. Keck M, Kober J, Riedl O, et al. Power assisted liposuction to obtain adipose- derived stem cells: impact on viability and differentiation to adipocytes in comparison to manual aspiration. J Plast Reconstr Aesthet Surg. 2014;67:1–8.
16. Alharbi Z, Opländer C. Conventional vs. micro-fat harvesting: how fat harvesting technique affects tissue-engineering approaches using adipose tissue-derived stem/stromal cells. J Plast Reconstruct Aesthet Surg. 2013;66:1271–8.
17. Shim YH, Zhang RH. Literature review to optimize the autologous fat transplantation procedure and recent technologies to improve graft viability and overall outcome: a systematic and retrospective analytic approach. Aesth Plast Surg. 2017;41:815–31.
18. Condé-Green A, Baptista LS, de Amorin NF, et al. Effects of centrifugation on cell composition and viability of aspirated adipose tissue processed for transplantation. Aesthet Surg J. 2010;30:249–55.