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Thirtyfour years of liposuction: past, present and future

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Abstract. – Initial, variably successful attempts of fat sculpting date back to the beginning of the 20th Century, but Gerard Illouz was the first to introduce the modern, safe, widespread method of liposuction. Preoperative injection of local anaesthesia, saline, distilled water, adrenaline and hyaluronidase, defined wet technique, established as a safe and effective adjunct to lipoaspiration. This procedure was initially based on an automatic pump system, but then the accuracy of syringe aspiration was popularized by Toledo in the eighties. Liposuction in the subcutaneous tissue, just 3-4 mm deep to dermis, also called superficial liposuction, is a modern effective evolution of the technique, but requires a good mastery in order to avoid disfiguring outcomes. Ultrasound and laser lipoplasty methods have provided further advancement in the range of technical choices offered to the plastic surgeon. Liposuction is a purely surgical procedure, and as such, carries risks of minor and major complications. In the nineties, an interplay between abdominoplasty and abdominal liposuction as simultaneous procedures, also called lipoabdominoplasty, has become more and more popular. Reinjection of the harvested fat with the purpose of liposculpture for both reconstructive and cosmetic indications is a relatively recent development which has established as a successful, world-wide accepted procedure. Adipose stem cells, extracted from the unlimited source represented by human adipose tissue, are a great promise for future tissue-engineering. Liposuction has nowadays become a safe, effective, popular procedure for contouring adipose tissue and human body in general, in many reconstructive and cosmetic indications.

Key Words:

Liposuction, Lipoaspiration, History of lipoaspiration, Fat grafting, Adipose stem cells, Fat injection.

Introduction

The first reported attempt for cosmetic sculpting of fat is most commonly attributed to Dr Charles Dujarrier in 1921. He was a French general surgeon, very respected and chief of the Department of Surgery at Saint Antoine Hospital. He had a dancer patient who wanted to improve the shape of her ankles and knees. He performed an excision of excess skin and subcutaneous tissue from her calf, but with a tragic result because he removed too much tissue and the sutures were too tight. This caused necrosis and amputation and resulted in the first lawsuit in the history of Plastic Surgery[1]. Dujarrier was condemned in the first instance, but absolved in appeal because the procedure was done for free.

Modern liposuction began approximately 30 years ago, initially as a closed technique, when the German physician Schrudde first published his results based on using a uterine curette in a "sharp" technique of subcutaneous surgery. Several other surgeons, including Kesselring and Meyer, used this technique through the mid-1970s, but such complications as persistent lymphorrhea, hematoma, skin necrosis, and localized skin excess created some doubt abouts the procedure[2,3]. In 1977 a patient of Illouz asked him to remove a large lipoma without a scar (Figure 1). A blunt cannula technique was pioneered by Illouz, who identified the aforementioned drawbacks and developed the first version of a "wet" technique with minimal blood loss and preservation of the neurovascular bundles. Illouz tirelessly disseminated the novel technique to physicians of different spe-

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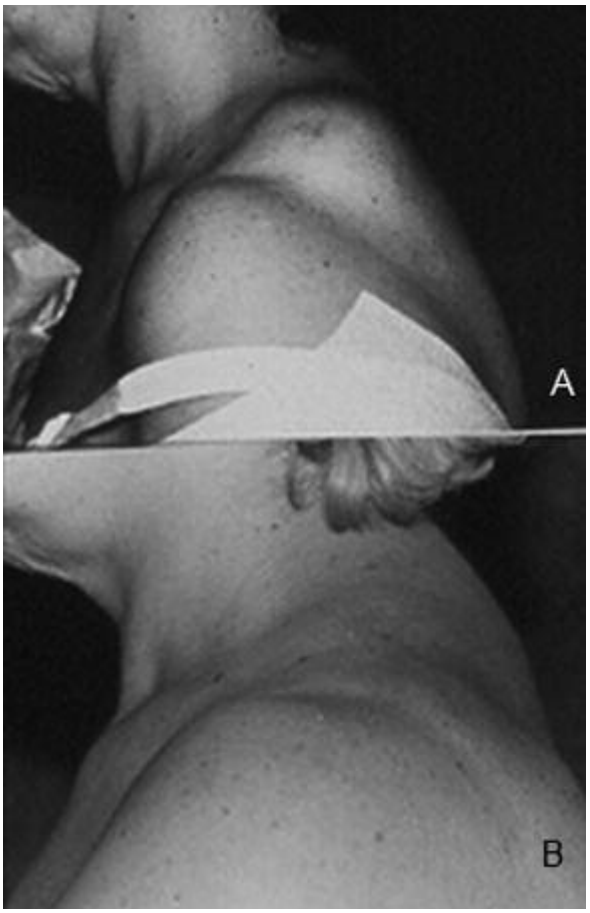

Figure 1. Illouz's first liposuction for a lipoma of shoulder. Preoperative and postoperative views.

cialties throughout the world[4]. His blunt cannula liposuction technique came to be the most accepted liposuction method around the world[5].

Patients and Methods

Patient selection is of major importance and might be the most critical factor for a safe, and aesthetically satisfying result in body contouring[3]. Not all patients who request liposuction are good candidates. Because liposuction is a technique of body contouring rather than weight loss, potential surgical candidates must be advised and counseled carefully on what results they can realistically expect. It has been proven that liposuction is not a treatment modality for cellulite and these patients should be warned that only the contour will improve but not the quality of the skin[6,7].

1975-1995: Evolution of Suction Lipectomy

Illouz used three different sizes of blunt-tipped cannulas (Figures 2, 3, 4) depending on the area to be aspirated. A 10-mm cannula was used for the flanks, buttocks, and hip areas, an 8-mm cannula was used for the knees, ankles, abdomen, and arms; and lastly a 5-mm cannula was used for the face. The wet technique or "dissecting hydrotomy", was another aspect of controversy and evolution. The initially described hypotonic formula was comprised of normal saline, distilled water, and hyaluronidase. Fifteen years later the formula had evolved as well: 1000 ml normal saline, 200 ml distilled water, 1000 IU hyaluronidase, 1 mg epinephrine, and 60 mg of lidocaine[8]. Over time plastic surgeons argued in favor of hydrotomy. "Wet technique meant dry surgeon", meaning that hydrotomy makes the procedure significantly less exhausting. The greatest advantage of hydrotomy, however, is the magnification of the deep fat layer that needs to be aspirated. The latter enables the surgeon to remain in the proper deep layer while preserving the superficial fat. In addition, there was significantly less bleeding with the wetting approach especially after the addition of epinephrine to the wetting solution[9]. As recently reported in a large series, Authors have been using Ilouz wet technique (1:1 ratio between volume aspirated and volume injected) as they find it superior to superwet and tumescent technique in terms of complications[10].

Liposuction was born originally as a mechanized procedure in which suction is based on aspiration through a vacuum pump[11]. Since 1988[12], the Brazilian Luiz Toledo has replaced the use of an automatic pump with disposable syringes of various sizes and gauges. With syringe liposuction, an exact knowledge of the aspirated volume in each body area is possible and also more mobility for the operator is obtained without the aspirating tube, which facilitates the surgery. At the end of the procedure we know the precise quanti-

Figure 2. Different types and sizes of cannulas.

Figure 3. Different types and sizes of cannulas.

ties of local anaesthesia infiltrated, the total aspirated and the percentage of pure fat harvested in each region, all data which are just approximate with the use of the lipoaspirator. As described by Toledo[13], the scrub nurse annotates, in all areas aspirated, displayed in the form of a map of patient's body, the quantity of local injected and the quantities of adipose tissue aspirated and/or injected in every single treated area, thereby increasing the precision and symmetry of the procedure.

Utilized sirynges have a volume of 60 ml and the model is "toomey-tip", with lumen of 8 mm. Syringes with smaller lumen, up to just 3 mm, are common, especially in Brazil, but the speed of aspiration is slower, the procedure is more difficult and there is a risk of breaking the tip of the syringe. Modern cannulas are made of zirconium, internally and externally. This relevantly reduces friction both in fat aspiration and fat injection,

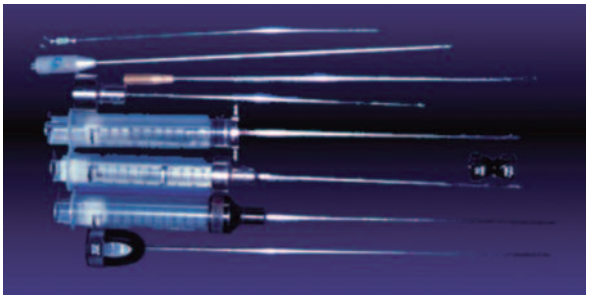

Figure 4. Different types and sizes of cannulas.

