Liporeinjection of Fat, Nanofat, and Stromal Vascular Fraction

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KEYWORDS

• Facial plastics • Fat transfer • Nanofat • Stromal vascular fraction

KEY POINTS

- Evolution of autologous fat transfer (AFT) has advanced from simple volume restoration to a regenerative cornerstone in facial plastic surgery, driven by improved understanding of adipose tissue biology.
- Adipose tissue acts as a dynamic endocrine and paracrine organ, with adipose-derived stem cells and stromal vascular fraction mediating angiogenesis, collagen remodeling, and dermal rejuvenation.
- Technological innovations of closed, sterile processing systems such as Puregraft, REVOLVE, Lipocube, and Tulip Nanofat enhance graft viability, standardization, and safety while minimizing contamination and operator variability.
- AFT bridges aesthetic refinement with regenerative medicine, offering both volumetric restoration and biologically driven skin rejuvenation.

INTRODUCTION

Over the past 2 decades, autologous fat transfer (AFT) has solidified its role as a fundamental technique in modern facial plastic and reconstructive surgery. Initially valued for volumetric restoration, its application has expanded to address the multifaceted nature of facial aging, which involves not only soft tissue descent but also underlying bony resorption and compartment-specific fat atrophy. By replenishing volume and restoring structural support, fat grafting effectively mitigates the aged, deflated appearance and has proven reliable for effacing deep rhytids, refining contours, and improving overall facial harmony. The perception of facial volume is intrinsically linked to youthfulness and vitality, making AFT a powerful tool for achieving natural-looking rejuvenation[1] (**Fig. 1**).

Autologous fat has many good qualities that make it an ideal filler. It is fully compatible with the body, easy to get from the patient, and can blend well with the body's own tissues. Far from being an inert energy depot, adipose tissue is now recognized as a complex organ that has hormone and immune functions.[2] This stromal vascular fraction (SVF), particularly the population of adipose-derived stem cells (ADSCs), secretes a potent array of growth factors and cytokines including vascular endothelial growth factor (VEGF), fibroblast growth factor (FGF), and hepatocyte growth factor (HGF) that promote neovascularization, modulate inflammation, and stimulate collagen synthesis, thereby contributing to improved skin quality and graft survival.[3]

Significant advancements have been made in standardized processing systems such as the REVOLVE, Puregraft, and Lipocube platforms, which use filtration, washing, or controlled centrifugation to purify and concentrate viable adipose components. Contemporary success is thus predicated on a meticulous protocol that emphasizes gentle harvesting with low-pressure aspiration,

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Abbreviations

ADSCs	adipose-derived stem cells
AFT	autologous fat transfer
ASC	Adipose-Derived Stem Cells
IL	Interleukin
PRP	platelet-rich plasma
SVF	stromal vascular fraction
TGF-β	transforming growth factor-beta
TNF-α	tumor necrosis factor-alpha

thorough processing to eliminate detrimental elements, and the precise, layered deposition of small aliquots of fat into well-vascularized recipient sites.

STROMAL VASCULAR FRACTION

SVF is a heterogeneous cellular population derived from adipose tissue, is comprised of ADSCs, endothelial cells, pericytes, macrophages, lymphocytes, and a diverse array of secreted growth factors and cytokines. The pluripotent ADSCs within this fraction possess multipotent differentiation capacity.[3] Concurrently, endothelial cells and pericytes play a critical role in facilitating angiogenesis, thereby ensuring the delivery of oxygen and nutrients to regenerate tissues and the removal of metabolic waste. Immune constituents, including macrophages and lymphocytes, contribute significantly to tissue repair processes through the secretion of key signaling molecules such as tumor necrosis factor-alpha (TNF-α), interleukins (IL-1, IL-6), and transforming growth factor-beta (TGF-β), which are instrumental in stimulating cellular proliferation, differentiation, and migration.[2,3]

