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An Overview on Fat Grafting

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Abstract:

Background: Fat grafting, also known as autologous fat transfer, has become an increasingly popular technique in both reconstructive and aesthetic surgery. The procedure involves harvesting adipose tissue from one area of the body, processing it, and reinjecting it into another site to restore volume, improve contour, and enhance tissue quality. Since fat is autologous, it offers a biocompatible and natural filler option compared to synthetic alternatives. In addition to volume restoration, transplanted fat contains adipose-derived stem cells, which may contribute to improved tissue regeneration and skin quality. Despite its advantages, the main challenges include variable graft survival, the need for multiple sessions, and potential complications such as fat necrosis and oil cyst formation.

Keywords: Fat grafting; Autologous fat transfer; Adipose-derived stem cells; Volume restoration; Regenerative medicine; Aesthetic surgery; Reconstructive surgery.

Introduction:

Autologous fat grafting has gained wide acceptance in both aesthetic and reconstructive surgery as a safe, biocompatible, and versatile technique. It involves harvesting adipose tissue from one site of the body and transferring it to another, restoring volume and improving contour while avoiding synthetic implants. The method has evolved significantly over the past decades with advances in harvesting, processing, and reinjection techniques improving clinical outcomes **(1).**

One of the key reasons for the renewed interest in fat grafting is the presence of adipose-derived stem cells (ADSCs) within the grafted tissue. These cells have been shown to contribute to angiogenesis, collagen remodeling, and skin rejuvenation, expanding fat grafting beyond volumization to a tool in regenerative medicine **(2).**

Despite these advantages, variability in graft survival and volume retention remains a major clinical challenge. To address this, novel strategies such as cell-assisted lipotransfer, platelet-rich plasma supplementation, and the use of extracellular matrix additives have been developed to enhance graft viability and long-term stability **(3).**

Another crucial aspect of modern fat grafting research is the accurate evaluation of graft outcomes. Recent studies have introduced advanced imaging modalities, including 3D volumetric assessment, MRI, and high-resolution ultrasound, to monitor fat survival and detect complications, thereby providing more objective and reproducible outcome measures **(4).**

More recently, optimization of technical parameters such as centrifugation forces and graft preparation protocols has been studied. Evidence suggests that moderate centrifugation improves fat graft viability by preserving the structural integrity of adipocytes and ADSCs, which translates into better long-term graft survival **(5).**

Fat grafting is a reconstructive and cosmetic procedure employed to address volume loss or contour deformities resulting from disease, trauma, congenital anomalies, tumor excision, or the natural aging process. Adipose tissue is considered an ideal filler due to its abundance, ease of harvest, low donor-site morbidity, cost-effectiveness, versatility, and biocompatibility **(6).**

Recent data demonstrate the remarkable potential of genetically modified, autologous fat grafts to heal large defects in bone, cartilage, and other connective tissues, including tendons. Theoretically, fats have a capacity for enhancing tenocyte regeneration and organizing into structures that resemble a healthy functional tendon complex. Furthermore, adipose tissues are an excellent source of stromal vascular fractions (SVFs) that have repair and regenerative potential **(7).** This may explain the role of fat grafting in accelerating the healing process and replacing damaged or missing cells. Accordingly, using fat grafting as an adjunct to tendon repair seems to be a promising concept **(8).**

Despite ongoing concerns about the survival and longevity of fat grafts post-implantation and the unpredictability of long-term outcomes, autologous fat grafting has been successfully utilized in various clinical scenarios. Challenges such as partial graft resorption and variability in volume retention persist; however, advancements in harvesting and processing techniques have enhanced graft viability. Clinical applications continue to expand, underscoring the procedure's versatility and effectiveness **(9).**

there is an abundance of literature supporting the efficacy of fat grafting in both aesthetic and reconstructive cases, including reconstructive breast surgery, reconstruction of retractile and painful scars, burns, as well as radiation dermatitis **(10).**

A. Fat harvesting

It is widely accepted that less traumatic methods of fat harvesting result in increased adipocyte viability and fat graft survival. Several techniques have been proposed for fat harvesting, and there is an ongoing debate in the literature as to which method produces more viable and functional adipocytes. The main techniques are vacuum aspiration, syringe aspiration, and surgical excision. There were experimental as well as some clinical studies supported direct fat excision over aspiration **(11).**

