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Complications of facial autologous fat grafting

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Abstract

Autologous fat grafting is a commonly performed procedure for facial volume augmentation and rejuvenation. While overall complication rates in the literature are low, adverse events related to fat grafting can range from minor to systemic and severe. It is crucial that the surgeon be aware of these potential complications, counsel patients appropriately, and take the necessary steps to mitigate these risks. Local graft site complications include contour irregularity, over- or under-volumization, prolonged edema and ecchymosis, fat necrosis, granuloma formation, and infection. Similar complications can also be seen at the donor sites, including contour irregularity, prolonged induration or erythema, infection, and skin pigmentation changes. Finally, the most severe complications, resulting from fat embolism due to intravascular injection, can result in vision loss or stroke. In this review, risk factors for adverse events, surgical techniques to mitigate risk, and potential treatment options for complications of autologous fat grafting are reviewed.

Keywords: Autologous fat grafting complications, volumetric facial rejuvenation

INTRODUCTION

One of the hallmarks of facial aging is the gradual atrophy of the superficial and deep fat pads of the face, with volume loss occurring most critically in the temporal, periorbital, and perioral regions[1-4]. Volumetric facial rejuvenation techniques can effectively address areas of aesthetic fat atrophy with injectable fillers or autologous fat grafting.

Autologous fat grafting has become an invaluable tool in facial cosmetic surgery to address facial aging changes. The concept was first described by German plastic surgeon Gustav Neuber in 1893 when he performed autologous fat transfer from the arm to the periorbital region to address scarring[5]. It was not until nearly a century later, in the 1980s, that it gained popularity with the advent of liposuction[6] and standardized techniques for fat harvesting, preparation, and grafting[7]. Autologous fat grafting is now a common practice for both aesthetic and reconstructive purposes, with the American Society of Plastic Surgeons (ASPS) estimating 33,877 cases of facial fat grafting by ASPS surgeons alone in 2022[8]. The International Society of Aesthetic Plastic Surgery (ISAPS) 2022 procedural statistics listed facial fat grating as the fifth most commonly performed surgical procedure for men and the ninth most common aesthetic surgical procedure overall, with 648,894 cases performed worldwide in 2022 and evidence of increasing popularity with a 10% increase from 2021 (ISAPS)[9].

Facial fat grafting offers an easily accessible, reliably biocompatible, and relatively cost-effective method for volume augmentation. Fat is most commonly harvested from the abdomen; other common harvest sites include the inner thighs, outer thighs, and medial knees. A meta-analysis of thirty studies of facial fat grafting in reconstructive surgery demonstrated a high satisfaction rate for both patients (91.1%) and surgeons (88.6%)[10]. A meta-analysis of reconstructive fat grafting by Boureaux *et al.* noted four studies reporting on patient satisfaction, with a patient satisfaction rate of 78%-100%[11]. Tuin *et al.* utilized a FACE-Q questionnaire evaluating satisfaction with overall facial appearance at 6 weeks, 6 months, and 1 year for 33 female patients who underwent cosmetic facial fat grafting. Patients demonstrated a statistically significant improvement in satisfaction with overall facial appearance at all time points compared to baseline[12]. A larger analysis of patient and surgeon satisfaction concerning facial fat grafting for non-reconstructive, purely aesthetic purposes has not been done.

As with any procedure, autologous fat grafting is not without risk. A meta-analysis of 4,577 patients[13] demonstrated an overall complication rate of 2.27%, with the most common complications being skin irregularities, prolonged edema (> 15 days), graft hypertrophy, fat necrosis, infection, acne, and telangiectasia. Schiraldi *et al.* published a meta-analysis of 5,479 patients[14] with a review of the literature and recommendation for describing complications of facial fat grafting as severe (life- or sight-threatening), moderate (requiring an additional surgical procedure), and minor (not requiring additional surgical intervention). Schiraldi *et al.* noted a 7.7% (354/4579) complication rate in their meta-analysis, with the major difference being the inclusion of intravascular injection in the reporting. Of the 354 complications reported in the study, the majority were intravascular injection (24.6%), followed by prolonged edema (20.0%), recipient site irregularities (16.1%), acne activation (14.1%), fat necrosis or lipogranuloma (8.5%), graft hypertrophy (6.2%), telangiectasia (4.2%), asymmetry (3.7%), prolonged erythema (1.7%), and infection (0.3%)[14]. The true incidence of fat grafting complications is probably unknown, given the likelihood that not all complications are reported in the literature; thus, a reasonable conclusion after analysis of the Schiraldi meta-analysis is that the overall complication rate is at least 7.7%, and probably higher.

