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History of Body Contouring

Malcolm D. Paul and Garrett Wirth

Abstract

The evolution of body contouring follows decades of procedures and technologic advances in body shaping. Beginning many decades ago with extensive surgical resections of skin and subcutaneous fat, the evolution was dramatically changed with the introduction of suction assisted lipectomy (liposuction). Further refinement in the technique of liposuction allowed more precise sculpting of the body and, most recently, has evolved to high definition liposuction. Following the introduction of liposuction in the early 1980s, energy based devices were developed to allow non or minimally invasive procedures to sculpt the body. The energy sources include laser energy, radiofrequency energy, ultrasonic energy, and plasma based energy. This evolution has provide the cosmetic surgeon with a variety of options to obtain optimal body contouring in a variety of clinical presentations. The safety and the efficacy of these procedures are the most important considerations in adopting new technology and techniques.

Keywords: liposuction, radiofrequency, energy

1. Introduction

Physical appearance has been of immense importance for centuries B.C. including the wives of Persian rulers (**Figures 1–3**) and as seen in portraits dating back to the Italian Renaissance (**Figures 4 and 5**). Although there were no procedures available to address unwanted excess truncal fat and loose skin, artists in the above cited figures portrayed the ideal male contour and the unattractive body contour in a young child. The child demonstrates early obesity with neck, truncal, and extremity lipodystrophy. Unaesthetic fat deposits or loose skin, especially the ones without response to diet or physical exercise, are a major concern to patients. Witness the frequency of body contouring procedures throughout the world where liposuction is the most common esthetic surgical procedure. There are, however, differences in the distribution of the body fat between male and female patients. Men have less body fat around the waist, especially in the abdominal area; women generally have a higher percentage of body fat than men, especially around their thighs and buttocks, which is called gynoid fat. In overweight women, normally, the deposition is mainly found below the waist.

2. Early treatment of abdominal lipodystrophy and skin excess

The earliest procedures that addressed excess skin and subcutaneous fat in the abdominal area were performed for functional indications, not for esthetic



Figure 1.
Symbols of beauty from the Persian Culture.



Figure 2.
Symbols of beauty from the Persian Culture.

improvements. Certainly, removing skin and fat (dermo-lipectomy) had the secondary benefit of having the patient look better. In 1880, in France, Demars and Marx reported a large resection of skin and fat from the abdominal wall. In 1899, Dr. Kelly (a Johns Hopkins Gynecologist) performed a panniculectomy with an elliptical transversal incision around the umbilicus [1]. In 1901, Peters described a similar surgery extracting 7450 g from a patient, including the umbilicus, without the undermining [2]. Gaudet and Morestin extracted fat and skin with correction of an umbilical hernia while preserving the umbilicus. Eventually, Babcock in 1916 described dermo-lipectomies using a vertical incision [3].



Figure 3.
Symbols of beauty from the Persian Culture.

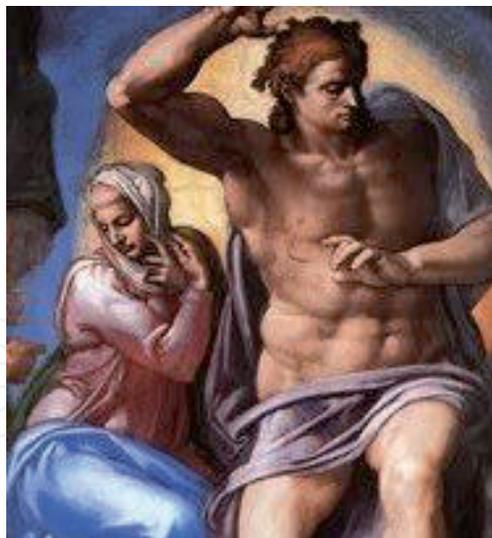


Figure 4.
Symbols of beauty from the Renaissance.

3. Evolving procedures in body contouring

Thorek performed the first umbilicus-preserving abdominoplasty in 1924 [4]. This was the first abdominal contouring procedure with esthetic benefits. Passot's contribution was to use undermining as a modification of Kelly's technique [5]. Vernon in the 1950s developed a novel concept by combining extensive undermining with the umbilical transposition and relocation, which is a procedure still in use today.