Brzezienski and colleagues showed 6 months following SVF transplantation, standardized imaging analysis revealed no alterations in pigmentation or melanin production. However, the treatment induced significant structural improvements, marked by increased skin density and dermal thickness. Preliminary clinical outcomes were satisfactory, with an absence of serious side effects including erythema, edema, ecchymosis, tenderness, or cyst formation. Correlative data further suggested that the observed thickening of the dermis was associated with enhanced blood perfusion at the dermal-subcutaneous junction.[4] Behrangi and colleagues preformed a case-control study specifically investigated the effect of SVF on acne scars. Findings indicated that epidermal, dermal, and complete skin thickness significantly improved from baseline in both the intervention (SVF + nanofat) and control (nanofat only) groups over one and 3 months. However, no significant difference was found in these thickness parameters between the 1-month and 3-month time points within either group. An intergroup comparison revealed that the SVF-treated group achieved significantly greater dermal and complete thickness after just 1 month. Critically, while sonographic (structural) improvements were noted in both groups, the SVF group demonstrated more rapid and pronounced visible

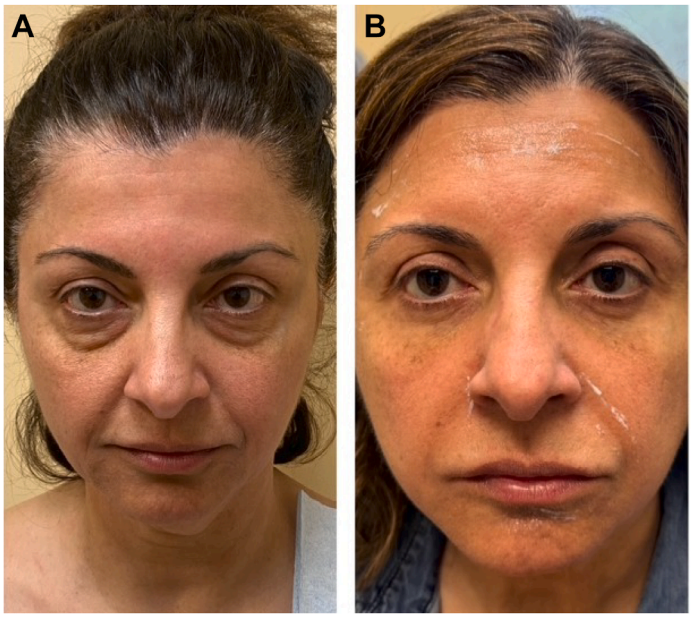

Fig. 1. Patient with fat grafting to her tear trough deformity and nasal labial fold for facial rejuvenation.

(apparent) cosmetic improvement. The study concludes that SVF acts as a potent complement to nanofat therapy, primarily by accelerating and enhancing the visible appearance of scar repair.[5] In a prospective, double-blind, randomized trial by van Dongen and colleagues, 40 mammoplasty patients received injections of SVF in one breast and a placebo in the other, serving as an intrapatient control. The results demonstrated that SVF significantly improved wound healing and reduced scar formation at the 6-month postoperative assessment. However, this beneficial effect was transient, as no noticeable advantage was observed at the 1-year follow-up.[6]

Yin and colleagues investigated the hypothesis that SVF enrichment could enhance both the survival and aesthetic outcomes of fat grafting. In a randomized trial of 50 patients, both the group receiving SVF-assisted fat grafts and the control group receiving fat grafts alone showed significant postoperative improvement in most skin quality indices. However, the SVF-enriched group demonstrated quantitatively superior improvement in wrinkles and skin texture. The proposed mechanism involves the SVF's endogenous induction of key growth factors (FGF, VEGF, and transforming growth factor [TGF]), which subsequently stimulate fibroblast activity and collagen production. These findings indicate that the combination of adipocytes and SVF significantly enhances the efficacy of facial rejuvenation therapy.[7] Research on fat graft enrichment using adherently cultured, pure adipose-derived stem cells (ASCs) demonstrated significantly improved graft volume and retention compared to nonsupplemented controls. Importantly, the long-term safety profile was comparable, with major complications occurring at similar rates in both ASC-enhanced and conventional fat grafting groups.[8] Van Dogen and colleagues analyzed the adjunctive use of SVF in facial lipofilling procedures supplemented with platelet-rich plasma (PRP) did not confer any measurable benefit to skin quality, aesthetic recovery, or patient satisfaction. Objective assessments revealed no significant differences between groups in parameters such as spots, pores, texture, vascularity, or pigmentation at any follow-up point. Notably, the absolute number of wrinkles was lower in the control group (PRP alone) at 12 months. Furthermore, the procedure itself, whether with or without SVF, did not yield a statistically significant improvement in any skin quality parameter from preoperative baselines. While patient satisfaction with overall facial appearance improved, this positive outcome was attributed to the lipofilling with PRP rather than the addition of SVF.[9]