The facial surgeon should be well-versed in the potential complications of fat grafting [Table 1], techniques to mitigate risk, and methods of treatment. This chapter details the complications of fat grafting, ranging from major (i.e., vision loss, cerebral infarct) to minor (i.e., prolonged edema, bruising). Considerations to minimize the risk of complications and potential treatment options for adverse outcomes are also reviewed.

MAJOR COMPLICATIONS

Inadvertent intravascular injection of harvested fat can lead to substantial complications resulting from fat

Table 1. Complications of facial autologous fat grafting

Major Complications	Minor complications
Intravascular injection leading to Stroke Vision loss	Poor graft survival leading to Contour irregularity Oil cysts Fat necrosis Granuloma Over-volumization Under-volumization Extended bruising or swelling Infection Donor site morbidity

embolism. Fat embolism can lead to soft tissue necrosis, as well as more serious complications including vision loss and/or stroke. In a recently published report of 49 cases of microfat embolism after autologous fat grafting to the face, the most common location of occurrence was the glabella (36.1%). These complications typically occurred in cases of large-volume grafting (average 16.7 mL injected)[15]. Similarly, in the meta-analysis of 5,479 patients published by Schiraldi *et al.*, the overall rate of intravascular injection was 1.6% (87/5,479). Of these 87 cases, the highest rate of vascular complications occurred in cases of multisite injections (16%-18.4%) and treatment of the glabella (16%-18.4%)[14]. Vascular complications occurred less commonly with the treatment of the forehead (10%-11.5%), temporal area (8%-9.2%), periocular region (5%-5.7%), nose (4%-4.6%), nasolabial fold (4%-4.6%), and cheek (1%-1.1%)[14]. Importantly, the use of a needle versus a cannula was not detailed in this study. A recent literature review by Moellhoff reported on arterial embolism after facial autologous fat grafting, finding the highest incidence with a single injection in the glabellar region or with injections in multiple facial regions (26%), followed by the temple) (16%) and the forehead (15%). The average volume injected was 21.5 mL + 21.5 mL. Occlusions occurred most frequently in the ophthalmic artery (43%), anterior or middle cerebral artery (18%), or both (23%)[16].

Vision loss

Intravascular injection of harvested fat into the dorsal, nasal, angular, or supraorbital arteries can lead to ischemic optic neuropathy and/or retinal vascular occlusion. The mechanism of injury involves relatively high pressure of injected fat leading to retrograde flow of the fat via anastomoses to more proximal arteries. The intravascular fat then travels anterograde into the ophthalmic artery and its branches, including the short posterior ciliary arteries and the central retinal artery. This can lead to sudden and irreversible vision loss due to acute ischemia of the optic nerve and/or retina[17-21]. Mortada *et al.* recently published a meta-analysis of ophthalmic complications of autologous fat grafting, including vision loss, ophthalmoplegia, and ptosis, with a total of 561 patients[22]. The forehead was the most common single site of injection (55%), followed by the periocular region (29%). In patients who received treatment in more than one area, the forehead and the temple region were the most common (95%). When all complications were pooled, ophthalmic artery occlusion and central retinal artery occlusion accounted for 50% and 29% of complications, respectively. The volume of fat injected varied from 1 mL to 68 mL[22].

Treatment for vision loss due to fat embolism is generally ineffective. In the literature review by Moellhoff *et al.*, all patients (n = 26) with ophthalmic artery occlusion after autologous fat grafting had permanent vision loss[16]. Conventional teaching encourages the lowering of intraocular pressure with paracentesis, topical antihypertensives, or oral carbonic anhydrase inhibitors. Ocular massage has been advocated to attempt to dislodge the embolus, but none of these techniques have been proven effective, even anecdotally. Systemic treatment with aspirin, steroids, or a heparin drip has been suggested, although without strong evidence to support these treatments. In contrast to hyaluronic acid-based fillers, where hyaluronidase may dissolve

intravascular product, there are no available agents effective for the dissolution of a fat embolus.