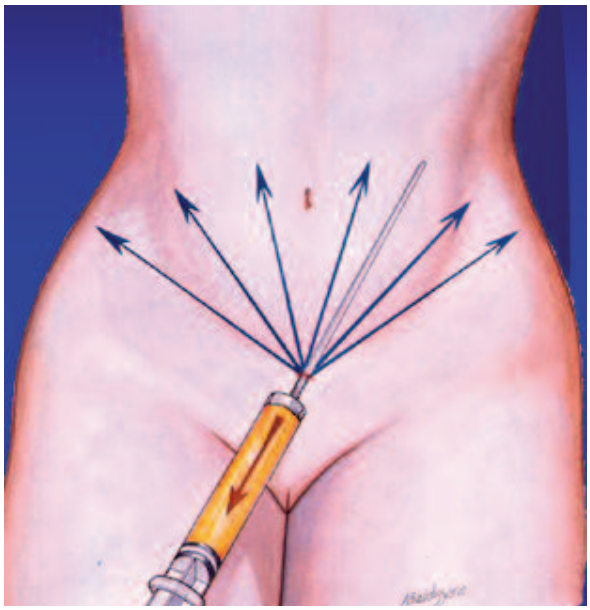

Figure 5. Syringe liposuction.

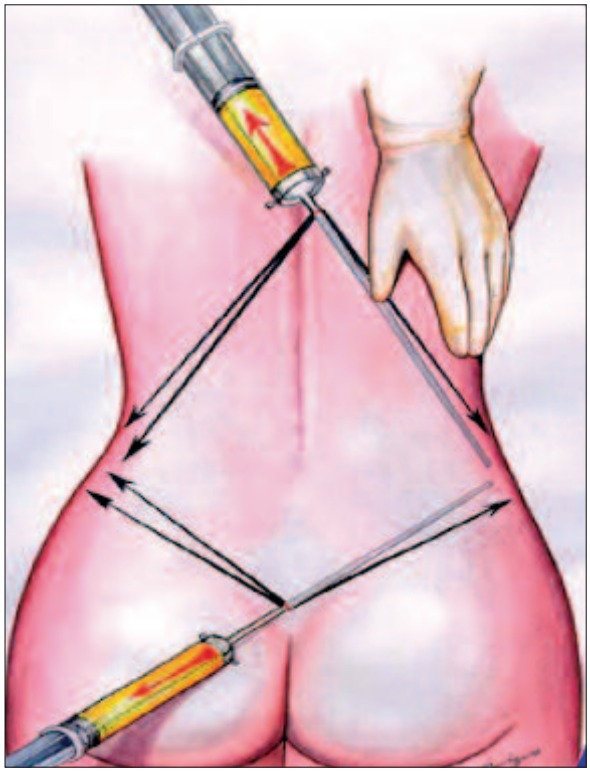

Figure 6. Syringe liposuction.

which facilitates the efforts in difficult areas such as the back. The main advantage of syringe liposuction is, therefore, the precision and accuracy in measurement of adipose harvested volumes, in addition to the possibility of injecting fat. The vacuum-pump assisted liposuction allows better comfort and less efforts for the operator, and is usually chosen for major lipoplasty procedures, also called megaliposuctions, in which quantity of fat to be removed is a priority over the topographic, symmetric, precise distribution of fat harvest. Many other differences are involved in the syringe or vacuum pump lipoaspiration[14] (Table I).

Taboo zones were not a problem anymore and hence all of the body could be reshaped with very satisfying results. Suction lipectomy was even used for face lipoaspiration of the submental and nasolabial sulcus areas[15]. Obesity, initially a clear criterion of exclusion, was no longer considered as such. Serial procedures were performed with a minimum interval of 6 months to achieve a satisfactory result[16]. There is no doubt that excessive aspiration of fat could result in severe complications or even death, and any volume above 5 L was still considered dangerous.

One major break-through was the introduction of "suction abdominoplasty". Patients with a combination of excess infraumbilical skin and large fat volume in the supraumbilical area could benefit from this procedure[8,17-21].

Advancement in instrumentation, techniques, and devices has taken suction lipectomy to a new era.

1995-2010: The Modern Era

Since there are no absolute dogmas in medicine the evolution and further refinement of liposuction was inevitable. Advancement in instrumentation, techniques, and devices has taken

Table I. Comparison between machine-based and syringe-based liposuctions.

Factor	Vacuum pump	Syringe
Cost of equipment	Expensive, 2 equipments are necessary in case one fails	Cheap
Disposable equipment	No	Yes
Maintenance and transport	Heavy, cumbersome	Light, easily transportable
Surgical control	Less precision. Exact measuring of volumes more difficult	Precise. Better measurement of quantities (liquid and adipose tissue)
Power of extraction	One athmosphere	One athmosphere
Speed of extraction	Less rapid	More rapid
Dead space	Exists, inevitable and relevant	Does not exist because saline is aspirated before fat
Surgeon's fatigue and comfort	More fatigue	Less fatigue
Quality of results	Good but not consistent	Excellent, good results are consistent, especially in superficial liposculpture
Symmetry of results in case of bilateral lipodistrophies	Symmetry is more difficult to aestimate in the big canisters	Precise. The syringe is a unity of measurement for volumes of liquid and adipose tissue
Noise during procedure	More or less depending on machine	Complete silence. Good athmosphere for both patient and surgeon
Risk of shock	Higher due to the nervous trauma on adipose tissue	Lower, the syringe is more delicate
Bleeding	Higher due to the direct action on capillaries	Lower, the syringe is more delicate
Volume of adipose tissue extracted in a given site	Smaller due to earlier bleeding	Greater, later bleeding
Multiple surgeons	Not possible	Possible, shorter procedure
Reutilization of the harvested fat	Evaporation and trauma of fat do not allow reuse	The syringe allows extraction, modification, processing (lavage) and reinjection of fat

suction lipectomy to a new era. Increased level of comfort and confidence with the procedure led surgeons to move more superficially, with the creation of superficial lipoplasty, and thus narrower cannulas were introduced. Illouz designed a multi-hole tetrafluoroethylene coated cannula with one lower and two lateral openings on each side to facilitate aspiration while at the same time improving the geometry of tunnels by avoiding leaving excess fat tissue in between them. On top of that, the addition of Teflon made the surgeon's task significantly easier because the cannula was slipping within the tissues without effort[8]. Development of more advanced, narrower cannulas led to the trend of superficial lipoplasty, where the surgeon could aspirate the superficial fat just 3-4 mm subdermal. Illouz had used this approach from the very beginning but always insisted that sufficient thickness should be left under the skin to avoid injuries that will later lead to inappropriate healing and dimpling of the skin. As a result he recommended that the opening of the cannula should be directed downwards to avoid the aforementioned sequelae.

Along with the new instruments, the "wet technique", the superficial liposuction, ways to improve and facilitate liposuction were developed as well. Ultrasound assisted liposuction (UAL) was first introduced by Kloehn[22] and popularized even more in the late nineties when Zocchi introduced the perforated cannulas[22,23]. Ultrasound is the process which turns electricity into mechanical vibrations and results in both thermal effects and mechanical effects to the surrounding adipocytes. These mechanical oscillations pass through the cannula that emits the waves from its tip[24-26]. The thermal effects play a role in fat dissolution and must be dissipated by tissue infiltration[27]. Graf et al conducted a study of 348 patients that all underwent UAL in Brazil. The use of UAL leads to preservation of vessels and better hemostasis[28]. Factors that may discourage the use of UAL are the thermal effects on the skin and nerves.