NANOFAT

Nanofat grafting has established a broad spectrum of clinical applications, demonstrating utility in scar repair, alopecia treatment, and general tissue regeneration, including breast augmentation. Its therapeutic potential is rooted in its rich content of adult stem cells and regenerative cellular components. These cells, derived from the adipose SVF, possess the capacity to differentiate into various lineages, such as adipocytes, osteoblasts, and chondrocytes, making them a valuable tool for targeted tissue restoration and structural remodeling. The prevailing processing method involves the mechanical emulsification of lipoaspirate by transferring it between connected syringes, followed by filtration to create a refined product capable of passing through fine-gauge needles (**Table 1**).

Clinical outcomes are promising, with some patients reporting improvements lasting up to 3 years, a benefit potentially linked to enhanced angiogenesis and graft survival in the aging dermal environment. A significant advantage of nanofat over its microfat and macrofat counterparts is its exceptional safety profile. Due to its liquid, nonstructural nature, it has not been associated with the severe complications sometimes seen with larger grafts, such as infections, granulomas, or cyst formation. The most reported adverse effects are minor and transient, including expected procedural sequelae like erythema, edema, bruising, and occasional mild hyperpigmentation. The consistent absence of severe or long-lasting adverse effects firmly supports nanofat's status as a safe therapeutic option in regenerative medicine.[10]

At the molecular level, nanofat is characterized by a rich secretome distinct from its microfat counterpart. Proteomic analyses reveal a significant enrichment of proteins involved in innate immunity, wound healing, and coagulation. Furthermore, nanofat contains uniquely elevated levels of key bioactive molecules, including coumaric acid known for its antioxidant and antimelanogenic properties as well as prostacyclin (PGI2), a potent vasodilator. This specific biochemical profile suggests a mechanism whereby nanofat grafting promotes tissue rejuvenation not only through its cellular components but also by enhancing local blood flow, reducing oxidative stress, and creating a regenerative microenvironment conducive to healing.[11]

Collective evidence indicates that nanofat therapy consistently enhances scar quality, particularly in the early postoperative phase across various scar etiologies including atrophic, acne, and postburn scars. These robust studies demonstrated significant improvements in scar appearance at 6 months but noted that these benefits were diminished by the

Table 1
Fat grafting size, collection method, and description

Fat Grafting Type	Size	Collection Method	Description
Macrofat	>2 mm	Harvested with larger Cannulas	Structural Fat used for nonfacial areas with cannulas ranging from 1.5–3 mm
Microfat	0.7–1.2 mm	Lipoaspirate passed through Screen sizer ranging from 0.1–1.2 mm diameter	Structural fat parcels able to be injected through cannulas ranging from .7 mm −1.4 mm
Nonfat	<0.7 mm	Emulsified Fat passed through 400–600 micron mesh repeatedly to become liquid consistency	Liquid product of matrix, stromal vascular cells, endothelial cells, deviod of actual adipocytes. Injected via 27 G needle or applied topically with microneedle channels