Because of this potentially devastating complication and the lack of effective treatment, minimizing the risk of fat embolus is of paramount importance. The surgeon should be knowledgeable of the course and depth of major blood vessels in the different regions of the face to avoid high-risk areas. Intravascular events are more likely to occur with smaller injection cannulas and needles[17]. The use of a blunt cannula with a large diameter (18-Gauge) can help reduce the risk of intravascular injection[7,11,14,17,19,21,23-25]. Further, injecting only while withdrawing the canula helps avoid intravascular injection. The use of epinephrine in local anesthetic within the recipient site causes blood vessel constriction, potentially decreasing the likelihood of intravascular injection. It is the authors' practice to utilize local anesthetic with epinephrine in the dermal entry site, the major facial sensory nerve locations, and low levels generally throughout the face (sometimes with tumescent anesthetic) to induce generalized vasoconstriction. Avoiding high-pressure injection may also help reduce the likelihood of retrograde flow into an intravascular space. The use of a 1 mL syringe limits the pressure needed for injection, thereby avoiding high-pressure injection[14,19]. In addition, holding the syringe with the plunger abutting the palm of one's hand rather than the thumb allows for slow and controlled pressure on the plunger during the withdrawal movement of the canula. Holding the syringe in standard fashion with the thumb controlling the advancement of the plunger may produce inadvertent high-pressure injections due to less control of the pressure and flow[25].

Stroke

Inadvertent intravascular injection can also lead to the devastating complication of stroke, or cerebral infarction. Cerebral infarction is a rare but life-threatening complication of fat grating. Intravascular injection can result in retrograde flow to the external carotid artery and carotid bifurcation. Subsequent anterograde flow to the internal carotid artery then leads to embolic occlusion of the anterior, middle and/or posterior cerebral arteries and their distal branches. Alternatively, intravascular fat can flow retrograde through communicating branches between the facial artery and internal carotid artery and then to the cerebral arteries. Symptoms of stroke depend on the affected vascular territory and include dysarthria and/or dysphasia, numbness and/or paresis of the face, upper and/or lower extremities, altered mental status, and vision loss.

Qian *et al.* reported a case of massive cerebral infarction following high volume (77 cc) autologous fat grafting to face, with embolic infarction of the right frontal, temporal, and parietal lobes[26]. This was presumed to be due to intravascular injection into the right superficial temporal artery leading to retrograde flow in the external carotid artery to the carotid bifurcation and then anterograde flow via the internal carotid artery. The same authors also review 24 additional reported cases of cerebral infarction after autologous facial fat grafting. The onset of symptoms occurred within 2 h of surgery for 17/24 (71%) and within 24 h of surgery for all cases. Danesh-Meyer *et al.* report a case of middle cerebral artery and ophthalmic artery embolic stroke following autologous fat grafting to the nose, also complicated by skin necrosis due to distal occlusion of the arterial supply to the nose[27]. The cerebral and ophthalmic arterial infarctions were likely the result of intravascular injection of fat into the dorsal nasal artery, with retrograde flow into the ophthalmic and internal carotid arteries, followed by anterograde flow to the middle cerebral and central retinal arteries[27]. Egido *et al.* reported a case of middle cerebral artery (MCA) embolism and vision loss after autologous fat transfer to the glabellar region, likely due to retrograde flow through the supraorbital artery to the internal carotid artery branch point and subsequent anterograde flow to the ophthalmic artery and MCA[28]. In the literature review by Moelhoff *et al.*, neurological impairment occurred in 8/10 patients with carotid artery occlusion, with 6 patients ultimately succumbing to the sequelae[16].

The same defensive injection techniques described above are critical to mitigate the rare risk of stroke from intravascular injection of autologous fat. Suspicion of stroke should prompt urgent referral to a stroke center.

OTHER COMPLICATIONS

Complications due to poor graft survival

Some of the most common complications from fat grafting (contour irregularity, oil cysts, fat necrosis) are due to poor survival of the graft. Understanding the physiology of graft survival aids the surgeon in optimizing conditions for fat grafting and minimizing risk factors for complications.

Grafted fat initially survives by imbibition, or diffusion of oxygen from plasma to the fat cells at the periphery of the graft[17,29]. The cells at the center of the graft undergo necrosis. In the intermediate zone between the periphery and the center, graft precursor cells replace the necrotic cells. The inflammation induced by the trauma of grafting and the hypoxic environment in this intermediate zone trigger a molecular cascade that leads to the neovascularization of the grafted fat. This neovascularization is necessary for long-term graft survival.

Adipocyte stress and trauma during harvest can lead to inconsistent fat survival and irregular contour. Shearing force or barotrauma from high-negative pressure mechanical suction can lead to fat cell rupture. Ruptured fat cells form the oil component of the harvested fat, which composes the supernatant after centrifugation. Any free oil that is present in the grafted fat is phagocytosed by macrophages, leading to inflammation, granuloma formation, and potential irregularity. During harvesting, gentle manual negative pressure on a large diameter (2 mm or greater) cannula can help minimize pressure-related trauma and shearing force on the fat cells[19,25].