Figure 5.
Symbols of beauty from the Renaissance.

Callia described aponeurotic suturing as an important component of his procedure in 1967, which involved an infra-inguinal incision. Pitanguy in the same year published a series of 300 abdominal lipectomies with an infra-inguinal incision [6]. Previously, the published literature consisted mostly of case reports of a few patients. In the 1970s, Regnault modified the Pitanguy's incision into the "W" incision [7]. In 1973, Grazer championed the "bikini line" incision used frequently today [8]. Grazer and Goldwyn in 1977 observed that abdominoplasty decreased anterior projection of the abdomen but did little to change waist diameter. This led to Psillakis' assertion in 1978 that muscular aponeurotic suturing was an underutilized tool to decrease waistline dimensions [9]. Somalo and Gonzalez-Ulloa extended the transverse abdominal incision circumferentially and introduced the belt lipectomy [10]. This concept would provide the background for many subsequent more aggressive procedures.

4. Evolution of liposuction

Describing the evolution of body contouring procedures would be entirely inadequate without presenting the chronologic events in the development of closed liposuction techniques. For certain, the most significant advancement in body contouring WITH OR WITHOUT concomitant excision of skin and subcutaneous fat was the development of closed liposuction.

Removing excess fat from localized body sites is not a new idea [11]. In 1921, in France, Charles Dujarrier tried to remove subcutaneous fat using a uterine curette on a dancer's calves and knees [12]. Unfortunately, he damaged the femoral artery, and the patient has lost her leg. One of the original and creative initiatives came from Schrudde in 1964, when he extracted fat from lower areas of the limb, through a visibly small incision, utilizing a curette. The unfortunate results from this surgical initiative were unpleasant hematomas and seromas [13]. Pitanguy, on the other hand, was in favor of a removal of both fat and skin in a block, in order to remove excess thigh adiposities in one act [14]. Of course, this was an excisional procedure, not closed liposuction. Significant visible incisions made this method quite unpopular and made closed, non-excisional, procedures preferred, but, at that time, not discovered. The field of modern liposuction began with the technique and new instruments developed by Arpad and Fischer [15, 16]. During their work in Rome, Italy, they managed to develop a blunt hollow cannula, with additional function of suction. Some of the previous cannula designs contained a cutting blade also. They made their results public in 1976 [17]. Fischer also started the crisscross tunnel formation method, from several incision sites. The new instruments brought very promising results avoiding the above complications.