12-month mark. This suggests that the primary role of nanofat is to accelerate the initial maturation and remodeling of scars, leading to faster early improvement, rather than fundamentally altering the long-term final appearance.[12] Tenna and colleagues performed a combined therapy for nanofat and PRP effectively fills scars and promotes tissue regeneration, as demonstrated across all patient cohorts. While the adjunct use of fractional CO_2 laser resurfacing improved overall skin texture, it did not confer an additional advantage in increasing skin thickness. Statistical analysis confirmed no significant difference in dermal thickness between the group receiving the laser combination and the group treated with nanofat plus PRP alone. The therapeutic benefit was consistently observed regardless of scar morphology including ice pick, boxcar, or rolling varieties or initial scar severity.[13]

Akbari and colleagues conducted a 7-month postintervention revealed that nanofat grafting significantly improved fine facial wrinkles across all measured biometric parameters, including volume, depth, and area. The data indicated a particularly enhanced treatment effect for wrinkles that were more severe at baseline, with these deeper and larger-volume deficits showing the greatest degree of improvement. These objective measures, confirming significant reduction in wrinkle characteristics, correlate with the observed pleasing clinical outcomes.[14] Clinical improvements from nanofat grafting for facial rejuvenation became apparent within weeks and progressed for up to 6 months. Histologic analysis of treated skin revealed the structural basis for these effects: a significant increase in both the density of collagen and the quantity of elastic fibers within the superficial dermis. This regeneration was further supported by a marked rise in cellularity, primarily fibroblasts, and an enhanced vascular network. The positive changes occurred without inflammation or alteration to the epidermal thickness.[15]

LIPOREINJECTION

Reinjection of processed fat is commonly performed using needles or cannulas ranging from 14 to 25 gauge. From a biophysical perspective, injection through smaller-gauge needles subjects' adipocytes to greater mechanical forces. According to Poiseuille's law, resistance to flow increases exponentially as lumen diameter decreases. This is supported by observations of altered cell morphology following injections through 20-gauge and 22-gauge needles, changes not typically seen with larger 16-gauge or 18-gauge instruments.[16,17] However, the clinical significance of these morphologic changes remains uncertain, as previous analyses have not demonstrated a clear correlation between needle diameter and long-term graft survival.

Technical recommendations vary among experts. Coleman advocates using a blunt 17-gauge cannula with a 1-mL syringe, depositing minimal amounts per pass. Little has described a technique of microstructural fat grafting using a 23-gauge blunt cannula for reinjection, following harvesting with a lipoplasty infiltration cannula and washing without centrifugation.[18]

GAUZE ROLLING TECHNIQUE

The cotton gauze rolling technique is a common method for processing lipoaspirate, with Telfa (Johnson & Johnson, New Brunswick, NJ, USA) rolls being the most frequently used material. In this process, harvested fat is placed on the gauze and rolled back and forth using an instrument like a forceps, wooden tongue sticks, or scalpel handle. This action allows the gauze to absorb the excess

oil, tumescent fluid, and blood, leaving behind the purified, golden-colored fatty tissue. The entire procedure is relatively quick, typically taking 2 to 4 minutes (**Fig. 2**).

TULIP TRANSFER DEVICE

The Nanofat Tulip Transfer system (Tulip Medical Systems, San Diego, CA, USA) represents a significant advancement in regenerative aesthetics and facial plastic surgery, specifically designed for processing and delivering autologous fat in a highly refined form (**Figs. 3** and **4**). Unlike traditional fat grafting techniques, which primarily focus on volumetric augmentation, the Tulip system mechanically emulsifies and filters lipoaspirate fat into a liquid suspension rich in SVF and ADSCs, while eliminating most viable adipocytes. This results in nanofat, which is ideal for improving skin quality, texture, pigmentation, and elasticity rather than contour or bulk augmentation. The closed, disposable, and sterile design of the Tulip system minimizes contamination risks and standardizes particle size through microfiltration, ensuring consistent output suitable for intradermal injection via fine-gauge needles (27 G–30 G). The regenerative efficacy of nanofat processed via the Tulip system is largely attributed to its high concentration of ADSCs and growth factors, which exert potent paracrine effects.[2,3] Mechanical processing through the Tulip system enhances the bioavailability of these factors by disrupting adipose tissue architecture while preserving cell viability and function. Moreover, nanofat contains adipose-derived microvascular fragments and extracellular matrix components that further support tissue integration and regenerative processes.[11]