Minimizing the processing time between harvest and injection reduces graft adipocyte ischemia. The goal of fat processing is to remove the oil and aqueous component from the lipoaspirate. There are several methods for fat processing: centrifugation, cotton gauze rolling, decantation, and filtration. Processing techniques should aim to minimize trauma to the fragile harvested adipocytes. Centrifugation has been shown to result in a higher concentration of fat progenitor cells in the lipoaspirate compared to Telfa processing[30,31], which can have a fat survival advantage. This advantage is thought to be due in part to vasculogenesis with increased adipocyte stem cells and vasculogenic mediators (i.e., vascular endothelial growth factor (VEGF), platelet-derived growth factor (PDGF). The standard centrifugation technique introduced by Coleman in 1997 described placing 10-milliliter syringes containing harvested fat and centrifuging at 3,000 rotations per minute (RPM) for 3 min[7]. The oil supernatant is then discarded and any residual wicked away with nasal packing. Alternative speeds and durations have been published without a clear consensus on best practice[32-39]. However, a low RPM centrifuge (1,000 RPM for 3 min) has been shown to enhance long-term fat graft survival by condensing adipose-derived stem cells while minimizing adipocyte trauma[33,37,40,41]. A concern with centrifugation is potential damage to adipocytes at higher centrifugal forces (greater than 1,300 RPM or 3,000 RPM, depending on the study)[33,37], although this is debated in the literature. Pulsfort *et al.* found no change in adipocyte damage when lipoaspirate from 13 different patients was centrifuged at 8 different speeds up to 15,000 RPM and noted a higher density of fat cells and fewer contaminants at higher RPMs[34]. Rohrich *et al.* found no significant difference in fat cell viability by quantitative assay when comparing non-centrifuged lipoaspirate to lipoaspirate centrifuged at 500 g, although the total number of samples or patients evaluated is not mentioned[42]. The lack of standardization of centrifugation speed and duration across studies makes comparison between them difficult.

There is wide variation in techniques and preferences for fat processing, without one method demonstrating clear superiority to the others[39,43]. Alternatives to centrifugation for processing include cotton gauze rolling, decantation, and filtration[44]. Gauze rolling involves gently rolling the lipoaspirate with the back of a scalpel or forceps on a nonstick gauze, such as Telfa (Medtronic), for a period of time until the aqueous and oil components are absorbed into the gauze, leaving the adipocytes on the surface of the gauze. The duration of gauze rolling varies between surgeons, usually between 1 and 5 min[30,45,46]. In comparison to centrifugation, gauze rolling on Telfa has demonstrated superior viability and retention at 10 weeks in a mouse model, which may be related to elevated VEGF and PDGF with this method[30] and minimal adipocyte trauma. Gauze rolling may be most feasible in small volume fat transfer, such as the face, rather than with large volume fat transfer, where centrifugation or filtration may be more efficient[45]. The goal of processing remains to remove as much of the non-adipocyte contaminants as possible while preserving the adipocyte viability.

Decantation involves natural separation of the lipoaspirate over time with the use of commercial devices. This method minimizes processing trauma to the adipocytes but is more time-consuming to achieve optimal separation of the adipocytes from the aqueous and oil components. Filtration involves the separation of the lipoaspirate components across membranes of differing pore sizes with the use of a commercially available device that uses suction or vacuum to assist filtration. This can be performed with or without washing (bathing the lipoaspirate with normal saline or lactated ringer solution). The viability and effectiveness of debris removal with filtration varies based on the system used, with these details outside the scope of this article.

Several biological additives have been demonstrated to affect fat graft survival. The use of albumin during harvesting and processing is now common practice, as it has been shown to maintain an isooncotic pressure environment for the adipocytes and enhance survival[47]. Standard practice now involves the addition of 1 mL of albumin to every 10 mL fat harvesting syringe to stabilize oncotic pressure in the lipoaspirate[48]. Similarly, the addition of platelet-rich plasma (PRP) has been suggested in some studies to improve fat survival[49,50] but has not yet been clinically proven. There are no large randomized clinical trials yet performed to assess efficacy and the optimal preparation methods and dosage have not been standardized. The use of adipose-derived stromal cells (ADSCs) is under investigation for safety and efficacy, with ADSCs thought to act as vasculogenic precursors with the potential to differentiate into pericytes and endothelial cells and support vascular proliferation or remodeling[51,52]. There are three randomized controlled trials investigating the clinical application of ADSCs, used in facial fat grafting for Parry-Romberg disease[53] and two in breast augmentation or reconstruction[54,55].

