Chapter

Complications and Solutions for Post-Operative Liposuction Deformities

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Abstract

In this chapter, the authors will review the complications associated with liposuction and laser liposuction procedures, using published reports as the guide to document these complications and deformities to the readers. In addition, the authors will also report on the use of tumescent anesthesia and the published documentation regarding safety concerns that have been presented via the use of tumescence versus general anesthesia when performing liposuction or laser liposuction. Real-world discussions also will take place in which the authors describe best treatment practices as solutions to those complications described. Liposuction and laser liposuction are wonderful procedures that have been performed for many years. Understanding and being able to identify and treat any untoward complications is extremely important to make everyone a better surgeon and a better physician.

Keywords: complications, liposuction complications, liposuction deformities, solutions for complications

1. Introduction

One of the most challenging aspects of liposuction is patient satisfaction. Patients undergoing liposuction, fat grafting or other forms of fat sculpting are present primarily for cosmetic reasons. Whether removing fat or adding it, contour correction is the goal. As such a very scientific and clinically complex procedure must have an esthetic outcome and the surgeon is truly acting as physician and artist.

G. Neuber is commonly called the father of fat grafting for his innovative 1893 transfer of fat from the arm to the orbital rim to correct an osteomyelitis deformity. Dr. Neuber is also the grandfather of the modern surgical suite and other than Ambroise Paré did more to revolutionize the aseptic technique than any predecessor [1].

Contour deformities have been the bane of our existence as practitioners since the dawn of the procedure. Khanna et. al. review a case by Dujarrier of a ballerina from whom fat was removed from the knee. Unfortunately, the femoral artery was damaged necessitating a below-the-knee amputation. Certainly, an unfortunate contour deformity [2].

The introduction of cannula in 1975 by the Fischer's, a father and son physician team, dramatically altered the landscape of liposuction. While still performed under general anesthesia, three small incisions were made allowing the introduction of blunt cannulas with suction. This allowed a more uniform, less invasive procedure [3]. The technique was further adapted until late 1987 when Klein reported the first use of the tumescent technique for performing liposuction under localized anesthesia. These solutions used very dilute lidocaine and epinephrine. This technique significantly improved outcomes via several mechanisms, as discussed below, and decreased the rate of serious complications. Before this liposuction was predominantly an inpatient procedure. The tumescent technique resulted in a shift of the procedure to outpatient clinics and day surgery centers. Klein continued to perfect the procedure and elucidate the metabolism of lidocaine and the maximum safe doses of lidocaine allowed [4, 5].

This chapter is dedicated to the discussion of post-procedure deformities resulting from liposuction, and an up-to-date review of their prevention and correction.

Of course, to the novice, the term deformity might only suggest areas of over or under treatment, but the term, in this case, is broad and must also include defects of the superficial layer (peau de orange, ulcerations, etc.), deformities of the intermediate and deep layers (over-correction, under-correction, hematomas, seromas) and those arising from damage to deeper structures (ablation of the gluteal sulcus, damage to the marginal mandibular nerve, etc.). More serious complications such as pulmonary embolism, the obese patient, volume overload and perforation of deeper structures are reviewed elsewhere [6].

2. Prevention

Iatrogenic deformities should be avoided. Technique and surgical environment each play a significant role in reducing the chance of clinical error. The facility in which liposuction is performed historically played a greater role in avoiding complications than it does today. The safety of outpatient surgical procedures improved after the formation of the American Association for Accreditation of Ambulatory Surgical Facilities (AAAASF) in 1980 [7]. The number of ambulatory care centers increased 20-fold from 275 in 1980 to 5500 in 2014. The first quality control measure implemented was a limitation on the total volume of fat aspiration. Centers using office-based anesthesia experienced a decrease in severe complications as safety protocols and standards were implemented. Most complications, however, were due to surgical technique rather than anesthesia or facility regulations.

The lowest fatality rates are reported with "true" tumescent liposuction in which general anesthesia is not used. Complication rates are decreasing as new technologies emerge, for example, laser liposuction [8]. Gupta et al. reviewed procedures across several accredited facilities and found evidence that in-office procedures are a very safe alternative when adequate patient selection is used. Overall complication rates for these procedures were estimated at 1.3%, lower than that for other larger facilities [9].