PUREGRAFT DEVICE

The Puregraft filtration system (BIMINI Healthtech, Plano, TX, USA) is a closed, single-use medical device designed for the purification of lipoaspirate in autologous fat transfer procedures. Available in a range of sizes (50 mL to 850 mL), it is engineered to accommodate both small-volume facial applications and large-volume reconstructive cases (**Fig. 5**). The system uses a specialized 74-micron internal filtering membrane, supported by an 800-micron outer mesh, to mechanically separate and retain viable adipocytes while efficiently removing contaminants such as erythrocytes, free lipids, and tumescent fluid. This process yields purified, transplant-ready adipose tissue within a clinically efficient timeframe of 10 to 15 minutes, minimizing graft exposure to air and potential external contamination.[19]

A key clinical advantage of the Puregraft system is its high efficiency in contaminant removal, consistently documented at more than 97%. This purification is achieved through gentle filtration rather than centrifugal force, which is theorized to better preserve the structural integrity of adipocytes and the biological activity of the SVF, including ASCs. This preservation of cellular viability and function is critical for graft survival, as the regenerative potential is heavily dependent on the presence of these progenitor cells to facilitate neovascularization and paracrine signaling. Peer-reviewed studies have demonstrated superior graft retention rates with Puregraft, reporting an average of 41% overall volume maintenance, which increased to 53% in patients under 55 years of age. This compares favorably to historical retention averages of approximately 32% associated with conventional centrifugation techniques.[19,20]

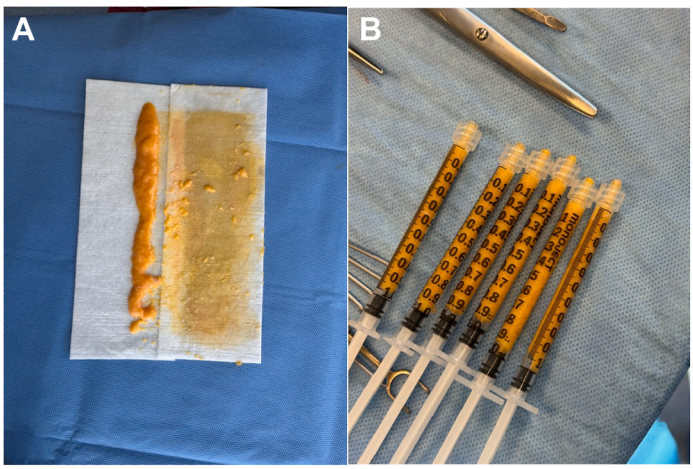

Fig. 2. Rolled gauze technique. (*A*) Harvested fat is placed on the gauze and rolled back and forth using an instrument like forceps, wooden tongue sticks, or scalpel handle. (*B*) Processed fat in 1 cc syringe ready for liporeinjection.

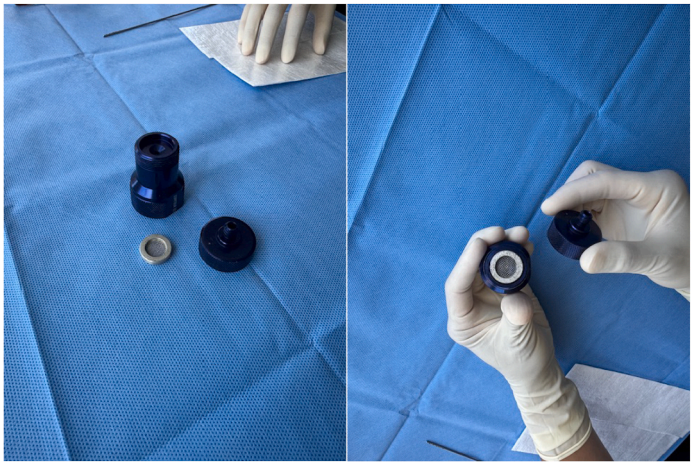

Fig. 3. Tulip system mechanically emulsifies and filters lipoaspirate fat into a liquid suspension rich in SVF and ADSCs, while eliminating most viable adipocytes. This results in nanofat, which is ideal for improving skin quality, texture, pigmentation, and elasticity rather than contour or bulk augmentation.