Additional additives shown to affect fat graft survival include lidocaine, insulin, erythropoietin (EPO), and beta-fibroblast growth factor. Lidocaine is thought to have a potential toxic effect on harvested fat[56] and has been shown to adversely affect graft survival[57]. The use of a dilute anesthetic may minimize this risk. *In vitro* and animal studies suggest that insulin may improve the survival of fat grafts by inducing the differentiation of adipose-derived stem cells[58,59]. The addition of EPO and/or VEGF to harvested fat has also been shown to increase fat graft survival and decrease fat necrosis and fibrosis in animal studies[59,60]. A study in rabbits demonstrated that the addition of insulin and beta-fibroblast growth factor to the transfer medium can improve fat graft survival[61]. The clinical applications of these and other additives on fat graft survival require further study.

An additional field of study is the pre-treatment and/or post-treatment of the recipient site to stimulate angiogenesis prior to graft harvest. The utility of pre- and/or post-treatment of the recipient site with light

or laser therapy shows some promise in animal models. Sert *et al.* investigated the effect of photobiomodulation with pre- and/or post-treatment of the recipient site polychromatic light (wavelength 600-1,200 nanometers) in a mouse model[62]. The group that underwent treatment to the recipient both before and after grafting (group 4) demonstrated enhanced fat graft retention compared to those without phototherapy (group 1) and those who underwent pre-treatment (group 2) or post-treatment (group 3) phototherapy alone. Histopathologic analysis of the grafted fat in group 4 at 2 months demonstrated enhanced vascularization and absence of necrosis, fibrosis, and inflammation relative to groups 1, 2, and 3. Similarly, Kim *et al.* used a rat model to evaluate the effect of recipient site pre-treatment with fractional carbon dioxide (CO_2) laser[63]. The treatment group underwent donor site pre-treatment with CO_2 laser (100 mJ pulse energy) 1 week prior to grafting. The fat grafts in the treatment group had greater microvessel density at postop day 1 and less inflammation, fibrosis, and vacuolization, with enhanced survival in the first 2 weeks compared to controls. This field warrants further clinical study.

Contour irregularity

Contour irregularity is one of the most common complications of autologous fat grafting, with an incidence rate of 0.54%-2.9% in recent meta-analyses[10,14,64]. Contour irregularity can be attributed in part to the imperfect predictability of fat survival.

A carefully executed pattern of placement of the grafts avoids contour irregularity. For optimal fat survival, the fat should be grafted in a manner that maximizes surface area exposure for plasmatic diffusion in the recipient site. The recommended diameter of the injection is 2-3 mm or less[17,65], using small aliquots (0.02-0.1 mL per pass)[19,23,65-67] to optimize oxygen diffusion and avoid fat necrosis. The passes should be performed in a smooth fanning or feathering pattern[19,23,25]. When using a fanning pattern, reducing the injected fat flow during the backstroke avoids overfilling near the injection site. The use of two separate injection sites for each location is advocated to allow overlap of each aliquot in a grid-like pattern for smooth placement[23,25]. Some surgeons recommend performing bilateral injections with fat harvested from the same donor site to optimize symmetry, given there may be differences in the composition of the fat from different donor sites[11].

It is also important to consider the appropriate tissue plane during injection for optimal contour. In areas where there are multiple soft tissue layers and thicker skin, fat can be grafted throughout the deep and superficial planes with minimal risk of contour irregularity. Such areas include the piriform region, midface and cheek, and chin[19]. Superficial or subcutaneous injection should be avoided in areas of thin skin to minimize contour irregularity, especially in the superior and inferior orbit and the tear trough area where skin and subcutaneous tissue is thin and less forgiving[11,19]. Fat grafting to the temple region is an important component of volume rejuvenation. Due to the anatomy of this region, injection must often be performed in the superficial plane as well as the deep plane, and injecting the superficial plane is more prone to contour deformity for the less experienced surgeon. For this reason, special care to perform uniform fanning with the placement of small aliquots from two separate injection sites is important in the temple area. Further, pre-tunneling the tissue plane with the cannula during transfer may help release tissue pressure for the graft to help optimize fat survival and minimize contour irregularity[17,19,65,68].