Laser-assisted Liposuction

Laser-assisted liposuction represents a precious and relatively recent advancement in the treatment of lipodystrophies and irregularities of adipose tissue. The laser can be administered internally or externally transcutaneously. The type of laser used is neodymium, yttrium, aluminium, garnet (Nd:YAG), with wave length of 1,064 nm and most commonly power of 6 watts, frequency of 40 Hz, 150 mJ of energy and pulsations every 100 ms. The laser beam is directly propagated to adipose tissue with which it keeps a direct contact. The action of the laser causes the rupture of the adipocyte membrane and consequent release of oily content into the extracellular fluid.

In addition, coagulation of collagen is found and microtunnels are created in the track of the laserbeam, along with coagulation of microvessels in the adipose tissue. Complications and final results of laser-assisted liposuction are similar to those obtained with the majority of liposuction techniques. In addition to the cytolitic effects on adipocytes, the laser can cause neoformations and remodelling of the collagen and reorganization of the reticular dermis. It is particularly indicated as an office-based procedure for localized areas of lipodystrophy in the body or face. The interction between laser and adipose tissue was initially described by Apfelberg[29] and Apfelberg et al[30,31] in 1992.

Blugerman[32], Shavelzon et al[33] and Goldman et al[34,35] report their experience with laser acting on adipose tissue and causing laserlipolysis. More recently Badin et al[37] analyse the laserlipolysis emphasizing the relevant tissue retraction obtained with this technique. Neira et al[38] show the likely formation of pores in the adipocyte wall following the action of an external laser. These results were subsequently questioned by Brow et al[39]. In a recent study Ichikawa et al[40] report histologic evaluations in patients and experimental animal models undergoing laserlysis. Kim and Geronemus[41] show a direct correlation between reduction of fat volumes and energy utilized, basing results on MRI scans. Low-level laser therapy externally applied through skin and preceeding liposuction has also been proposed as a method to cause fat liquefaction before aspiration, but the utility of this treatment was subsequently disproved.

Complications

Ecchymosis is inherent in liposuction and varies according to the individual, the size of the treated area, and the extent of the treatment. Edema usually subsides within several weeks, but in distal areas, such as the calf or ankle, it may persist from six months to a year. Induration will subside in a similar fashion. Hyperesthesia or dysesthesia are common sequelae of the procedure, which will gradually improve in three to six months after surgery. A minor degree of waviness over the skin also improves within a period

of months, as do minor bulges or depressions resulting from edema. Hyperpigmentation diminishes gradually, and in more serious cases, it responds well to treatment with topical agents. True complications that are possible include contour defects, permanent skin color changes, infection, emboli, hematomas, or seromas.

Major complications, with a lethal effect, are reported in 1:5000 cases according to Grazer and De Jong[42] in 2000 among the plastic surgeons. Higher rates are described when liposuction is performed by other specialists. The most frequent cause of death was deep venous thrombosis (DVT) associated with pulmonary embolism (23.1%). Abdominal and bowel perforations are reported as the second commonest lethal event (14.6%). In 10% of cases the death was caused by the use of local anaesthesia, sedation and other medications. This last percentage is probably underestimated because in some cases the death occurred after discharge from hospital, due to the late peak concentration of lidocaine. Bleeding, formerly the most relevant cause of death due to lipoaspiration, represents just a 4.6% of lethal events according to this study, which was conducted after introduction of the tumescent and superwet techniques of infiltration. With the new methods of injections, the new identified risk factors are office-based or multiple procedures, excessive infiltration and intoxication from lidocaine or adrenaline (usually with some hour-delayed onset), excessive removal of adipose tissue with volume depletion in the third space, postoperative respiratory depression, early discharge. The risk of DVT is associated with blood flow stasis, trauma and possible hypercoagulation status. Intermittent compression devices for legs, early mobilisation and the use of low molecular weight heparins can reduce the risk.

The event of perforation is extremely rare, but represents a severe complication. The abdominal wall has areas of variable resistance and subclinical abdominal hernias can sometimes be observed during abdominoplasty. They can be up to 1-2 mm small and usually localize in the supraumbilical median line, site of highest risk for perforation. This complication can occur not only during aspiration but also during the infiltration, for which finer and sharper cannulas are sometime utilized. To reduce the risk of perforation, the cannula tip has always to be accompanied by the palm, in particular in obese patients, in whom it is difficult to visualize the cannula, and the position should be hyperextension of the abdomen and severe abdominal pain should always suggest the occurrence of a possible perforation, which may require a laparotomy.

Subclinical fat emboli are very frequent, as proven by Kenkel et al[43] in 2004 in pigs, but real risks from this event are far lower than in orthopaedic procedures.

Localized infections are not frequent after lipoaspiration, but can sometime occur, especially in case of early return to normal activities. Local infections are easily treated, whereas toxic shock syndrome, a systemic disease caused by the toxin of *Staphylococcus aureus*, is a life threatening event. It presents with fever, diarrea, nausea and vomiting, up to the more specific rash and oliguria. This syndrome can even progress to necrotising fascitis, requiring urgent debridement and intensive care.

Lipo-abdominoplasty

With the evolution of superficial suction lipectomy in the 90s the indication for skin resection became less common and the limits of skin retraction changed. Nevertheless, there is a clinical cut-off where superficial liposuction is not adequate and the need of skin resection is mandatory[44].

The first principle/consensus is that skin flaccidity that cannot be corrected with liposuction needs to be removed by resection. The second principle is that depending on the amount of excess skin (infraumbilical, or infra and supraumbilical), the interplay of abdominoplasty and liposuction can widely vary[45-48]. When performed in a conservative and reasonable manner, this technique generates superb aesthetic outcomes and promotes the benefits of both techniques (Figure 7 to 11). Illouz emphasized on the fact that a maxi-abdominoplasty with maximum undermining, combined with a maxi-adipoaspiration results in maximum risk of complications especially in the obese patient group. Up until Illouz[49] published his experience with minimal undermining in 1992, surgeons would undermine 100% of the abdominal flap with inevitably high complication rates, mainly necrosis. Saldanha et al[50,51] established the term “lipoabdominoplasty” and standardized a selective undermining corresponding to 30% of the traditional undermining thus preserving the abdominal perforators. In the supraumbilical region the Authors practised liposuction (wet technique) using a 3-4 mm cannula and maintaining sufficient subdermal fat thickness to avoid vascular impairment. In the infraumbilical region, they start by undermining a

Figure 7. Liposuction. Preoperative and postoperative views.

median tunnel towards the upper abdomen in order to preserve the lateral arterial perforators that perfuse the adipocutaneous flaps. Following this lipoabdominoplasty approach, they managed to achieve high-quality aesthetic outcomes and also reduce the rate of seromas, dehiscence, and flap necrosis compared with the abdominoplasty only group[52]. Pereira and Sterodimas[53] in 2009, introduced the composite body contouring, a technique which combined 3 in 1 procedures. Liposuction of the back, thighs along with lipografting of the buttocks and lipoabdominoplasty. They reported excellent patient satisfaction, and low complication rates. Interestingly, there was no flap and/or skin necrosis, fact that confirms the safety and reproducibility of such a procedure.

Liposuction and Fat Grafting

In 1985, Illouz et al began grafting aspirated fat for correction of irregularities after liposuction[54]. Since then, a very wide variety of applications for fat grafting has developed including: gluteal contouring, breast augmentation, face rejuvenation, and reconstructive surgery (breast, Parry-Romberg syndrome, HIV lipodystrophy, etc)[55-69]. In 1996, Pereira et al published their 5-year experience with fat grafting in the gluteal and lower limb area (Figures 12 to 17). The Au-