Fatality rates for liposuction appear to be very low overall, and exceedingly rare with pure tumescent anesthesia. Hanke et al. surveyed Fellows of the American Society of Dermatologic Surgery. 15,336 respondents reported complications. Of those, none reported a fatality. Skin irregularity (dimpling, retraction) occurred at a rate of 0.34% and was the third most frequently reported complication. Other reported contour deformities included hematomas/seromas (0.17%), patient dissatisfaction with appearance (0.08%) and ulceration (0.01%) [10]. These results are

comparable to a review of 9002 patients by Boeni and Waechter-Gniadek of which 0.1% had hematoma/seroma and 0.01% had skin necrosis [6].

3. Technique

A good medical history should be taken as part of preventing complications including contour deformities. A well-informed patient who understands every step of the process suffers less anxiety and tolerates mild discomfort more easily. Discomfort limits access to deeper fat compartments makes fibrous areas harder to treat and often leads to a partial treatment or hurried treatment.

There are no formalized standards for preoperative assessment. However, there is consensus in the literature. Araco et al. exclude patients with a body mass index (BMI) > 30, patients with "severe" cardiovascular or pulmonary disease and patients with altered liver function, platelet function or vascular instability (Raynaud's) [11]. In a review, Wells and Hurvitz restricted patients to anesthesia classes 1 or 2 [12]. Smokers should be advised that they may have poor wound healing. Patients with diabetes should be advised of an increased risk for infection as well as delayed wound healing. A hemoglobin A1C of 6.5 or less indicates a decreased risk of adverse events. Skin laxity post-liposuction may not tighten as well in smokers, diabetics or post-menopausal women [13].

A thorough physical examination should be performed. Surgical scars in the treatment area, abdominal herniations, areas of contour deformity and the grade of skin laxity should be noted. After liposuction, previous surgical scars that are not released (e.g. caesarian section, appendectomy) may act as shelves and dramatically change the overall contour. Similarly, severe skin laxity will not significantly correct and will remain a deformity. Likewise, excessive fat removal may leave lax skin that was not obvious before the volume was removed. Unfortunately, it is difficult to predict how a patient's skin will tighten. Several factors play a role, including environment and genetics. Premenopausal women and women on estrogen supplementation may have the best improvement in post-liposuction laxity. This may be because estrogen directly increases fibroblast activity and contributes to collagen and elastin synthesis [14].

The patient's expectations are of course just as important as our own. Excellent communication must exist between the provider and patient at every step. The patient must be well versed in the entire procedure they have elected to undergo. Realistic expectations are very important, as the patient may have an idealized image of themselves post-liposuction that exceeds the parameters of the treatment or may even necessitate a more advanced procedure (abdominoplasty). Photographs that depict realistic results should be reviewed.

After consent, photographs should be taken of the patient in a normal anatomic position. Afterwards, using either a mirror or photographs, the provider should personally discuss with the patient the areas to be treated and give a detailed expectation of results. Proper consideration should be given to the body site being treated. The body should be placed in an anatomic position when considering your approach and mapping. Tensing of musculature may reveal adhesions, herniations, diastasis or asymmetries not otherwise evident. Cellulite, scars, skin textural differences and asymmetry should be carefully noted.

Contour markings should be drawn topographically using a permanent marker and photographs retaken. Care should be taken to mark areas to avoid or that need excess caution (subcostal margin, iliac crest, gluteal crease). Some providers also mark areas where more extensive liposuction might be desired, such as the border of the rectus abdominus. Asymmetry should be noted. Scars and previous surgical sites should be demarcated.

The safe tumescent technique is discussed elsewhere. During tumescence, pre-tunneling is beneficial. Passing the infusion cannula through deep and superficial fat layers distributes tumescence more uniformly, preventing "hot spots" of patient discomfort. Using a fanning pattern prepares the tissue for larger cannulas during suction and helps with uniformity. Once liposuction begins, gradually larger bore cannulas can be used, starting with smaller cannulas. Fanning patterns should overlap in minimally two areas and preferably three. The use of gradually larger bored microcannulas is unique to in-office tumescent liposuction. Patients experience more pain when larger cannulas are used immediately, effecting the physician's ability to take their time uniformly suctioning the treatment area. This will result in poor liposuction techniques and possibly significant contour irregularities. This is especially true around the umbilicus, where fat compartments are isolated from the rest of the abdomen and anesthesia is harder to obtain if tumescence is insufficient. This may lead to under-correction around the umbilicus (**Figure 1**). Larger bore cannulas can be used under general anesthesia by an experienced physician. However, they run the risk of contour deformity because large volumes are removed with each pass. Microcannulas pass easily through septae even in superficial layers and allow a "fine tuning" approach without causing irregularities of the skin surface. They also cause less trauma to fibrous bands connecting the skin to the deeper fascia layers, allowing the skin to remain in its normal position during the natural skin tightening that occurs over the following months. Large bore cannulas should be restricted to use by experienced providers who are very adept with tumescence and volume management. Microcannulas also decrease the risk of bleeding and hematoma formation. An 8 mm cannula transects fewer vascular components than a 2 mm cannula. Similarly, the probability of leaving a large potential space is decreased using the microcannula technique thus decreasing the risk of seroma.