Kesselring and Meyer [18] published their surgery results of sharp curettage aided by a suction device in 1978, but their method did not receive a wide acceptance. Fournier, in Paris, showed an early interest in the Fischer's liposculpture technique [19]. He was an initial enthusiast of the "dry technique" in which no fluids were infiltrated into the patient prior to liposuction. Fournier would become a world leader in liposuction and fat transplantation, eventually insisting on the benefits of tumescent anesthesia and making a great contribution in opening new horizons and ideas to surgeons from different parts of the world. Illouz, a French gynecologist, was quite attracted by the Fishers' work. His preferred method was the "wet technique", which consisted of a solution of hypotonic saline together with hyaluronidase inserted into the adipose tissue before the aspiration. Illouz thought that the solution itself was a "dissecting hydrotomy" which would catalyze the removal of fat and thus reduce trauma, as there was smaller amount of bleeding. Illouz received worldwide publicity and promoted this method. The first US surgeon to visit France to learn the new area of liposuction was Lawrence Field in 1977, a Californian dermatologic surgeon. Other surgeons from the States, coming to conferences and educating themselves about new methods in the literature, also showed an interest in the area. One of them was Norman Martin, an otolaryngologist. He visited Illouz in 1980 and quickly started with liposuction surgeries in Los Angeles in 1981 [20, 21]. It was 1982 when a group of physicians from various specialty disciplines received lectures from Illouz and Fournier. At the annual meeting of the American Society of Plastic Surgeons (known at that time as The American Society of Plastic and Reconstructive Surgeons) in 1982, Dr. Illouz, for the first time in front of an audience of Board Certified Plastic Surgeons presented his technique of closed liposuction utilizing hollow cannulas of 1 cm in diameter connected to a suction pump with one atmosphere of negative pressure to extract fat that was pretreated with his wetting solution. The photographs (presented in carousel slide format) showed pre and pos-op photos of women who underwent liposuction of their "saddle bags" with only one cm. scars. This was remarkable in light of the existing treatment option which required large incisions (as published by Pitanguy) for the performance of dermo-lipectomies of this area. After this meeting, a task group formed by the American Society of Plastic and Reconstructive Surgeons visited Europe to learn and form opinions about this new procedure. Several pioneers in the closed technique of liposuction visited Dr. Fred Grazer after the national presentation in 1982 and I had the privilege of attending this small group course. Dr. Frank Ashley, former Chairman of the Division of Plastic Surgery at the University of California attended as well to learn this revolutionary technique. Dr. Grazer named this new procedure Suction Assisted Lipectomy. Important pioneers in the closed liposuction technique had developed cannulas which were quite aggressive when compared to the 5 mm and smaller cannulas in widespread use today. Schrudde, Kesselring, and Illouz left their cannulas in Dr. Grazer's office and they are of historical importance as one studies the refinement in the performance of liposuction (**Figures 6–9**). Julius Newman, otolaryngologist and cosmetic surgeon, together with his associate Richard Dolsky, who was a plastic surgeon, together taught the first American course on liposuction, held in Philadelphia in 1982. The five live surgery workshops were held in Hollywood, California, in June 1983, under the authority of the American Society of Cosmetic Surgeons and the American Society of Liposuction Surgery. There were altogether 10 dermatologists in attendance. The American Society of Plastic Surgeons and The American Society for Esthetic Plastic Surgery subsequently developed teaching courses and symposia to teach closed liposuction to fully trained, Board Eligible and Board Certified Plastic Surgeons. Subsequently, the core curriculum in accredited Plastic Surgery Resident Training Programs included didactic and hands-on training in liposuction.



Figure 6.
Examples of first generation suction cannulas.

The development of the Tumescant (from Latin meaning swollen or being swollen) Technique for performing Liposuction, described in publications by Dr. Jeffrey Klein [22–26], a Dermatologist, had an enormous impact in the safe and more easily performed liposuction procedure. The formula currently includes Lidocaine 2%, Sodium Bicarbonate, and Epinephrine (1–1,000,000), added to 1 liter of Sodium Chloride (if Ringers Lactate is substituted for Normal Saline, sodium bicarbonate is not added to the solution). The tumescant technique was modified such that only a 1:1 or 1.5:1 ratio of tumescant fluid to expected aspiration volume is injected rather than a 2 or 3:1 ratio which was the initial ratio in the Klein tumescant solution. The introduction of the tumescant liposuction technique allowed for the office-based removal of fatty deposits under no sedation, minimal Class 1 sedation, intravenous sedation, or general anesthesia. (Safe guidelines and other safety considerations are described below).

As the number of cases increased dramatically over the years, important additions to the options in body contouring occurred. Lockwood's observance and, perhaps the discovery, of the SFS (superficial fascial system) [27–29] resulted in his landmark publications wherein he utilized this fascial system for important



Figure 7.
Examples of first generation suction cannulas.



Figure 8.
Examples of first generation suction cannulas.

support of elevated soft tissue flaps including abdominal and lower extremity flaps that were elevated and repositioned to correct soft tissue ptosis. Liposuction was a component of his body contouring procedures. Certainly, liposuction allowed remodeling of the abdomen and lower extremities combined with, based upon the clinical anatomical findings, surgical excision of excess skin and subcutaneous tissues. Prior to Lockwood's description of the SFS, lower extremity medial thigh lifts were accompanied by migrating, unattractive scars. He also utilized the SFS in his High Lateral Tension Abdominoplasty to obtain improved contours and favorable scars as a trade-off for important excision of redundant soft tissues.



Figure 9.
Examples of first generation suction cannulas.