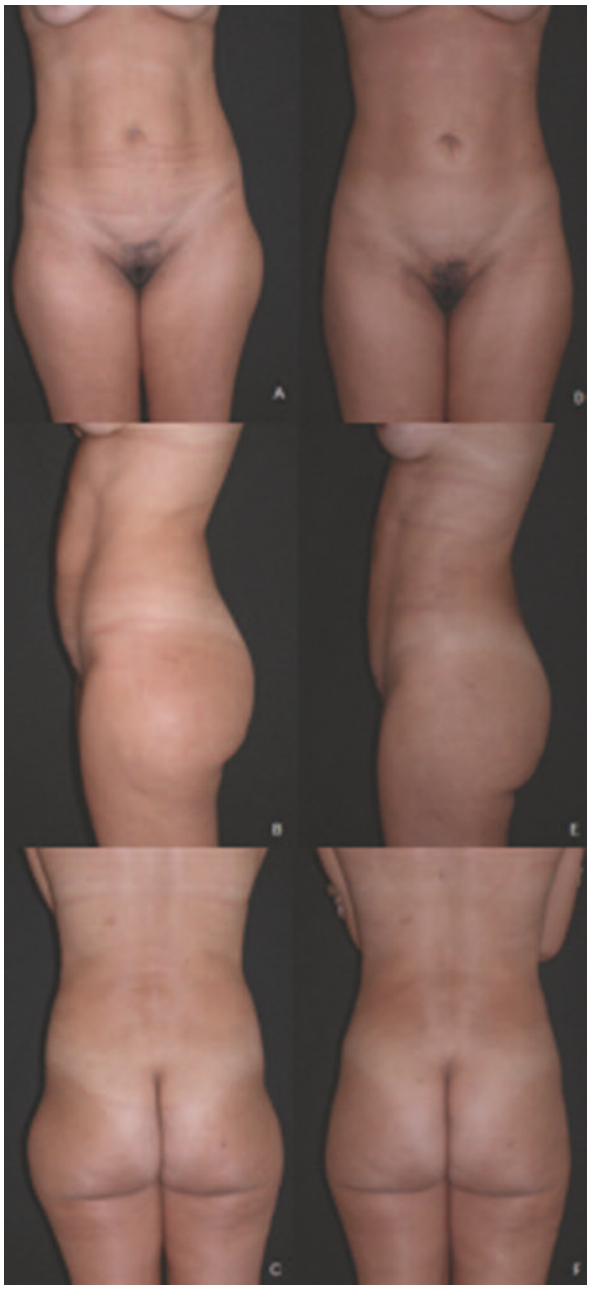

Figure 8. Liposuction. Preoperative and postoperative views.

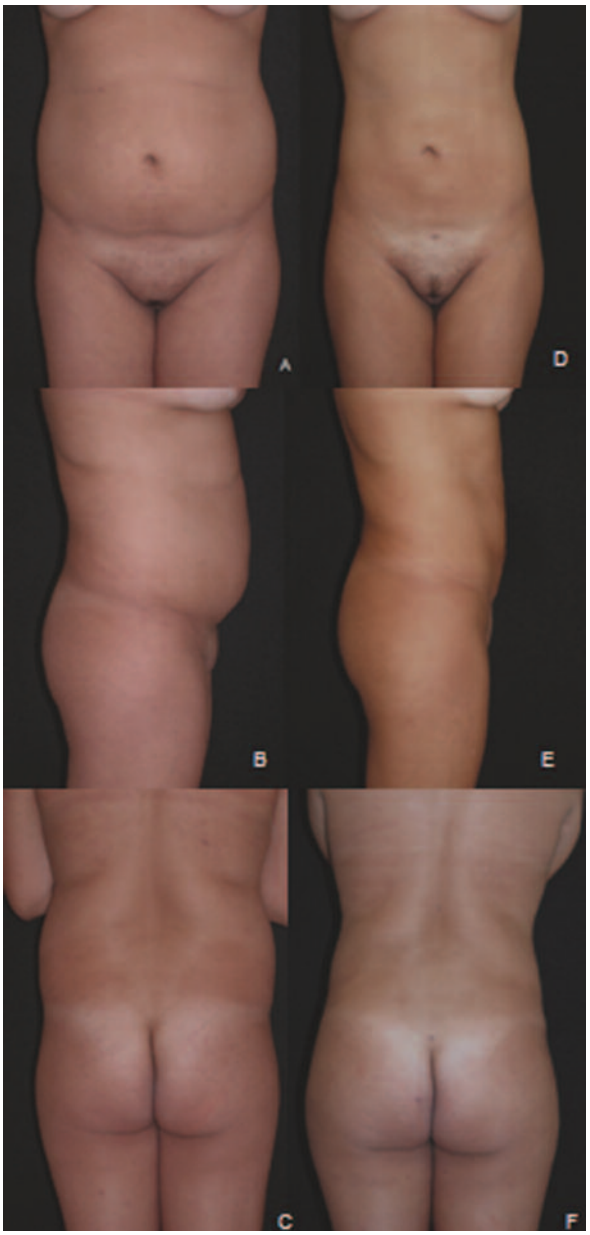

Figure 9. Liposuction. Preoperative and postoperative views.

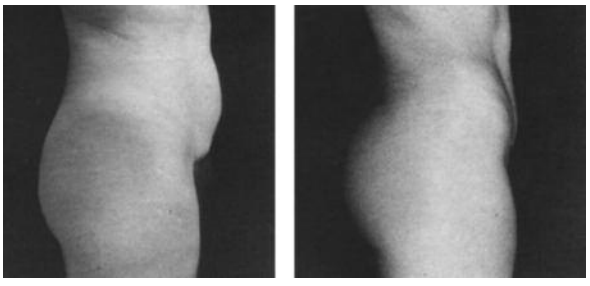

Figure 10. Liposuction. Preoperative and postoperative views.

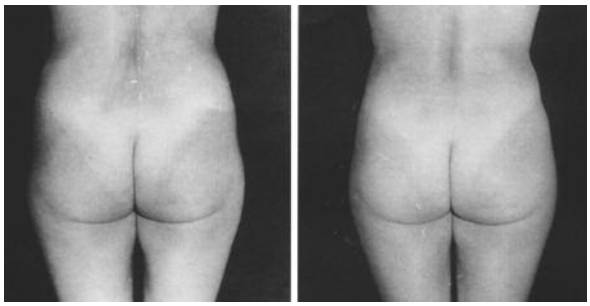

Figure 11. Liposuction. Preoperative and postoperative views.

thors report very high satisfaction rate, low volume of fat absorption (less than 20%) and very low complication rates (approximately 2%). In a different case series Pereira and Sterodimas reported their experience with fat grafting and correction of Banana fold deformity. They report very satisfactory results and no complications after the procedure. Fat can also be used to improve breast contour and/or increase breast volume. Both for cosmetic and reconstructive purposes, fat grafting to the breast appears to be a very useful approach. Spear et al[61] in 2005 published his experience with fat grafting to the

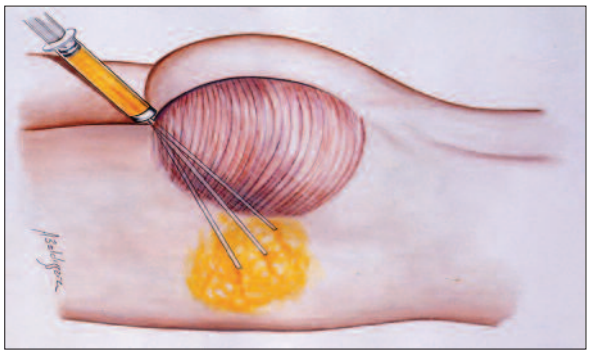

Figure 12. Fat grafting in the gluteal and lower limb areas.

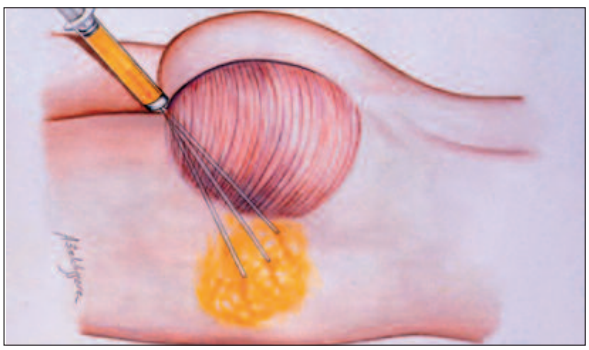

Figure 13. Fat grafting in the gluteal and lower limb areas.