There are different natural fat deposits in the body; surgeons should identify the most suitable area after an accurate examination of the patient. The abdomen is the most common site of fat harvesting; the second is the trochanteric region (saddlebags) and the inside of the thighs and knees (**12).**

The harvesting of fat grafts can be performed via a “wet” method or a “dry” method. The “wet” method involves the injection of the donor site with a fluid solution (commonly referred to as Klein's solution) containing 0.9% NaCl, epinephrine, and a local anesthetic **(13)**. This technique causes hydrodissection and enlarges the target fat layer, thus facilitating the subsequent aspiration with decreased pain and ecchymosis **(14)**. It has been observed that low shear stress leads to improved graft survival; in fact, the shear stress exerted on harvested fat has been determined to be a factor affecting adipocyte viability **(15)**. Alternatively, a “dry” method without the tumescent fluid could be used. However, the “dry” technique may lead to a greater requirement for analgesics **(16)**.

Fat processing

The most commonly employed techniques for fat graft preparation include sedimentation, filtration, washing, and centrifugation. These processing steps are essential because lipoaspirate comprises not only viable adipocytes but also undesirable components such as blood, fibrous tissue, and cellular debris. These non-adipose elements may provoke inflammation at the recipient site, potentially compromising graft survival. In particular, the presence of blood can accelerate fat resorption, while injected debris may give a misleading sense of volume, as it is quickly reabsorbed postoperatively **(17).**

After the centrifugation, three layers are observed: the first layer includes lipids, which can be poured off using absorbent material; the second layer consists of fatty tissue; and the third layer contains blood, tissue fluid, and local anesthetic and is ejected from the base of syringe. The middle layer is routinely used for adipose tissue grafting (**Figure 1).** The identification of an optimal processing method will increase the number of viable cells and ultimately increase fat engraftment and retention over time **(18).**

Figure 1. Lipoaspirate after centrifugation. From top to bottom: First layer of lipids, second layer of fatty tissue, and third layer of blood and local anaesthetics **(19)**.

B. Fat injection

Despite a long history of clinical use and the evolution of fat-transfer techniques, no consensus exists on the best technique and the longevity of results, yet the principles of fat reimplantation are based on optimal recipient-site vascularity for increased fat survival. Through a skin incision of a size corresponding to the diameter of the cannula, the fat graft is inserted at the level of the anatomical region affected. Small-gauge cannulas are thought to reduce trauma to the recipient site, thus reducing the risks of bleeding, haematoma formation, and poor graft oxygen diffusion. Because revascularization starts at the periphery, ischaemic time is longer in the centre of the graft. Therefore, fat reinjection in multiple small-volume sessions is preferred over one single injection. Usually, through multiple access sites, multiple tunnels are created on insertion, but fat is injected only during withdrawal of the cannula in a "fanning-out" pattern. Fat grafts are distributed in small aliquots and fanned out to varying depths in the soft tissue to avoid excessive interstitial pressure at the recipient site and overcrowding of the transplanted adipocytes **(20).**

Over the past two decades, fat grafting techniques have evolved significantly—from basic free transfers of intact adipose tissue, which were often inconsistent in correcting volume deficits, to advanced strategies involving free composite fat-cell transplantation. When executed correctly, these modern approaches offer not only reliable volume restoration but also regenerative benefits to recipient tissues. Current research highlights the role of adipose-derived stem cells (ASCs) in enhancing tissue repair and regeneration, attributing their efficacy to the secretion of bioactive molecules such as cytokines and growth factors that support angiogenesis, reduce inflammation, and promote tissue remodeling **(21).**

➢ **Adipose-derived stem cells (ADSCs)**

Adipose-derived stem cells (ADSCs) are adult multipotent, mesenchymal stem cells located in adipose tissue that have recently become popular in the field of regenerative medicine for cell-based therapies. ADSC can undergo self-renewal, differentiate into other types of cells, such as tenocytes and myocytes, and also secrete many growth factors themselves. They are easily harvested via liposuction in large quantities with very little donor site morbidity **(22).**