Fat should be suctioned sequentially first from deeper layers then superficial layers. If the original layer suctioned is too superficial, there is a tendency on behalf of new practitioners to assume the tissue, they are grasping is the only area that needs treatment and deeper layers of fat are overlooked. Power-assisted liposuction and laser-assisted liposuction are also rapid and may increase contour irregularities. In an analysis of 2398 patients, contour deformities occurred at a rate of 5.9% when only power-assisted liposuction was used [15].

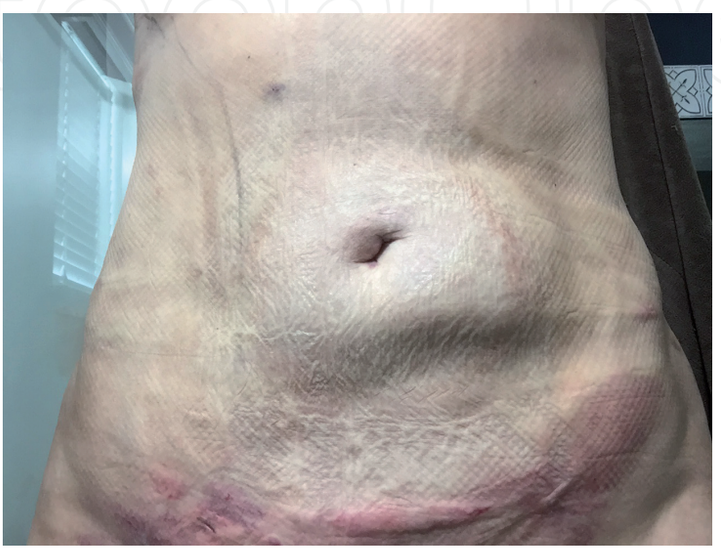

Figure 1.
Periumbilical under-correction.

4. Under correction

Under correction occurs when an area of fat is not adequately removed. In almost all instances, this contour deformity is entirely technique-based. The most common areas are the arms, flanks, the periumbilical region and above the knee [16].

The primary cause of under-correction is patient discomfort. Inadequate tumescent volume, poor deep tumescence and incorrect lidocaine concentrations lead to intraoperative pain or systemic side effects. As discussed above, care should be taken to tumesce deeper layers adequately and then suction should be started in these layers first. Pitman et al. recommend the total fluid administered should be approximately double the volume of expected aspirate, meaning an approximate 1:1 ratio of tumescence to fat if all tumescence was aspirated [17]. This is a reasonable rule of thumb keeping in mind the maximum dose of 55 mg/kg lidocaine. Typically, 21–22% of injected fluid is not absorbed, making the ratio of fat removed to fluid absorbed 11:1. Matarasso recommended that this should be kept in mind during longer or more complicated large volume procedures when calculating fluid replacement and to achieve "consistency in reporting" authors should standardize comments on volumes of injectate, aspirate, and infranatant fluid fractionation [18].

More fibrous areas, such as the male chest, the outer hip or the submentum may require a higher concentration of lidocaine in the tumescent fluid. In the authors' opinion, the 1:1 recommendation still applies. Taking too long to perform the procedure can lead to patient discomfort and incomplete liposuction. Smaller cases should be selected first until the technique is comfortable and familiar.

Under corrected areas can typically be corrected with repeat liposuction. There is no consensus as to when second liposuction can be performed. It is inadvisable to perform a second procedure during the healing process when inflammation, edema and fluid retention are still present. Most physicians are comfortable waiting 3–4 weeks if the intent is in correct volume. Tissue laxity and lymphedema must be excluded as causes. Pinch testing and sweep testing, as described by Toledo and Mauad, help to identify residual fat deposits [19].