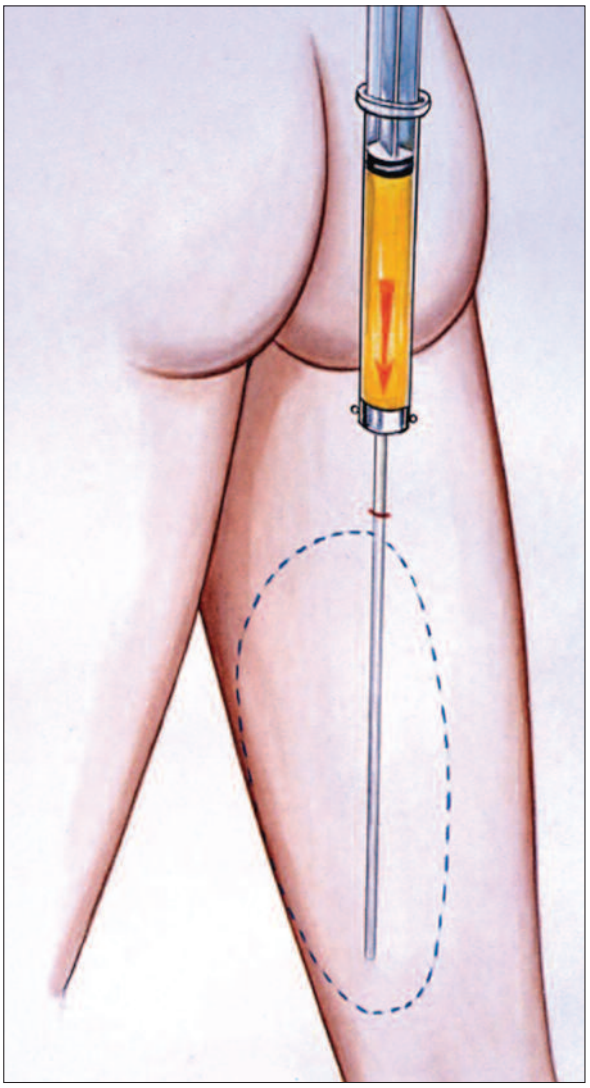

Figure 14. Liposuction of lower limbs.

breast for correction of significant contour deformities after breast reconstruction which otherwise would require more complicated and riskier procedures.

There is a major clinical need for strategies that adequately reconstruct the soft tissue defects after deep burns, tumor resection, or trauma. Adipose stem cell application has recently been suggested as a possible novel therapy, and because of stem cells pluripotentiality and unlimited capacity for self-renewal, they represent a great promise for tissue engineering and are expected to allow significant advances for distinct reconstructive procedures (Figure 18). Adipose tissue is the most abundant and accessible source of adult stem cells. After the introduction of liposuction, adipose tissue harvesting has become easier[4]. While

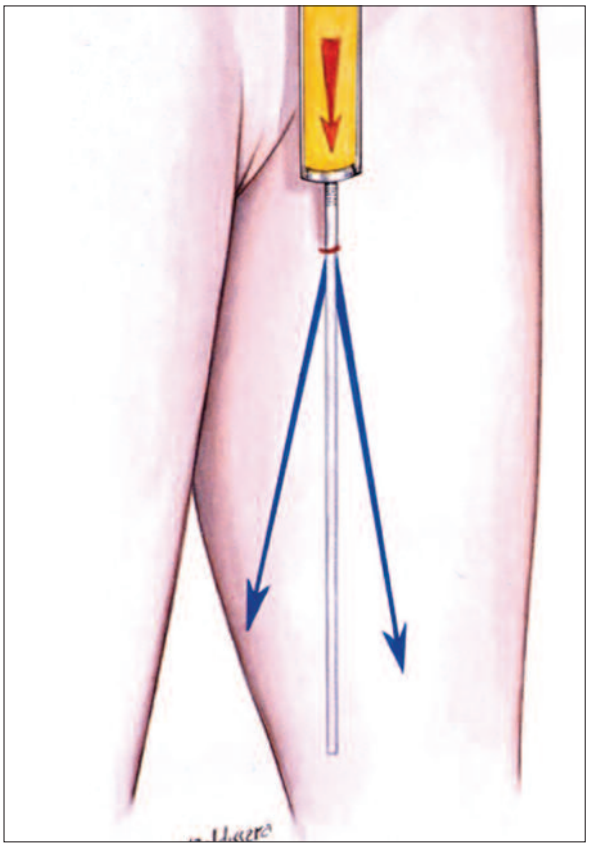

Figure 15. Liposuction of lower limbs.

there is some debate as to whether the cells originate in the fat tissue or are perhaps mesenchymal or peripheral blood stem cells passing through the fat tissue, the adipose-derived stem cells (ADSCs) represent a readily-available source for isolation of potentially useful stem cells. Human processed lipoaspirate contains pre-adipocytes that possess one of the characteristic pathways of multipotent adult stem cells and are able to differentiate *in vitro* into mesenchymal lineages. Adipose tissue, in addition to committed adipogenic, endothelial

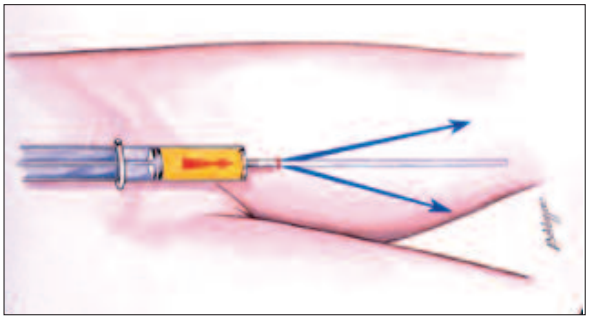

Figure 16. Liposuction of lower limbs.

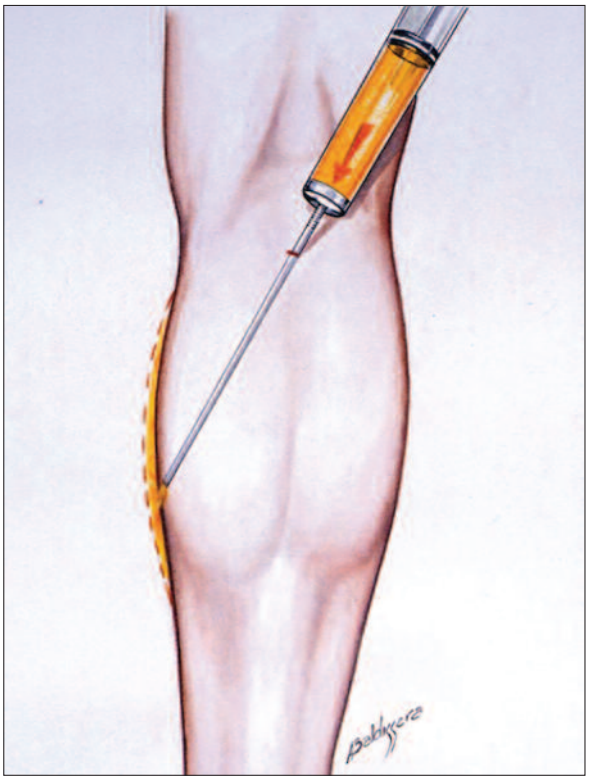

Figure 17. Liposuction of lower limbs.

progenitor cells and pluripotent vascular progenitor cells, also contains multipotent cell types, adipose-derived stem cells, that in cell culture conditions have shown to have an impressive developmental plasticity including the ability to undergo multilineage differentiation and self-renewal[70]. Adipose tissue has the same potential for growth of adult mesenchymal totipotential stem cells of bone marrow and can eventually be differentiated easily by the use of specific growth factors and according to the needs and applications in other cellular lines (osteogenic, chondrogenic, myogenic, epithelial). Their pluripotency, proliferative efficiency, and low donor morbidity have been amply confirmed[71]. Their therapeutic use in preclinical studies and experimental clinical trials has been documented[72,73]. Cell-assisted lipotransfer (CAL) (Figure 19) is a novel approach to autologous fat transplantation in which adipose-derived stem cells are attached to the aspirated fat[74].