At the present time, some international legislations, such as the UK legislation, prevent the use of stem cells in clinical practice so "fat grafting: without further processing is considered the next best alternative. It is clinically already widely utilized by plastic surgeons for soft tissue reconstructions and aesthetic procedures **(19)**

Types of fat grafting:

The classification of fat grafts into macrofat, microfat, and nanofat has revolutionized modern fat grafting by enabling clinicians to customize procedures based on target area, functional goals, and aesthetic outcomes. These categories correspond to different levels of adipose tissue processing, particle size, and cellular composition, making them suitable for a range of clinical applications—from volumetric augmentation to skin regeneration. Recent studies highlight the critical role of processing techniques, adipose-derived stem cells, and injection strategies in determining graft success **(23).**

1. Macrofat Grafts: Traditional Volume Restoration

Macrofat grafting refers to the use of relatively unprocessed lipoaspirate, typically harvested with larger cannulas (3–4 mm), retaining larger adipose clusters. This form of fat is widely applied in areas requiring significant volume restoration, such as the gluteal region, breasts, or cheeks. Although macrofat provides structural bulk, it is prone to lower survival rates due to limited diffusion of nutrients into the center of large fat lobules, leading to central necrosis and cyst formation if not properly handled **(24).**

Recent improvements in harvesting and reinjection techniques—such as using multi-level, small aliquots and blunt-tip cannulas—have helped mitigate complications. Studies now emphasize the importance of injection technique and recipient site vascularity in enhancing macrofat graft survival, rather than relying solely on graft volume **(25).**

2. Microfat Grafts: Structural Grafting with Better Integration

Microfat refers to adipose tissue that is refined into smaller particle sizes (approximately 500–1000 µm) through gentle centrifugation or filtration, without damaging the adipocytes. This type of grafting is primarily used in facial contouring, periorbital rejuvenation, and hand reconstruction, where precision and soft contouring are essential.

Unlike macrofat, microfat allows for better cellular integration, improved revascularization, and a more natural aesthetic result. Microfat retains viable adipocytes and a significant number of adipose-derived stem cells (ASCs), contributing to both volumetric correction and tissue regeneration. Studies have shown that microfat grafting can be used effectively in cases of facial lipoatrophy, scarring, and radiation-induced skin damage **(26).**

3. Nanofat Grafts: Regenerative Therapy Without Volume

Nanofat is an emulsified and filtered form of lipoaspirate that contains no intact adipocytes, but is rich in stromal vascular fraction (SVF), including mesenchymal stem cells, pericytes, and growth factor-secreting cells. First described by Tonnard et al. and subsequently refined in technique and clinical application, nanofat is used for skin rejuvenation, scar revision, and regenerative therapy, rather than for volumizing purposes **(27).**

Mechanically processed nanofat is injected superficially (e.g., intradermally), and studies show significant improvements in skin texture, elasticity, pigmentation, and vascularity. The regenerative potential is attributed to the high concentration of bioactive molecules and stem cells, which promote angiogenesis, collagen synthesis, and anti-inflammatory effects. Nanofat has shown promise in a variety of clinical contexts including periorbital dark circles, atrophic scars, and chronic ulcers, and is often used in combination with PRP or microneedling for synergistic effects **(28)**.

Type	**Particle Size**	**Adipocyte Content**	**Stem Cell Content**	**Main Use**	**Clinical Benefit**
Macrofat	Large (>1000 µm)	High	Moderate	Buttocks, breasts, cheeks	Structural volume replacement
Microfat	Medium (500–1000 µm)	Moderate–high	Moderate–high	Face, hands, contouring	Better integration, smoother contour

Nanofat	Small (<100 µm)	None	High (SVF-rich)	Skin rejuvenation, scars, pigmentation	Regeneration, angiogenesis, anti-aging

Table 1. Classification of fat graft types based on particle size, cellular composition, and clinical application. The table summarizes the key differences between macrofat, microfat, and nanofat in terms of their physical properties, biological content, and therapeutic use in aesthetic and regenerative procedures **(29).**

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