Prior to liposuction, upper extremity unwanted fatty deposits with or without accompanying excess skin required large excisions of skin and subcutaneous tissue with resultant unfavorable scars. Liposuction has allowed fatty deposits to be removed through small access incisions and the incisions needed for skin and subcutaneous tissue removal have decreased in length.

Combined with available energy-based devices, soft tissue retraction can be an important component to body contouring of the head and neck, extremities and anterior and posterior trunk.

Fat grafting, although introduced by Gustav Neuber (1850–1932) late in the 19th century [30], was authenticated and refined with the landmark work of Sydney Coleman [31]. He introduced structural fat grafting which required small amounts (macrografts) of fat carefully placed in parallel tunnels, separated by adjacent blood vessels which nourish the grafted fat. Without a doubt, his contribution brought fat grafting to the armamentarium of cosmetic physicians and surgeons with a method that proved that grafted fat, when obtained, processed, and carefully injected in tiny amounts (0.1 cc or less) survived. He also showed how the stem cell component of fat grafts rejuvenate the skin, improve dermatologic skin conditions, with improved texture, etc. Fat grafting has evolved to include soft tissue augmentation of the face and breast, revision of breast reconstruction, treatment of post-augmentation mammoplasty contour deformities (including capsular contraction), contour deformities from prior liposuction and/or skin and subcutaneous fat excisions, and treatment of depressed scars. It is included in High Definition Liposuction further defining the underlying abdominal wall musculature. Fat grafting has evolved to the production of smaller particles including nanofat introduced by Tonnard [32].

Recently, cosmetic surgeons have injected Tranexemic Acid (TXA) and have observed an impressive decrease in blood loss. It has been used intravenously and topically as well, but the addition of tranexemic acid to the liposuction infusion has seen its' application in closed liposuction. TXA is safe and its' application has been studied in other cosmetic procedures with a notable decrease in blood loss [33].

When one looks at the statistics regarding obesity and morbid obesity with 40% of Americans considered obese and 18% considered severely obese as of 2019 with severe obesity defined as a BMI greater than 35 (Research performed at the Harvard T.H. Chan School of Public Health) it is clear as to why liposuction which is consistently listed in position 1 or 2 of the 5 most frequently performed cosmetic

surgical procedures in the U.S. and dermolipectomies (270,670 liposuction and 140,381 abdominoplasties performed by Board Certified Plastic Surgeons) are so popular, increasing in numbers yearly (American Society of Plastic Surgeons Annual Statistics, 2019). Moreover, bariatric procedures to treat morbid obesity have evolved in tandem with body contouring procedures to address excess skin throughout the body after significant weight loss.

In summary, Liposuction has evolved from the removal of fatty deposits in the neck, upper and lower extremities, and anterior and posterior trunk to artistic remodeling of the shape of the face, neck, extremities, and trunk, performed alone or in combined treatment with various energy based devices.

5. Safety considerations in performing liposuction

5.1 Combining suction lipectomy with other procedures

Safety in liposuction combines proper education, patient selection, and proper application of science while achieving the goal of esthetics. Providing safe surgery in a hospital or accredited surgery center (or Ambulatory Surgery Center (ASC) has become increasingly a topic of discussion as the roles of fat grafting (breast surgery, Brazilian Butt Lift, facial surgery, etc.) have increased. Office based procedures can be done safely and should still follow proper guidelines. As noted above, the role of wetting solutions allowed safe and reproducible results over the past several decades.

There are various oversight organizations and governmental regulations that have been well established. These are designed to help ensure patient safety. As this is not a comprehensive review of each organization, some general parameters are presented below. For those that will be using freestanding ASCs through Medicare and or Medicaid, rules include An ASC must be certified and approved to enter into a written agreement with CMS, The regulatory definition of an ASC does not allow the ASC and another entity, such as an adjacent physician's office, to mix functions and operations in a common space during concurrent or overlapping hours of operations., and ASCs are not permitted to share space, even when temporally separated, with a hospital or Critical Access Hospital outpatient surgery department, or with a Medicare-participating Independent Diagnostic Testing Facility (IDTF), as noted on CMS.gov. (REF- CMS.gov). ASCs must comply with a multitude of state as well as federal regulations and statutes. This includes proper licensing, Health Insurance Portability and Accountability Act (HIPAA) and more (REF ASCassociation.org). Furthermore, the ASC is also responsible to ensure that the providers comply with all the standards that govern ensuring professional training, equipment, medications, physical layout of the facility and operational safety. Outpatient surgery is suited best for healthy people undergoing minor or intermediate procedures (plastic surgery, ob-gyn, limited urologic, ophthalmologic, or ear, nose and throat procedures and procedures involving the extremities). However, health care reform and the Affordable Care Act of 2010 have expanded the types and complexity of surgical procedures, with much of the growth driven by advancements in anesthesia and technology. (REF AAAASF.org).