Discussion

Illouz[75] always emphasized on the principles that must be followed at all times in order to achieve optimum, aesthetically pleasant results. The core idea is to avoid trauma to the connective tissue septi that connect the skin to the underlying structures. By doing so, one can achieve (1) better skin retraction postoperatively, and (2) retain blood vessels, lymphatics and nerve endings. From the very beginning he introduced the importance of blunt instrumentation for atraumatic aspiration. Additionally, he emphasized on the anatomic layers of the fat and insisted to aspirate deeply and retain the superficial fat, as removal of the latter can cause postoperative contour irregularities in the inexperienced hands[75]. The liposuction technique is easily reproducible for almost all areas of the body. It can be combined with other procedures to improve the final outcome both in cosmetic (e.g. abdominoplasty) and reconstructive (e.g. defating of the flaps) surgery. It has permanent results and there is no recurrence of the

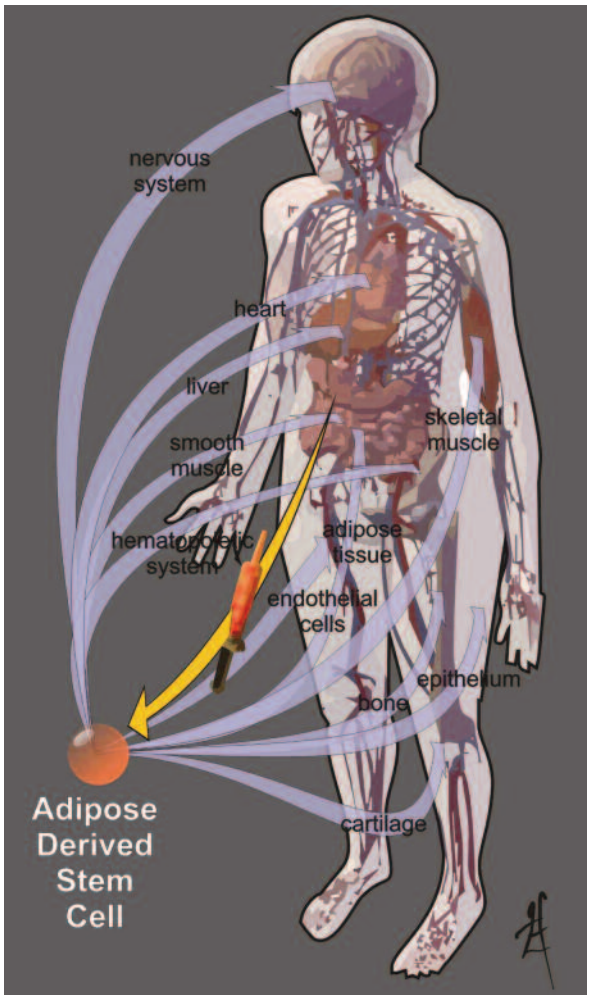

Figure 18. Potential differentiations and applications of adipose-derived stem cells.

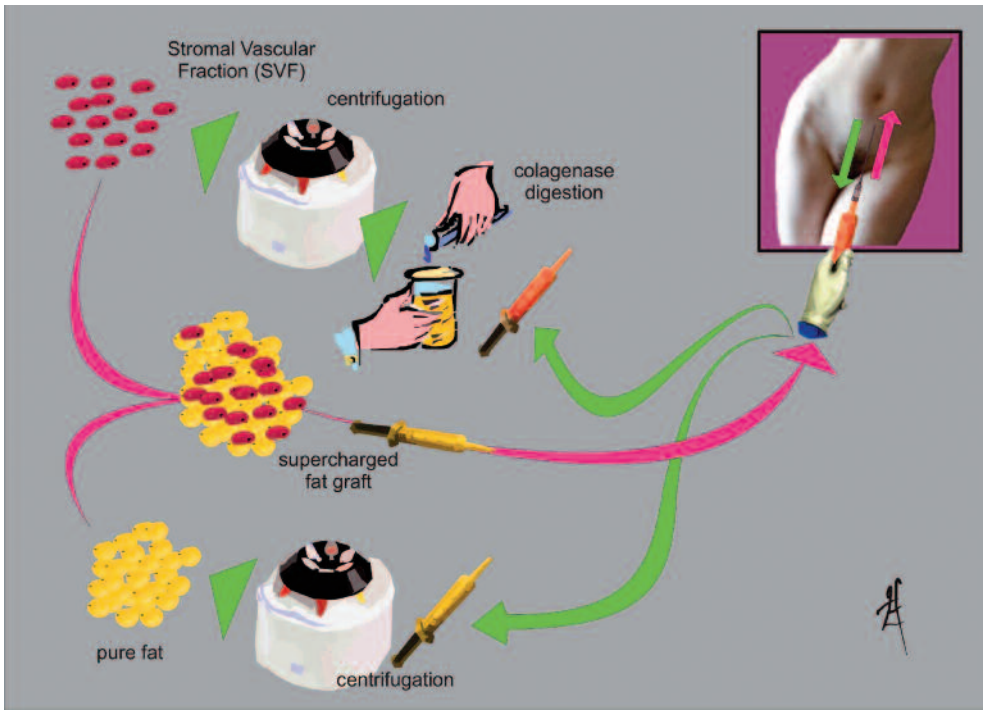

Figure 19. Cell-assisted lipotransfer (CAL): harvested fat is partly cocentrated and purified through centrifugation and partly utilized to extract adipose-derived stem cells. The 2 components are fused together and reinjected.

fat tissue once removed. The latter supports the adiposity's theory main concept: "once an adipocyte is destroyed it cannot reoccur"[77]. Last but not least, the significantly lower complication rate (seromas, hematomas, skin irregularities) when compared to other body contouring modalities[77-79]. The main limitation of liposuction, as early identified by Illouz[75], is the poor outcomes in patients who have extensive lipodystrophy with ptosis. Poor skin quality will not achieve satisfactory results and these patients are more likely to benefit from some type of dermolipectomy rather than pure lipoaspiration. Another precaution that one should keep in mind is the volume of the aspirated fat. Illouz[75] initially reported 6 pounds of aspirated fat as a safe cutoff[75]. The interplay of volume injected, volume aspirated, total blood loss, and intravenous fluid administration is also very important for the appropriate management of the patient[80,81] The arguments against the wetting approach included potential contour distortion, allergies, and inadequate rupture of the adipocytes. Illouz[75] felt that none of these had substantial basis because: (1) experienced surgeons should not be bothered by temporary local distortion secondary to local anesthesia, (2) allergies have never been encountered in his series which included thousands of cases, and lastly (3) 20% more fat cells are lysed secondary to hypotonic hydrotomy. Over time plastic surgeons argued in favor of hydrotomy. "Wet technique meant dry surgeon", meaning that hydrotomy makes the procedure significantly less exhausting. The greatest advantage of hydrotomy, however, is the magnification of the deep fat layer that needs to be aspirated. The latter enables the surgeon to remain in the proper deep layer while preserving the superficial fat. In addition, there was significantly less bleeding with the wetting approach especially after the addition of epinephrine to the wetting solution[9]. Liposuction has been largely embraced by the surgical community during the last 34 years.

Fat injection was another point of conflicts and controversies. Some claimed it worked some other that it did not. Fat transfer for composite body contouring became the new "hot shot" and research started on whether adipose cells will survive after injection or not. Early experience noted that fat graft reabsorption was the main drawback, with 50-90% graft loss[82-84]. Studies have shown that the ideal way to harvest fat is by using a 10 ml syringe connected to a 2 mm cannula[85]. It is also wise to avoid using lidocaine as part of the tumescent solution when fat grafting, is because studies have indicated decreased adipocyte proliferation after exposure to lidocaine[86]. As a final point, the plane of the injected fat has been shown to affect the survival of adipocytes. A recent study[87] showed that injecting into the supramuscular plane has a better

graft take compared to the subcutaneous or submuscular planes. Today, centers around the world offer fat grafting as their final perfecting procedure after breast reconstruction in order to further enhance cosmetic outcomes or to correct congenital anomalies[62,68]. Illouz and Sterodimas[69] published their 25-year experience with autologous fat transplantation to the breast. Three groups of patients were included in the study: (1) after breast reconstruction, (2) congenital breast asymmetries, and (3) breast augmentation. The Authors[69] report excellent cosmetic results, high patients' satisfaction as well as low complication rates. Caution, however, is mandated due to the fact that the most common complication of breast lipografting is formation of liponecrotic cysts. As a result it is mandatory for the surgeon to know the appearance of the breast on mammography and ultrasonography and the evolution of fat necrosis patterns after fat injection. In conclusion, fat is viewed as the ideal filler as it is not allogenic, it is widely available, easily collected and with minimal morbidity. Adipose tissue stem cell-based regenerative strategies hold tremendous promise, although this potential must be balanced against stringent standards of scientific and clinical investigation, before developing 'off-the-shelf' tissue engineering products[73].