When the volume to be corrected is relatively small, cryolipolysis may be a reasonable consideration. Coolsculpting has been Food and Drug Administration (FDA) approved for fat reduction of the chin, abdomen, thighs, flanks, bra fat and buttocks. The results have been reviewed in several publications. Submental fat reduction can be as much as 2 mm, with 83% satisfaction [20]. Fat reduction in the abdomen was as much as 27%, the bra area 20%, the flanks 25%, the inner thigh 20% and the outer hip 29% [21]. The technique remains safe, and erythema occurs in almost all patients. The incidence of post-treatment sensitivity treatment ranged dramatically from 0.6% in one study to 73% in another, with gradual improvement over 2 months. 29–96% of patients reported at least mild pain during the procedure, but this resolved and 1 week later only 2.5% reported pain [22].

External ultrasound devices can also be used to decrease small areas under correction. Several devices exist. External ultrasound devices heat fat via a photoacoustic effect. Specific frequencies heat fat faster and more selectively. Free lipids can be detected in lymphatic fluid post-treatment, verifying cell membrane permeability and/or cell death [23]. There is no consensus on the best intensity settings, frequency of ultrasound, or frequency of treatment. A few reviews of larger patient populations do exist, indicating improvement in volume [24]. High-intensity focused ultrasound (HIFU) focused at a depth of 1.1–1.6 cm, results in almost immediate adipocyte death primary via acoustic cavitation and heating. Apoptosis may also play a role. An excellent review by Atiyeh and Chahine of several studies

reported a mean waist circumference reduction of 2–5 cm. Overall, HIFU resulted in a "modest" reduction in fat, but most studies had inaccurate and inconsistent measuring tools. These authors recommended HIFU for non-obese patients seeking a minimal reduction in volume [25]. This makes HIFU reasonable for small areas remaining after liposuction. Anecdotally, our clinic uses HIFU for exactly this purpose, often combined with radiofrequency to promote dermal heating and subsequent tightening.

Radiofrequency non-invasive body contouring may also be of some benefit for contour irregularities. Radiofrequency heats fat indirectly by orienting water molecules in an electric field. Subsequent spinning results in heat and eventually adipocyte death. The frequency of devices ranges from 3 kHz to 24 GHz and may be unipolar, monopolar, or bipolar. These treatments typically involve heating the skin above 42°C for a 15–45 min period. Higher intensities may destroy fat more quickly but are typically not tolerated by the patient. Most studies demonstrate improvement in skin tightening but a few studies demonstrate volume reduction as high as 20%[26] Radiofrequency is safe to use for small areas but should be avoided directly over bony structures, in patients with metal implants or defibrillators or those with metallic intrauterine devices.

Diode lasers emitting 1060 nm infrared light have recently been introduced. With these devices, abdominal fat may be reduced by as much as 19% and submental fat by 26.4% after a single treatment. The devices are relatively new, and we await larger studies [27]. Likewise, low-level laser light therapy (LLLT) devices may have some effect on localized adiposity. However, these devices vary wildly in efficacy, treatment intensity, treatment time and treatment endpoint. Typically, these results are experienced more slowly and maybe less than ideal for correcting contour deformities post-liposuction. Some evidence exists demonstrating LLLT plus liposuction may be beneficial, but that LLLT as a stand-alone procedure is not sufficiently effective [28–30].

In the last 2–3 years high-intensity focused electromagnetic (HIFEM) field treatment has shown efficacy in inducing muscle hypertrophy and fat reduction [31]. Katz et al. demonstrated an average reduction in abdominal fat of 19% from 1 month after treatment and 23.3% from 3 months after treatment using HIFEM in patients BMI 20–30 kg/m^2. Each patient received for 30-minute treatment spaced 2 days apart over 2 weeks. The treatments were highly tolerated. Cellular controlled apoptosis appears to be the predominant mechanism [31]. The procedure is also an option for treatment of other sites, such as the calves or arms [32].

Finally, liposhifting may be appropriate for small under corrected areas. This technique involves anesthetizing the area, then gently loosening fat with a cannula (without suction). The loosened fat is gently rolled out to the desired contour and a garment placed to fix the tissue in place. Several patients in our practice have had excellent results with this technique [33].

5. Overcorrection

In the case of overcorrection, excess fat has been removed from the subject such that the desired contour is depressed. These occur in every possible anatomic site but are most evident where the esthetic result is visible ventrally. The abdomen is the most common site, primarily because of the larger area, although it is the least technically difficult. However, more technically difficult sites include the outer and inner thighs and the posterior upper leg [16]. Treatments for overcorrection include reinjection of aspirated and prepared fat (see below), the release of fibrous bands using either mechanical or enzymatic release (e.g. as seen in areas of bound down skin or cellulite), and various fillers, specifically poly-L-lactic acid (PLLA).