5.2 Wetting solutions and volume extractions

Wetting solutions were covered earlier in this chapter. The surgeon should become familiar with the various solutions. Furthermore, the amount of blood loss with the different must be accounted for by the surgeon to maintain safety.

(ADD TABLE FOR APPROXIMATE BLOOD LOSS?) That percentage of blood loss can range from 1% with solutions such as tumescent and superwet to nearly 40% in the infranatant with the dry technique. (REF?) Preoperatively the patient should be healthy and optimized and laboratory studies should be checked to help guide proper patient selection. These solutions can also vary in terms of lidocaine load to the patient. The surgeon should be familiar with the correct calculations to not over-deliver lidocaine to the patient as well as understanding that absorption can be variable between patients. As lidocaine absorption from the subcutaneous fat, the plasma lidocaine levels may not peak until 10–12 hours after delivery. Furthermore, chronic disease, stress, tobacco use, hormones, and more will influence the protein binding and when the peak will effect the patient. Care must be taken and individualized for each patient.

Volume extraction concerns have evolved to help protect patients, but discussions continue how to apply and ensure proper application. In general, the most commonly accepted guideline is based on “Large volume lipoplasty” as greater than 5000 cm³ of supranatant fat during a single surgery. Volumes greater than this can be done, and patient safety parameters should be utilized and regulations followed. These large volume liposuction procedures can be completed in a hospital setting or often mandate overnight monitoring. Patient age, general health and even the percentage of body surface are examples of considerations. While we have discussed lidocaine issues previously, general fluid shifts should be considered for patient safety as well. High quality teamwork and communication with all team members are critical. Volume overload, shock, pulmonary edema, hypovolemia, myocardial infarction are all risk factors, as is fat embolism. Proper teamwork, communication, monitoring, etc., are so important to add to proper patient selection.

Cannula selection is another component of patient safety, from tissue injury to contour irregularities. Proper cannula selection is a combination of education, experience, esthetic goals and more. While there is a role for some of the cannulae that can cut (release of fibrous bands) or “post-tunneling” (such as basket cannulae), the accepted safe cannula systems are generally blunt tipped. These most commonly range from 2 to 5 mm, but larger are available for harvesting and smaller are often used for fat grafting. Furthermore, the number of holes, location and patterns of the holes will all play a role in both efficiency of fat extraction and patient safety. While the cannulas play a role in patient safety, so do the aspiration devices and assistance devices (syringes, pumps, oscillating tips, energy based, etc.) must be considered for patient safety. Proper education on the devices, mechanisms of action, technique, etc. must be employed to avoid complications such as thermal injury, contour irregularities, incorrect cannula positioning and more.

Beyond the previously mentioned complications of liposuction, the surgeon must also be concerned about several other issues and these include Fat Embolism Syndrome, bleeding, and Deep Vein Thrombosis among others. Bleeding and clotting issue concerns should be addressed pre-, intra-, and postoperatively. A complete history should discuss any family history of blood clots, early myocardial infarction, multiple miscarriages, bleeding history, previous deep vein thrombosis, etc. Several measures can be done on the day of surgery such as proper patient and operating room temperature, placement and application of sequential compression devices before induction and not being removed until after the patient is fully awake (home compression therapies are also available), and even consideration for pre and post operative anti-thrombotic (chemoprophylaxis) medications. Early ambulation has been a largely accepted proper therapy to help minimize deep venous thrombosis and pulmonary embolism risk. Fat Embolism Syndrome (FES) is less understood, but classically demonstrates respiratory distress, petechial rash along with cerebral dysfunction. Other concerns include tachycardia, fever,

hypocalcemia and even thrombocytopenia. FES is the syndrome that is a secondary consequence of Fat Embolism. Proper diagnosis is critical for the patient long term outcome and the surgeon should be familiar with the diagnosis and willing/able to work with other team members to get early and proper treatment for the patient.