Finally, some patients may be at higher complication risk due to lifestyle or surgical history. Current or former smokers should be counseled on the unpredictability of fat survival, since smoking limits oxygen diffusion and viability of grafted fat. Patients with prior liposuction or surgery of the donor sites may also pose a higher risk for contour irregularity, as previous surgery causes scarring and ischemia of adipose tissue in the host bed. Fat grafted from areas that have previously undergone liposuction is more likely to

have a higher oil component due to fat cell trauma, which may increase the risk of contour irregularity. When possible, fat should be harvested from areas that are liposuction-naïve. Additionally, areas of previous instrumentation from fat grafting, open surgery, trauma, or radiation can cause fibrosis and reduced vascularity in the graft site, which may make uniform and smooth distribution and survival of grafted fat more challenging. In areas with significant scarring, the use of a Y-tipped cannula can help create a broader dissection plane for lipoinjection[23]. Prior intense pulsed light, radiofrequency, or ultrasound aesthetic facial treatments can also lead to impaired vascularization to grafted fat, given the effects of these procedures on the deep dermis and subcutaneous layers.

Contour irregularity can be addressed with liposuction or direct excision when appropriate, or with additional grafted fat to the hypo-volumetric regions. Injected triamcinolone and deoxycholic acid can also be effective tools for contouring micro-irregularities. An appropriate treatment strategy starts with initial test doses and incrementally increases doses over time to achieve a final satisfactory contour.

Oil cysts

Fat survival depends on adequate vascular supply offering adequate plasmatic diffusion of oxygen. Small volume distribution of grafted fat helps maximize the surface area exposure for oxygen diffusion. Fat necrosis occurs when the volume of the grafted fat creates a central zone of ischemia. Too great a distance between the central zone of the graft and the surrounding blood supply can lead to ischemia and fat necrosis within the graft. Adipocyte ischemia can also occur

in the setting of blood or injected medication such as steroid that can create distance between the fat and its surrounding blood supply[23]. Adipocyte trauma during harvest can also lead to fat necrosis. In large areas of necrosis (> 10 mm), the development of oil cysts can occur. Inflammatory response to the oil cysts can lead to calcification. Oil cysts are more common with large-volume injections of autologous fat in areas of the body (i.e., breast, buttocks) as compared to the face[21]. Oil cysts can typically be treated with drainage and rarely surgical excision[25].

Granuloma

Granulomas can form as an inflammatory response to debris in the fat graft. This debris includes oil, fibrous material, or blood. When the fat is processed by centrifugation, the supernatant containing oil and the aqueous infranatant containing cellular debris should be discarded. The use of high oil content fat should be avoided[18]. In the early phases of healing, granulomas can be treated with needle drainage, warm compresses, massage, and intralesional triamcinolone or 5-fluorouracil injections. Persistent granulomas may require surgical excision for treatment.

Over- or under-volumization

Fat survival with autologous fat grafting is unpredictable, although techniques can be used to optimize fat survival and minimize the risk of fat necrosis. A meta-analysis[10] of 12 studies reporting on volume retention after autologous fat grafting found 50%-60% of grafted volume present at 1-year follow-up, although reported ranges vary widely (20%-80%)[65]. Given the expectation that up to 50% of the fat may not survive, it is common to slightly overtreat the grafted areas in anticipation of some fat necrosis. Regarding the eyelid and tear trough specifically, Maamari *et al.* advise against large volume (> 1.5-2.0 mL per side) grafting and recommend injecting perpendicular to the tear trough to avoid the appearance of linear deposition along the orbicularis retaining ligament[19]. It is the authors' experience that fat grafting in the perioral and temporal regions have the lowest survival rates due to increased perioperative muscular activity and reduced vascularity, respectively; thus, a planned slight over-volumization is typically performed in these areas to attain the desired final result. When treating any region on the face (i.e., temporal hollow,

sub-brow fat pad, tear trough, malar region, chin, lips, mandibular angle, perioral region, and ear lobes), the authors typically transfer 1-2 cc per side per region depending on the extent of volume loss. It is important to consider each patient's unique anatomy and volume deficiency when deciding how much fat to graft to each site.

Overcorrection is less common in single-stage procedures and is more often seen with multiple fat grafting procedures[25]. Overcorrection can also result from inadequate consideration of the typical survival rates of the specific graft beds. Fat graft hypertrophy can occur in postoperative weight gain[69,70], which can result in delayed over-volumization of grafted regions. This is an important consideration in patient counseling in select cases. There is one reported case of delayed onset diplopia following orbital fat grafting caused by fat graft hypertrophy due to weight gain. This was successfully treated with surgical excision of the grafted fat[69].