Determining the effectiveness of any cosmetic procedure involves subjective rather than objective criteria. However, survey findings from among physicians who use liposuction indicate that the procedure achieves a high level (up to 80 percent of surgeons and 90 percent of patients) of good results with a very low level of complications[78]. In the hands of an experienced practitioner, complications from this procedure are very low. It is very important that potential liposuction patients be counseled in advance about the differences between the natural sequelae of the procedure versus a true medical complication.

Conclusions

The practice of medicine today is more than the relief of pain and disease. When the negatives of a patient's appearance are corrected, his or her opportunities for a better life with a more positive self-image are improved. Liposuction is now an accepted and safe procedure that can be used by experienced and skilled practitioners to assist in improving a patient's aesthetic appearance. With proper patient selection and good counseling on realistic expectations, liposuction can be expected to achieve excellent results with a low complication rate.

References

1) Flynn TC, Coleman WP, 2nd, Field LM, Klei JA, Hanke CW. History of liposuction. Dermatol Surg 2000; 26: 515-520.
2) Kesselring U. Regional fat aspiration for body contouring. Plast Reconstr Surg 1983; 72: 610-619.
3) Hetter G, ed. Lipoplasty: The Theory and Practice of Blunt Suction Lipectomy. Boston: Little, Brown & Co, 1984.
4) Illouz YG. Body contouring by lipolysis: a 5-year experience with over 3000 cases. Plast Reconstr Surg 1983; 72: 591-597.
5) Newman J. Lipo-suction surgery: Past-present-future. Am J Cosmet Surg 1984; 1: 19-20.
6) Illouz YG. Refinements in the lipoplasty technique. Clin Plast Surg 1989; 16: 217-233.
7) Khan MH, Victor F, Rao B, Sadick NS. Treatment of cellulite: Part II. Advances and controversies. J Am Acad Dermatol 2010: 373-384; quiz 385-376.
8) Illouz YG. History and current concepts of lipoplasty. Clin Plast Surg 1996; 23: 721-730.
9) Hetter GP. The effect of low-dose epinephrine on the hematocrit drop following lipolysis. Aesthetic Plast Surg 1984; 8: 19-21.
10) Triana L, Triana C, Barbato C, Zambrano M. Liposuction: 25 years of experience in 26,259 patients using different devices. Aesthet Surg J 2009; 29: 509-512.
11) Illouz YG. Une novelle technique pour les lipodystrophies localisees. Rev Chir Esthet Langue Franc 1980; 19: 3-10.
12) Toledo LS. Syringe liposculpture for face and body. In: Annals of the International Symposium "Recent Advances in Plastic Surgery", Sao Paulo, Brazil, Estadao, March, 3-5, 1989; 177.
13) Toledo LS. Syringe liposculpture. Clin Plast Surg 1996; 23: 683-693
14) Lewis CM. Comparison of the syringe and pump aspiration methods of lipoplasty. Aesth Plast Surg 1991; 15: 203-208.
15) Illouz Y. Remodelage de la silhouette par lipolyseaspiration ou lipectomie selective. Ann Chir Plast Esthet 1984; 29: 162-179.
16) Illouz Y. Body sculpturing by lipoplasty. London: Churchill Livingstone, 1988
17) Elbaz JS. Esthetic abdominoplasty with preliminary liposuction. Ann Chir Plast Esthet 1987; 32: 148-151.
18) Matarasso A. Liposuction as an adjunct to a full abdominoplasty. Plast Reconstr Surg 1995; 95: 829-836.

19) Matarasso A. Abdominolipoplasty: a system of classification and treatment for combined abdominoplasty and suction-assisted lipectomy. Aesthetic Plast Surg 1991; 15: 111-121.

20) Ousterhout DK. Combined suction-assisted lipectomy, surgical lipectomy, and surgical abdominoplasty. Ann Plast Surg 1990; 24: 126-132; discussion 132-133.

21) Illouz YG. En bloc abdominoplasty: a new, safer and more esthetic technique. Ann Chir Plast Esthet 1990; 35: 233-242.

22) Kloehn R. Liposuction With "Sonic Sculpture": six years' experience with more than 600 patients. Aesthet Surg J 1996; 16: 123-128.

23) Zocchi, ML. Basic physics for ultrasound-assisted lipoplasty. Clin Plast Surg 1999;26: 209-220.

24) Igra H, Satur NM. Tumescent liposuction versus internal ultrasonic-assisted tumescent liposuction. A side-to-side comparison. Dermatol Surg 1997; 23: 1213-1218.

25) Lawrence N, Cox SE. The efficacy of external ultrasound-assisted liposuction: a randomized controlled trial. Dermatol Surg 2000; 26: 329-332.

26) Thornton LK, Nahai F. Equipment and instrumentation for ultrasound-assisted lipoplasty. Clin Plast Surg 1999; 26: 299-304.

27) Zocchi ML. Ultrasonic assisted lipoplasty. Technical refinements and clinical evaluations. Clin Plast Surg 1996; 23: 575-598.

28) Graf R, Auersvald A, Damasio RC, Rippel R, de Araújo LR, Bigarelli LH, Franck CL. Ultrasound-assisted liposuction: an analysis of 348 cases. Aesthetic Plast Surg 2003; 27: 146-153.

29) Apfelberg D. laser-assisted liposuction may benefit surgeons and patients. Clin Laser Mon 1992; 10: 259-264.

30) Apfelberg D, Rosenthal S, Hunstad J. Progress report on multicenter study of laser-assisted liposuction. Aesth Plast Surg 1994; 18: 259-264.

31) Apfelberg D, et al. Results of multicentric study of laser-assisted liposuction. Clin Plast Surg 1996; 23: 713-719.

32) Blugerman G. Laserlipolysis for the treatment of localized adiposity and "cellulite". Abstr World Congress Liposuction Surgery. Dearborn, MI, USA, 2000.

33) Schavelzon D, Blugerman G, Goldman A. Laser lipolysis. Abstracts of the 10th International Symposium on Cosmetic Laser Surgery Las Vegas, USA 27-29 April 2001.

34) Goldman A, Schavelzon D, Blugerman G. Laser lipolysis: liposuction using ND:YAG laser. Rev Soc Brasil Cirugia Plast 2002; 17: 17-26.

35) Goldman A, Schavelzon D, Blugerman G. Laserlipolysis-Liposuction with Nd:YAG laser. Translation of Laserlipolise-lipoaspiracao com Nd:YAG laser. Rev Soc Bra Laser 2003; 2: 1-3.

36) Goldman A. Lipoaspiracao a laser-laserlipolise no contorno corporal. Rev Brasil Cirugia 2002; 3: 92-93.

37) Badin A, Moraes, L, Gondek L, Chiaratti MG, Canta L. Laser lipolysis: flaccidity under control. Aesth Plast Surg 2002; 26: 335-339.

38) Neira R, Arroyave J, Ramirez H, Ortiz CL, Solarte E, Sequeda F, Gutierrez MI. Effect of low-level laser therapy on abdominal adipocytes before lipoplasty procedures. Plast Reconstr Surg 2002; 110: 912-922.

39) Brow S, Rohrich R, Kenkel J, Young VL, Hoopman J, Coimbra M. Effect of low-level laser therapy on abdominal adipocytes before lipoplasty procedures. Plast Reconstr Surg 2004; 113: 1796-1804.

40) Ichikawa K, Miyasaca M, Tanaka R, Tanino R, Mizukami K, Wakaki M. Histologic evaluation of the pulsed Nd:YAG laser for laser lipolysis. Laser Surg Med 2005; 36: 43-46.

41) Kim KH, Geronemus RG. Nonablative laser and light therapies for skin rejuvenation. Arch Facial Plast Surg. 2004; 6: 398-409.

42) Grazer FM, de Jong RH. Fatal outcomes from liposuction: census survey of cosmetic surgeons. Plast Reconstr Surg 2000; 105: 436-447.

43) Kenkel JM, Brown SA, Love EJ, Waddle JP, Krueger JE, Noble D, Robinson JB Jr, Rohrich RJ. Hemodynamics, electrolytes and organ histology of larger-volume liposuction in a porcine model. Plast Reconstr Surg 2004; 113: 1391-1399.