Proper patient selection, maximizing pre-, intra- and post operative management is the responsibility of the surgeon. The surgeon should coordinate the team and maintain maximum communication so that all team members can maximize their experience and opportunities to protect the patient.

As suction lipectomy became universally accepted as a stand-alone procedure, it was quickly added to other body contouring procedures. Frequently, liposuction is performed along with reduction mammoplasty, abdominoplasty, high-definition liposuction, brachioplasty, thigh lifts, lower body lifts, gynecomastia, breast reconstruction, etc. Although liposuction can be safely added to other body contouring procedures, it has been shown to increase morbidity and mortality when combined with a full abdominoplasty especially worrisome in patients with a high BMI and/or a high Caprini score [34].

6. Evolution of energy based devices

The early methods of performing closed liposuction included hand held aspiration (Toomey syringe liposuction) connected to a cannula, or connecting the suction cannula to a suction pump with one atmosphere of negative pressure, but still requiring manual movement of the cannula to break up and remove the fat. One of the most important advances in facilitating the removal of fat in a closed system was the introduction of Power-assisted Liposuction. Several devices were manufactured and quickly adopted to facilitate the removal of fat with less effort.

Following the introduction of Power-assisted Liposuction, the development of Ultrasonic Energy based emulsification of the fat followed by suction lipectomy was introduced by Michele Zocchi, M.D. [35]. There was an evolution in the machinery required to perform the emulsification procedure, but the surviving technology was manufactured under the name of Vaser, engineered by Sound Surgical Technologies. This method of dissolving fat and causing energy to be delivered to the dermis has found its' most important application in "High Definition Liposuction", importantly advanced and refined by Alfredo Hoyos [36]. Other indications for ultrasonic emulsification of fat include the closed treatment of gynecomastia.

The technique of applying freezing temperature to dissolve the fat through apoptosis (CoolSculpt) has received important acceptance in the Cosmetic Surgery community, has enormous social media presence, but complications are common with neo-fat formation and "shark-bite" contour complications being reported.

Laser based energy has also been developed (Smart Lipo) where a small diameter probe is inserted into the fatty deposit and energy is applied to dissolve the fat. This requires a two step procedure, is quite tedious due to the small size of the fiber, with the risk of skin burns.

Radiofrequency based energy has emerged as the most commonly energy based method of emulsifying fat and stimulating fibrous septae contraction as well as dermal tightening. Impressive pre and post-op measurements of circumference are seen when this energy based system is used alone or in combination with suction assisted liposuction. Real time monitoring of internal and external body temperatures ensure safe application of the energy (InMode,Ltd., Yokneam, Israel).

Plasma based energy systems are available (Renuvion J-Plasma) which dissolve the fat, but lack sophisticated temperature monitoring.

High intensity focused ultrasound devices are available, but has enjoyed limited market penetrance due to the minimal improvement shown when compared to other energy sources.

7. Summary

In summary, physical image has always been important. The history of body contouring began with procedures that were performed for functional benefits and evolved to cosmetic improvement in multiple areas of the body. The introduction of liposuction provided an incredible option in body contouring and became the number 1 or number 2 most performed cosmetic surgical procedure. Often combined with open surgical techniques, liposuction frequently allowed procedures to be performed with smaller incisions and was advanced to allow important sculpting of the face, neck, extremities, and trunk. Fat grafting provided improved volume and contour to soft tissues. The introduction of energy based devices allowed for the tightening of fascial networks and dermal remodeling often performed along with liposuction.

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Author details

Malcolm D. Paul* and Garrett Wirth
Department of Plastic Surgery, University of California, Irvine, USA

*Address all correspondence to: mpaulmd@hotmail.com

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