It can be very helpful to annotate the expected amounts of aspirate on a photograph or body map. Then during the procedure documentation can be made as to actual volumes extracted. Toledo and Mauad recommend collecting several syringes of fat initially so that overcorrected areas can be grafted immediately [19]. We find it helpful to have the patient stand at the end of the procedure so that contour irregularities can be assessed. In a supine patient, contour irregularities can be observed by stretching the skin and looking for subtle changes in contour. These areas can then be further assessed with a pinch test. Care must be taken not to overcorrect and undercorrected area causing the provider to go back and forth between sites. While it is often helpful to blend the hills surrounding under corrected sites into the normal contour, this can be an easy pitfall and reinjection may be a better option. Overcorrection can also occur in what Klein refers to as a "spoke and wheel deformity". This occurs when suctioning occurs repeatedly at the base of a fanning pattern where more passes occur. Avoid this by stopping suction on entry and exit and during changes in direction.

Overcorrection also occurs in the mons pubis, where vulvar edema can be problematic. This area should be approached very conservatively. Even a mons pubis that appears to have significant volume may be deceptive because the fibrous borders of this area make small amounts of fat seem larger. Overcorrection of this area can result in painful intercourse.

By collecting several syringes at the beginning of the procedure fat can be saved for same-day reinjection. Fat graft survival is based on several factors. Larger cannulas decrease the sheer force of adipocytes against the cannula wall. Adipocytes exposed to higher vacuums can also suffer damage. Larger and shorter cannulas have better adipocyte viability based on Poiseuille's law because pressure drop is directly related to the length of the cannula and inversely related to the 4th power of the radius. A larger bore dramatically decreases the change in pressure an adipocyte must undergo. Fat should be cleaned of blood and tumescent fluid, but centrifuging may be damaging [34]. There is a 1470 diode laser powered to disrupt septa but not destroy adipocytes. This works because water-containing septae preferentially absorb 1470 nm infrared energy over adipocytes. Adipocytes are then collected in a mesh basket within the container and excess tumescence, blood and oil are suctioned out in a two-step process. This fat is reported to be over 90% viable [35]. The addition of platelet-rich plasma may nearly double fat graft survival (55–89%) [36]. Platelet-rich fibrin may be beneficial as well, as it releases growth factors more quickly to adipocytes at risk of death (greater than 300 μm away from the periphery of the transfer) [37]. Reinjection should be performed in small aliquots using only gentle pressure. Distribute it in a fanning pattern to increase vascular exposure. Depending on the method of collection and fat preparation, the problematic area should be injected with an additional 50–100% over baseline to allow for resorption. Liposhiftng is beneficial if the over-corrected area is adjacent to a larger volume of fat.

Cellulite and scar depressions can be released using a forked cannula. These release fibrous bands in a technique called subsicion [38]. After release, cellulite and scars may be fully corrected and no further treatment is needed, otherwise fat grafting or poly-L-lactic acid may also be used.

Collagenase may be an additional off-label consideration to improve bound-down scarring or cellulite. Collagenase derived from *Clostridium histolyticum* has recently been FDA approved for treating cellulite and has been used for Dupuytren's contracture and Peyronie's disease as early as 2013 [39]. The most common side effects have been ecchymosis and pain at the injection site but reports of edema and hematoma exist [40].

Poly-L-lactic acid (PLLA) is a deep dermal filler that stimulates collagen formation by activating fibroblasts. Volume correction can persist for 2 years or more. Results may not be seen for 4–8 weeks, and injections typically are placed 4–6 weeks apart. Correction of depressed areas is temporary, and results may not be visible for several weeks after injection. Unlike autologous fat transfer, overcorrection is not recommended here. Several sessions are needed. The technique can be cost-prohibitive for larger areas. Each syringe provides only 5–12 ml of fluid depending on dilution. Fillers should not be used on the day of liposuction. Time should be allowed for swelling and edema to subside. Also, 1% lidocaine with epinephrine is often used in reconstituting ploy-L-lactic acid and this complicates calculations of maximum lidocaine dose after tumescence when numerous syringes are used. We have had success with the correction of gluteal cellulite and volume using PLLA (**Figure 2**) but found no case reports using PLLA specifically for overcorrection.