Under-volumization can be treated with repeat fat grafting or postoperative filler injections. If over-volumization results in persistent large nodules or palpable masses, the provider can consider surgical excision of the grafted fat if necessary. Microliposuction can be an effective treatment for generalized facial overfill, especially in the cheek region, and in extreme cases, maxillary deprojection with a high-speed drill via a swinging eyelid approach can help restore a more normal contour proportion[Figure 1][71]. Addressing overcorrection with triamcinolone or deoxycholic acid injection, massage, ultrasound, as well as liposuction or fat excision can be considered in severe cases[17].

Extended bruising or swelling

Extended (> 2 weeks) bruising or swelling is a rare complication of autologous fat grafting[11,19], occurring in 0.6% of patients in a recent meta-analysis of 1,287 patients[28]. The risk of prolonged bruising and swelling can be minimized with preoperative discontinuation of anticoagulant and antiplatelet therapy, if appropriate, as well as preoperative avoidance of vitamin E, fish oil, and ginkgo biloba[19]. Intraoperative use of local anesthetic with epinephrine at the injection entry sites can minimize target tissue bruising, and adequate use of Klein's tumescent technique during harvesting along with centrifuging can limit blood in the final injected graft mixture. Care should be taken to withdraw the injection cannulas close to the insertion site prior to changing the direction of harvest or injection, to minimize tissue trauma and repeated passes through the same tissue[19]. Warm compresses and intense pulsed light (IPL) are potential options to help with persistent bruising. Lymphatic massage may help improve postoperative edema.

Infection

Infection is reported as a rare complication of autologous fat grafting, with incidence rates ranging from 0.10%-0.54% in meta-analyses of autologous fat grafting for cosmetic and reconstructive purposes[10,29]. Infection can occur after fat necrosis or hematoma[21]. Fat harvest and grafting should be performed under sterile operating conditions to minimize infection risk. Intraoperative antibiotic prophylaxis is commonly used to minimize infection risk[19] and is the authors' standard practice. The authors also advocate the use of a topical antibiotic ointment for harvest incision sites and graft sites in the immediate postoperative period. Delayed infection should raise suspicion for possible mycobacterial infection. Suspicion of mycobacterial infection should initiate referral to an infectious disease specialist and specific antibiotic therapy[72].

Donor site complications

The most common site of graft harvest is the abdomen, followed by the hips, trochanteric areas, medial and lateral thighs, and medial aspect of the knees[11,25,73]. Homer *et al.*'s review of 416 cases of autologous fat grating reports a complication rate of 5.5%, with donor site contour irregularities (1.2%) [Figure 2] and induration (1.2%) the most common adverse occurrences[74]. Prolonged erythema (0.9%) and infection