The purported benefit of gentle filtration over centrifugation lies in the avoidance of high gravitational forces and mechanical shear stress, which have been shown in vitro to induce adipocyte lysis and potentially diminish ASCs functionality.[16] By relying on size-based separation under low pressure, Puregraft aims to isolate intact, functional cellular components while purging elements that can incite inflammation and graft resorption. Furthermore, the closed-system design not only enhances sterility but also standardizes the processing protocol, reducing interoperator variability and improving the predictability of graft quality. This reproducibility is a significant asset in both clinical practice and research settings where standardizing the graft material is essential for evaluating outcomes.

LIPOCUBE DEVICE

The Lipocube system (Lipocube Biotech, London, UK) represents an integrated technological platform for processing autologous adipose tissue, designed to meet the demands of both regenerative medicine and aesthetic surgery. This system enables clinicians to process lipoaspirate into a range of specific graft formulations, including SVF, millifat, microfat, and nanofat, each tailored for distinct clinical applications. A fundamental advantage of the platform is its closed, sterile, single-use design, which standardizes the processing workflow, significantly minimizes the risk of contamination, and enhances overall procedural efficiency.[21]

The LipoCube SVF device employs a combination of controlled blade geometry, fluid dynamics, and centrifugation to mechanically isolate and concentrate regenerative cells from adipose tissue, producing a high-yield SVF suspension without enzymatic digestion. This allows for intraoperative reinjection of a cell-rich product. In contrast, the LipoCube Nano device mechanically emulsifies fat into an ultrafine nanofat graft, characterized by a high concentration of bioactive cells and growth factors but minimal adipocytes, making it suitable for intradermal injection and skin rejuvenation. The LipoCube Hybrid Mini integrates selective filtration with centrifugation to purify adipose tissue for volume restoration, completing the process in approximately 12 minutes. The primary benefits of the Lipocube ecosystem are its consistent production of high-quality, cell-rich grafts, which contributes to improved graft survival through enhanced revascularization and paracrine activity, all within a closed system.

REVOLVE DEVICE

The REVOLVE System (Allergan Aesthetics, Irvine, CA, USA) is a closed, single-use platform designed

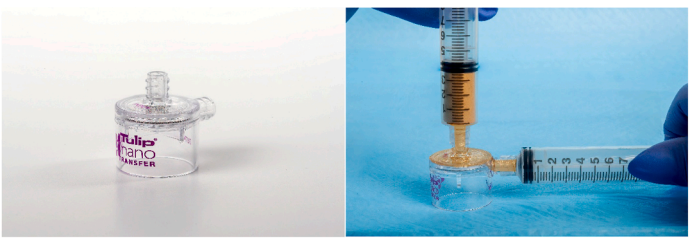

Fig. 4. 90° nanofat Tulip transfer system. (Puregraft®. Used with permission from Bimini Health Tech.)

Fig. 5. Puregraft's purification is achieved through gentle filtration rather than centrifugal force, which is theorized to better preserve the structural integrity of adipocytes and the biological activity of the SVF, including ASCs. (Tulip NanoTransfer™. Used with permission from Tulip Medical Products.)

to streamline the processing of autologous adipose tissue for grafting procedures. The performance of the REVOLVE System stems from its mechanical purification, which avoids the high gravitational forces of centrifugation that can compromise adipocyte integrity. By combining active washing with size-based filtration (200-μm mesh), the system selectively retains large, viable fat globules (>1000 μm) while eliminating aqueous waste and RBC debris.[22,23] This process preserves the stromal vascular fraction's vasculogenic mediators, such as VEGF and FGF, which are critical for graft revascularization and long-term retention.