Recently allograft adipose matrix (AAM) has been introduced for volume correction. An AAM was developed by the processing of recovered adipose tissue as a human cell and tissue products (HCT/P) allograft [41]. It is stored at room temperature and as such can quickly be reconstituted if overcorrection is observed. Injection of an adipose-specific matrix promotes adipocyte differentiation, proliferation, and neovascularization. Patients generally tolerate injection very well. Biopsy of treated temporal tissue revealed an increase in adipocytes and blood vessels at 8 weeks. Gold et al. observed that AAM generally appears to follow the same trend as autologous fat grafting and may reach final volume more quickly. Thus, the underlying mechanisms of fat grafting and AAM may be similar [42]. More experience is needed with this product, but it seems to have great potential.

Millifat (2–2.5 mm "parcels" of fat) may be an alternative solution to mild superficial contour deformities, probably by the same mechanisms as AAM and grafting. Nanofat (500 μm particles) can similarly be used to improve skin texture and assist in volume support [43]. This is typically introduced via microneedling or a 25 gauge cannula.

Figure 2.
Correction of cellulite and volume using PLLA. Photo courtesy: Jamie Wilson PA-C.

6. Other contour deformities

Seromas account for 2–5% of complications from liposuction [44]. Seromas are a result of excessive fat removal and destruction of fibrous bands using either larger cannulas or aggressive techniques. They occur when a potential space is created and fills with fluid. They usually occur within 2 weeks post-operatively. Proper garment fitting is essential in avoiding seromas. Scrotal and vulvar swelling is a frequent complication especially when the suprapubic is suctioned. This is primarily due to edema from fluid movement due to gravity and rarely a hematoma or seroma. Bodysuits are available that put pressure on the suprapubic, but care must be taken that the garment is not so tight that edema in the vulva or scrotum results in cyanosis or numbness. Needle aspiration is the primary treatment, followed by compression. The seroma may need to be drained several times until it stops forming. It is important to manage seromas so that a permanent cavity is not created.

Hematomas form via a similar mechanism when vascular damage is sufficient for blood to fill a potential space (**Figure 3**). Larger cannulas, muscle trauma and aggressive liposuction increase the risk of hematomas. After tumescence Klein recommends a period of detumescence to allow vasoconstriction and so that tissue is more easily pinched and manipulated. A good medical history should include the use of blood thinners, including over-the-counter non-steroidal anti-inflammatory drugs (NSAIDS) and herbal supplements such as garlic, ginseng, and *Gingko biloba*.

Prevention of hematomas, bleeding and ecchymosis may be achieved by adding tranexamic acid (TXA) to the tumescent fluid. Rodriguez-Garcia et al. report a decrease in blood loss as measured by hematocrit [45]. Adding TXA to lipoaspiration sites post-liposuction also has decreased bruising [46].

Drainage of hematomas followed by compression is essential and may require several treatments. Rapidly developing hematomas may indicate a significant vascular bleed and require direct compression. In severe cases, a drain may be required. A chronic hematoma can form a fibrotic mass, and some have demonstrated calcification. If left untreated, hematomas can take months to resolve. It has been postulated that laser-assisted liposuction may have a lower rate of bleeding and ecchymosis because of cauterization. The 1064/1319 nm devices may improve skin tightening slightly better than others. The risks of thermal injury and ulceration are increased using lasers. Radiofrequency assisted liposuction (RFAL) devices demonstrate a very safe profile. The rate of minor complications including hematomas

Figure 3.
Post-liposuction hematoma of the right lower abdomen at 1 week.

is significantly reduced with second-generation RFAL devices as reviewed and discussed by Chia et al. [47].

Normally temporary hyperpigmentation is the only residual evidence of an access port after healing. Keloids and hypertrophic scars can occasionally occur at these sites. They can also occur where ulceration or necrosis occurred. A patient with a history of keloids should be warned about the increased risk. The risk of scarring is increased if an undersized port undergoes significant friction. The treatment of hypertrophic scars and keloids is generally the same. Intralesional triamcinolone 5–10 mg/cc injected once every 4–6 weeks is usually sufficient to flatten the scar. Silicone sheets, gels and gentle massage are very helpful but are much slower. Transcutaneous delivery of triamcinolone or 5-flourouracil has been reported as beneficial. Laser-assisted delivery of medications via fractional ablated channels may prove promising, but the FDA has warned against using products not designed to be used systemically or subcutaneously. Botulinum toxin may also act via myofibroblasts. Hypertrophic scars respond to fractionated ablative lasers via a remodeling mechanism and this may be appropriate as sole therapy.