44) Bozola AR, B. A. Abdominoplastias. In: Melega JM (ed) Cirurgia Plastica, Fundamentos e Arte-Cirurgia Estetica. MEDSI, Sao Paulo. 2003.

45) Avelar JM. Abdominoplasty without panniculus undermining and resection: analysis and 3-year follow-up of 97 consecutive cases. Aesthet Surg J 2002; 22: 16-25

46) Nahas FX, Ishida J, Gemperli R, Ferreira MC. Abdominal wall closure after selective aponeurotic incision and undermining. Ann Plast Surg 1998;41: 606-613; discussion 613-617.

47) Toledo LS. The overlap of lipoplasty and abdominoplasty: indication, classification, and treatment. Clin Plast Surg 2004; 31: 539-553, v.

48) Graf R, de Araujo LR, Rippel R, Neto LG, Pace DT, Cruz GA. Lipoabdominoplasty: liposuction with reduced undermining and traditional abdominal skin flap resection. Aesthetic Plast Surg 2006; 30: 1-8.

49) Illouz YG. A new safe and aesthetic approach to suction abdominoplasty. Aesthetic Plast Surg 1992; 16: 237-245.

50) Saldanha OR, De Souza Pinto EB, Mattos, WN Jr., Pazetti CE, Lopes Bello EM, Rojas Y, dos Santos MR, de Carvalho AC, Filho OR. Lipoabdominoplasty with selective and safe undermining. Aesthetic Plast Surg 2003; 27: 322-327.

51) Saldanha OR, Federico R, Daher PF, Malheiros AA, Carneiro PR, Azevedo SF, Saldanha Filho OR, Saldanha CB. Lipoabdominoplasty. Plast Reconstr Surg 2009; 124: 934-942.

52) Saldanha OR, Azevedo SF, Delboni PS, Saldanha Filho OR, Saldanha CB, Uribe LH. Lipoabdominoplasty: the Saldanha technique. Clin Plast Surg 2010; 37: 469-481.

53) Pereira LH, Sterodimas A. Composite body contouring. Aesthetic Plast Surg 2009; 33: 616-624.

54) Illouz YG. The fat cell "graft": a new technique to fill depressions. Plast Reconstr Surg 1986;78: 122-123.

55) Matsudo PK, Toledo LS. Experience of injected fat grafting. Aesthetic Plast Surg. 1988; 12: 35-8.

56) Guerrerosantos J. Autologous fat grafting for body contouring. Clin Plast Surg 1996; 23: 619-631

57) Pulagam SR, Poulton T, Mamounas EP. Long-term clinical and radiologic results with autologous fat transplantation for breast augmentation: case reports and review of the literature. Breast J 2006; 12: 63-65

58) Lewis CM. Correction of deep gluteal depression by autologous fat grafting. Aesthetic Plast Surg 1992; 16: 247-250.

59) Toledo LS, Mauad R. Fat injection: a 20-year revision. Clin Plast Surg 2006; 33: 47-53

60) Bircoll M. Cosmetic breast augmentation utilizing autologous fat and liposuction techniques. Plast Reconstr Surg 1987; 79: 267-271.

61) Spear SL, Wilson HB, Lockwood MD. Fat injection to correct contour deformities in the reconstructed breast. Plast Reconstr Surg 2005; 116: 1300-1305.

62) Missana MC, Laurent I, Barreau L, Balleyguier C. Autologous fat transfer in reconstructive breast surgery: indications, technique and results. Eur J Surg Oncol 2007; 33: 685-690.

63) Zheng DN, Li QF, Lei H, Zheng SW, Xie YZ, Xu QH, Yun X, Pu LL. Autologous fat grafting to the breast for cosmetic enhancement: experience in 66 patients with long-term follow up. J Plast Reconstr Aesthet Surg 2008; 61: 792-798.

64) Pereira LH, Sterodimas A. Macroscopic and microscopic proof of long-term survival of gluteal fat transplantation. Plast Reconstr Surg 2009; 123: 162e-163e.

65) Pereira LH, Sterodimas A. Free fat transplantation for the aesthetic correction of mild pectus excavatum. Aesthetic Plast Surg 2008; 32: 393-396.

66) Guerrerosantos J. Autologous fat grafting for body contouring. Clin Plast Surg 1996 ;23: 619-631.

67) Kaufman MR, Miller TA, Huang C, Roostaeian J, Wasson KL, Ashley RK, Bradley JP. Autologous fat transfer for facial recontouring: is there science behind the art? Plast Reconstr Surg 2007; 119: 2287-2296.

68) Sterodimas A, Huanquipaco JC, de Souza Filho S, Bornia FA, Pitanguy I. Autologous fat transplantation for the treatment of Parry-Romberg syndrome. J Plast Reconstr Aesthet Surg 2009; 62: e424-426.

69) Illouz YG, Sterodimas A. Autologous fat transplantation to the breast: a personal technique with 25 years of experience. Aesthetic Plast Surg 2009; 33: 706-715.

70) Liu ZJ, Zhuge Y, Velazquez OC. Trafficking and differentiation of mesenchymal stem cells. J Cell Biochem 2009; 15: 984-991.

71) Ogawa R. The importance of adipose-derived stem cells and vascularized tissue regeneration in the field of tissue transplantation. Curr Stem Cell Res Ther 2006; 1: 13-20.

72) Sterodimas A, De Faria J, Correa WE, Pitanguy I. Tissue engineering in plastic surgery: an up-to-date review of the current literature. Ann Plast Surg 2009; 62: 97-103.

73) Sterodimas A, de Faria J, Nicaretta B, Pitanguy I. Tissue engineering with adipose-derived stem cells (ADSCs): current and future applications. J Plast Reconstr Aesthet Surg 2010; 63: 1886-1892.

74) Sterodimas A, de Faria J, Nicaretta B, Papadopoulos O, Papalambros E, Illouz YG. Cell-assisted lipotransfer. Aesthet Surg J 2010; 30: 78-81.

75) Illouz YG. Illouz's technique of body contouring by lipolysis. Clin Plast Surg 1984; 11: 409-417.

76) Bjorntorp P, Ostman J. Human adipose tissue dynamics and regulation. Adv Metab Disord 1971; 5: 277-327.

77) Pfulg ME. Complications of suction for lipectomy. Plast Reconstr Surg 1982; 69: 562-563.

78) Vilain R. Suction curettage or not: that is the question. Plast Reconstr Surg 1982; 69: 1026-1027.

79) Schrudde J. Suction curettage for body contouring. Plast Reconstr Surg 1982; 69: 903-904.

80) Kenkel JM, Lipschitz AH, Luby M, Kallmeyer I, Sorokin E, Appelt E, Rohrich RJ, Brown SA. Hemodynamic physiology and thermoregulation in liposuction. Plast Reconstr Surg 2004; 114: 503-513; discussion 514-505.

81) Rohrich RJ, Leedy JE, Swamy R, Brown SA, Coleman J. Fluid resuscitation in liposuction: a retrospective review of 89 consecutive patients. Plast Reconstr Surg 2006; 117: 431-435.

82) Chajchir A. Fat injection: long-term follow-up. Aesthetic Plast Surg 1996; 20: 291-296.

83) Niechajev I, Sevcuk O. Long-term results of fat transplantation: clinical and histologic studies. Plast Reconstr Surg 1994; 94: 496-506.

84) Mikus JL, Koufman JA, Kilpatrick SE. Fate of liposuctioned and purified autologous fat injections in the canine vocal fold. Laryngoscope 1995; 105: 17-22.

85) Gonzalez AM, Lobocki C, Kelly CP, Jackson IT. An alternative method for harvest and processing fat grafts: an in vitro study of cell viability and survival. Plast Reconstr Surg 2007; 120: 285-294.

86) Shoshani O, Berger J, Fodor L, Ramon Y, Shupak A, Kehat I, Gilhar A, Ullmann Y. The effect of lidocaine and adrenaline on the viability of injected adipose tissue–an experimental study in nude mice. J Drugs Dermatol 2005; 4: 311-316.

87) Karacaoglu E, Kizilkaya E, Cermik H, Zienowicz R. The role of recipient sites in fat-graft survival: experimental study. Ann Plast Surg 2005; 55: 63-68.