Preclinical evaluations demonstrate that the REVOLVE System significantly enhances graft quality by preserving biological components. In vitro analyses reveal that REVOLVE processed tissue contains a higher concentration of viable adipocytes, SVF cells compared to decantation or centrifugation methods. REVOLVE grafts exhibited 85.6% fat content with negligible free oil (0.4%) and cellular debris, whereas decanted

Table 2
Different techniques and clinical applications

Processing Technique	Devices/Systems	Advantages	Limitations	Clinical Applications
Harvested with large cannulas, minimal processing	Coleman technique (centrifugation optional)	Structural support for volume restoration in nonfacial areas	Less suitable for fine facial injection due to larger parcel size	Gluteal augmentation, breast reconstruction, large-volume contouring
Filtered or sized through screens; gentle washing	Coleman microfat; Puregraft (filtration); Revolve (washing/ filtration)	Injectable through smaller cannulas, maintains structural adipocytes	Retention rates vary; requires vascularized bed for survival	Facial volumization, tear troughs, lips, temples, nasolabial folds
Mechanical emulsification and filtration into ultrafine particles (<0.1 mm)	Tulip system, Lipocube Nano	Rich in stromal vascular fraction and ADSCs; regenerative properties	Minimal volume effect; mainly regenerative, not structural	Skin rejuvenation, scar treatment, pigmentation, and wound healing

grafts averaged only 72.1% fat content.[23,24] This purification translates to improved biological activity. REVOLVE-processed fat showed 145.2% more viable adipocytes and 363.5% more SVF than decanted grafts, supporting enhanced regenerative potential 15. In vivo studies using rodent models corroborate these findings, with REVOLVE achieving 73.2% fat retention significantly higher than decantation (37.5%) and comparable to centrifugation (67.7%) while concurrently reducing inflammatory contaminants.[24]

SUMMARY

Autologous fat transfer has evolved significantly, establishing itself as a fundamental technique that extends beyond volume restoration to encompass regenerative applications. This progression reflects advances in the understanding of adipose biology, particularly the role of the SVF and ADSCs. Through paracrine signaling, these cells contribute to processes such as neovascularization, immunomodulation, and extracellular matrix remodeling, which support graft integration and improve outcomes in both aesthetic and reconstructive settings.

The introduction of specialized processing systems such as Puregraft, REVOLVE, Lipocube, and the Tulip Nanofat system has addressed historical challenges related to graft variability and retention. These systems employ distinct methods, including filtration, washing (**Table 2**), centrifugation, and emulsification, to purify and concentrate viable cellular components while reducing inflammatory debris. Autologous fat transfer continues to develop through integration of biological insight and technological innovation. Refined processing systems have enhanced the reproducibility and efficacy of fat grafting, supporting its expanded use in regenerative and aesthetic surgery. Ongoing research will be essential to optimize protocols and fully realize the potential of this versatile technique.

CLINICS CARE POINTS

- Stromal vascular fraction (SVF) enriched fat grafting may enhance early dermal remodeling and skin rejuvenation through angiogenesis, collagen synthesis, and paracrine signaling from adipose-derived stem cells. Clinical studies demonstrate improved dermal thickness, rhytids reduction, and accelerated scar remodeling, although some benefits may diminish over time.
- Optimal graft survival depends on atraumatic technique, including low-pressure harvest, meticulous purification, and layered placement of small aliquots into well-vascularized recipient sites. Removal of free oil, blood, and tumescent fluid may reduce inflammation and graft resorption.
- Nanofat functions primarily as a regenerative biologic rather than a structural filler because mechanical emulsification removes most viable adipocytes while preserving SVF and bioactive mediators. It is best suited for skin quality improvement, scar treatment, and fine rhytids, with a favorable safety profile and minimal long-term complications.
- Closed-system processing platforms such as Puregraft, REVOLVE, Lipocube, and Tulip Nanofat improve graft standardization, sterility, and contaminant removal while preserving stromal vascular fraction viability. Filtration and washing-based systems may provide superior graft purity and retention compared with traditional centrifugation or decantation methods.

DISCLOSURE

The authors have no disclosures or conflicts of interest to declare.

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