Superficial skin irregularities are very common. Illouz reports 8.2% of patients experienced skin irregularity post-procedure [48]. Superficial aspiration can result in a bound down or peau d'orange appearance with dermal scarring and fibrosis. Avoid this by always keeping the cannula window faced downward away from the dermis. Illouz as well as Dixit and Wagh recommend leaving 5 mm of fat beneath the dermis and over the fascia to prevent scarring and waviness [16, 48]. Lax skin may tighten better by traumatizing the subdermis either mechanically or with heat. Devices using ultrasound, radiofrequency, lasers, and helium plasma are marketed for this purpose. Care must be taken not to damage the fragile superficial vascular plexus and lymphatics. Being too aggressive near the dermis can result in dimpling, ecchymosis, ulceration and permanent reticular erythema referred to as erythema ab lipoaspiration (**Figure 4**). Correcting peau d'orange skin and erythema ab lipoaspiration is incredibly difficult. Mesoglycan-based therapy orally at a dose of 50 mg twice daily worked in one case report of erythema ab igne, which is similar. Treatment lased 1 month at twice a day and 2 months at daily dosing [49]. Cho et al. report a case of a 23-year-old woman with erythema ab igne treated with a 1064 nm ND:YAG using low fluences (1.8–2.5 J/cm^2, 2 passes). She was treated with three treatments separated by 2 weeks [50].

Post-inflammatory erythema and ecchymoses may be improved with intense pulsed light (IPL). In the authors' opinion, IPL is beneficial for post-liposuction erythema generally. Using a broadband light device, a 560 nm filter and a 4.5 cm spot size (12 J cm, 30 ms and 20° cooling; two passes) every 2 days resulted in improvement of ecchymoses and erythema after 2 weeks.

Permanent skin creases frequently occur after liposuction when redundant skin folds onto itself. Properly fitted garments that do not pinch or fold the skin are essential. The patient should be made aware that folds of the skin should be flattened when the garment is adorned. Even when a garment is in place, sitting in certain positions can fold the skin. Folded skin can make permanent creases with resulting shelves of redundant tissue that persist indefinitely (**Figure 5**). Treatment can be challenging and includes lymphatic massage to assist in scar release and fluid drainage from the area superior to the crease. Subcision using a forked cannula may be required. If this is performed the area can scar again, which may be alleviated with fat grafting below the site or collagenase as discussed elsewhere. Collagenase may also be considered, especially if followed with radio-frequency and targeted pressure energy. This has been demonstrated clinically with cellulite as a model [51].

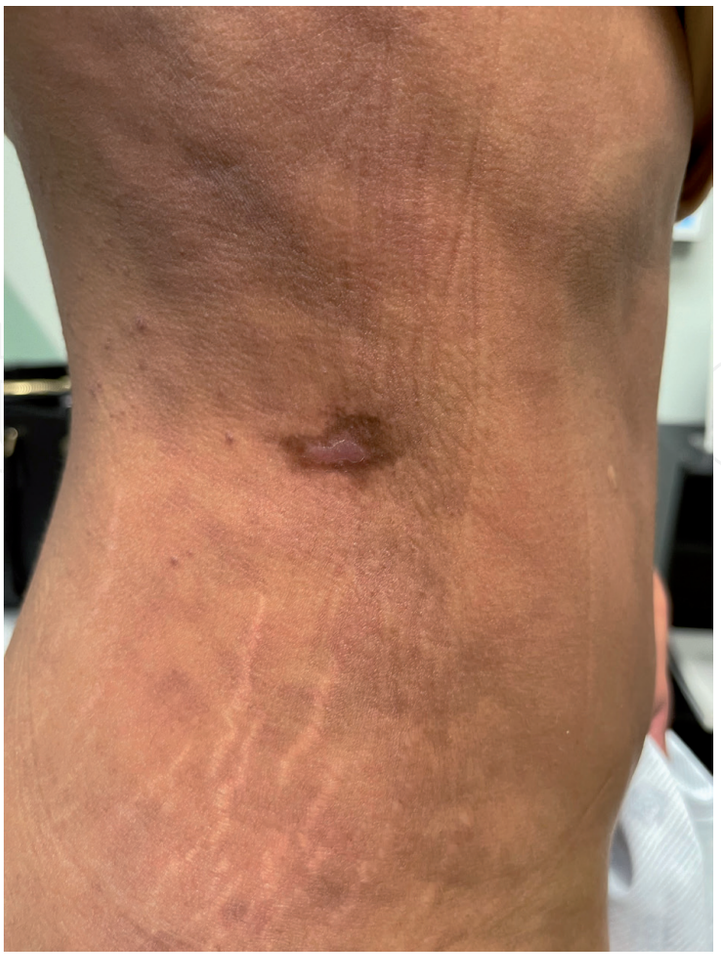

Figure 4.
Scar from dermal necrosis from laser-liposuction.