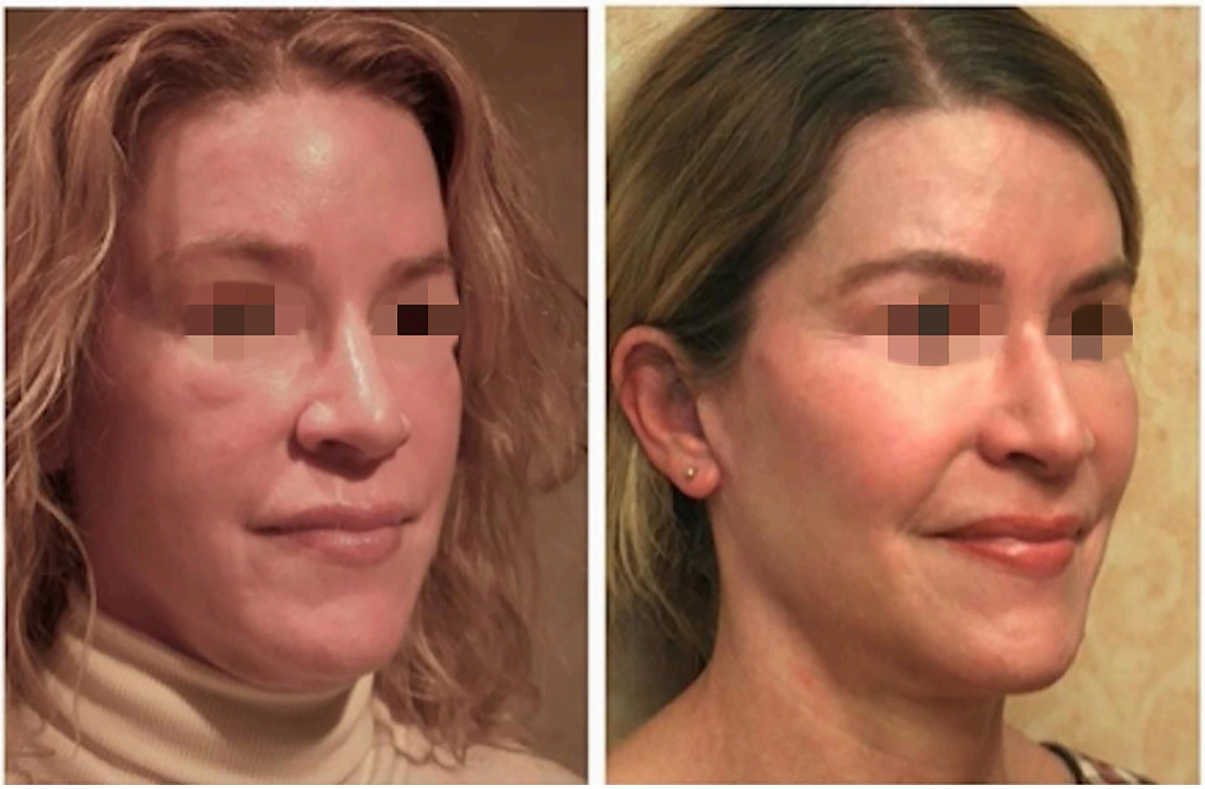

Figure 1. Over-volumization after autologous fat grafting (left). The photo on the right is taken after surgical excision of excess grafted fat via microliposuction and lower fat removal blepharoplasty.

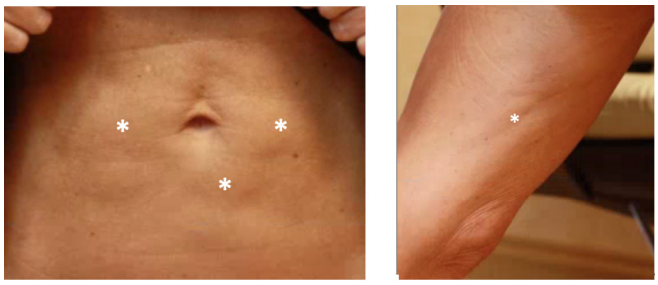

Figure 2. Donor site contour irregularity of the abdomen (A) and lower extremity (B), with the contour depression denoted by an asterisk (*).

(0.5%) were also noted, although less common. A higher incidence of donor site complication correlated with lower body mass index (BMI), even when contour irregularity was excluded. These conclusions are important discussion points during preoperative counseling of risks of autologous fat grating with patients with low BMI. Maamari *et al.* also analyzed donor site adverse events and noted the occurrence of post-inflammatory hyperpigmentation (PIH) at harvest incisions in some patients[19]. Liposuction should be performed in the deeper subcutaneous plane to minimize surface irregularity from harvesting close to the skin. A fanning pattern should be used with attention to equivalent and well-distributed harvesting at each site. When choosing the site of entry for fat harvest, it is prudent to place the incisions in the least conspicuous location that can provide the appropriate distance and angle to the harvest location. Sutured closure of the harvest site incisions and careful postoperative scar management are important to produce

optimal healing. Intralesional triamcinolone and/or 5-Fluorouracil, as well as topical corticosteroids and/or hydroquinone, are effective options for hypertrophic and hyperpigmented healing.

CONCLUSION

Autologous fat grafting is an increasingly popular and effective method for robust volume rejuvenation to address facial aging changes. In general, autologous fat transfer is a safe treatment modality. Very rarely, severe complications- ischemia, vision loss, or stroke-can result from inadvertent intravascular injection, which can be best avoided with the use of a large bore blunt cannula, low-pressure injection, particularly when treating the glabella and periocular regions. Less severe, but still rare complications include contour irregularity of the recipient or donor site, fat necrosis or lipogranuloma formation, and asymmetry. These complications can be addressed primarily by prevention, but additional procedures can be performed to treat contour or volume imperfections or to excise oil cysts, nodules, or granulomas. Common minor complications include temporary donor and injection site irregularity, as well as acne activation, and prolonged erythema or edema. These complications typically improve with conservative treatment.

DECLARATIONS

Authors' contributions

Made substantial contributions to the conception, design, and writing of the manuscript: Brown K, McCoskey M, Nakra T

Availability of data and materials

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Conflicts of interest

Dr. Tanuj Nakra is a shareholder of AVYA Skincare LLC. There are no other conflicts of interest for the authors.

Ethical approval and consent to participate

Not applicable. Written permission was obtained from the patient for the use of identifiable photographs.

Consent for publication

Consent for publication was obtained from the patient.

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