Figure 5.
(a) Post-liposuction creases from the inappropriately worn garments. (b) The same patient after massage for a month.

Liposhifting may also be beneficial [33]. Bound-down skin that moves with muscle contraction is attached to the fascia. This should be carefully subcised. An alternative is triamcinolone injection and/or 5-flourouracil injectable solution. (Illouz) Chacur et al. reported a case of liposuction fibrosis and dermal scarring treated with a combination of subcision, injected polymethyl methacrylate and fractionated CO_2 (epidermal). A single session resulted in notable improvement

extending to 4 years [52]. It should be remembered that triamcinolone can also cause fat atrophy and in some cases fat atrophy may exacerbate the problem.

7. Specific sites

The gluteal sulcus is a problematic area. This area must be strictly avoided and there should never be an attempt to create an artificial gluteal sulcus using liposuction in patients. Disruption of the fibrous septae that create the inferior gluteal sulcus can lead to gluteal ptosis. Correction of this deformity is almost entirely surgical, although autologous fat grafting has shown some benefit in rebuilding the curvature of the buttock. Sozer and Eryilmaz described a successful split gluteal flap for this repair [53]. Others have described using anchoring de-epithelialized skin flaps. Subcutaneous threading improved to grade 2–5 gluteal ptosis to grade 2 or better. More severe ptosis improved in only 14% of cases [54].

The banana fold represents redundant fat and skin below the gluteal sulcus. Most authors recommend superficial liposuction of this area. This procedure should be reserved for the most experienced practitioners. Deeper or more aggressive liposuction can cause a double banana fold. Autologous fat transfer can improve double folds [55]. Gonzalez reported a dermotuberal anchorage buttock-lifting technique which must be performed surgically [56].

Liposuction of the submentum is straightforward and takes very little time. Overcorrection is common in this area and bound down skin is the result. Small areas can be injected with triamcinolone and only rare cases may need subcision. Massage can make a dramatic difference if tissue is bound down to the platysmal fascia. The laxity common in this area may tempt a clinician into over-treating the subdermis. However, the normal inflammation occurring in the subdermal layer has a profound effect on neck laxity, as can also be seen with cryolipolysis and mesotherapy. The marginal mandibular nerve traverses the jawline within 2 cm of the area below the melolabial fold. The nerve is superficial but beneath the platysmal muscle. The clinician can easily penetrate the plastymal muscle without realizing it, although the patient usually describes some discomfort. When this happens, suctioned fat is noticeably blood-tinged and bleeding often occurs from the port. Likewise, it is not wise to suction on the superficial surface of the platysma because inflammation can cause a paralysis of the marginal mandibular and the corner of the mouth will drop. Over 90% of marginal nerve injuries recover over several months without treatment. In severe cases, a platsymal motor nerve transfer can restore nerve palsy [57].

Breast deformities include depressions and dimpling, especially in the upper pole. This area rarely needs to be liposuctioned. Most problems occur during fat grafting. If fat is injected in a fan-like pattern from the axillary fold a potential space is created and unsightly fat collects in the axillary fold. It is common for liposuction to result in temporary lumpiness that persists for several weeks. That said, mammography is recommended if a new lump appears greater than a month after liposuction [58].

The calves and ankles can be difficult when trying to maintain a natural curvature. In women, overcorrection in this area results in a markedly masculine appearance. Liposuction should not be performed on the calf if the pinch test is less than 2 cm of fat. The calves should be assessed when standing normally, standing on the toes, and supine [59]. The ankle is at special risk of ulceration, as well as nerve damage and varicosities. Fat transfer to over corrected areas of the calf and ankle suffers from lack of vascularity for the graft, and results are disappointing. While there are no case reports, dermal fillers may be preferred.

In summation, the physician is faced with a canvas of options for body contour correction. When in capable hands, liposuction has evolved to be an extremely safe and gratifying option. As with any surgical procedure, the complications are many. But with the advent of new energy technologies, new research of combination treatments, and a more mature understanding of older options (e.g. fat grafting) the options available for correcting the inevitable rare complication are better than they have ever been. In addition to energy devices, new injectables, such as nanofat, collagenase, deoxycholic acid and PLLA to name, a few have given the surgeon a palette of options never before available. Armed with these, we can provide our patients with the absolute best outcomes available to modern medicine.

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