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Nano Fat Application in Treatment of Old Scars

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Abstract:

Nanofat is an innovative derivative of autologous fat grafting, extensively studied for its regenerative potential in both aesthetic and reconstructive plastic surgery. Unlike traditional fat grafts, nanofat is emulsified and filtered to eliminate mature adipocytes while preserving the stromal vascular fraction (SVF), which is rich in adipose-derived stem cells (ADSCs), growth factors, and cytokines. This biologically active component promotes angiogenesis, collagen remodeling, and tissue regeneration. Nanofat injections have shown promising results in facial rejuvenation, scar treatment, skin quality enhancement, and healing of chronic wounds. The simplicity of harvesting, minimal invasiveness, and autologous nature of nanofat make it a valuable tool in regenerative medicine.

Keywords: Nanofat, stromal vascular fraction, adipose-derived stem cells, regenerative plastic surgery, skin rejuvenation, fat grafting.

Introduction:

Nanofat grafting is a revolutionary technique in the field of plastic and reconstructive surgery, combining the volumizing benefits of fat grafts with the regenerative potential of adipose-derived stem cells (ADSCs). Unlike traditional fat transfer, nanofat is processed through mechanical emulsification and filtration, resulting in a fluid rich in stromal vascular fraction (SVF), which includes mesenchymal stem cells, endothelial progenitor cells, and growth factors. These components contribute to skin regeneration, angiogenesis, and dermal remodeling without adding volume, making nanofat particularly valuable in facial rejuvenation, scar revision, and chronic wound healing.

Recent studies have highlighted the biological activity of nanofat and its clinical applications. For instance, **Bianchi et al. (1)** demonstrated significant improvement in dermal thickness and elasticity following nanofat injections in periorbital rejuvenation. Additionally, **Svolacchia et al. (2)** reported enhanced healing outcomes and scar quality when nanofat was applied to post-surgical wounds.

Given its autologous nature, minimal donor-site morbidity, and high safety profile, nanofat represents a promising modality in regenerative aesthetic surgery and continues to gain popularity in clinical practice.

The concept of nanofat was first proposed many years ago, where the obtained particulate fat was extracted for mechanical emulsification followed by filtration to obtain SVF-gel rich in ADSCs. By repeating or improving this nanofat preparation method, researchers have successively reported the preparation techniques of nanofat. Studies indicated that all mature adipocytes in nanofat were destroyed **(3).**

Nanofat is rich in SVF and ADSCs, which can regulate neovascularization and tissue regeneration through paracrine effects or directly differentiate into adipocytes to improve fat graft survival rates and play an essential role in tissue repair and regeneration **(4).**

The intradermal use of nanofat for the treatment of superficial rhytids is highly recommended. Microfat and nanofat injections are typically performed concurrently. Microfat offers soft tissue structural support and filling effect, whereas nanofat enhances skin quality and promotes tissue regeneration in applications of scars, chronic wounds, and facial rejuvenation **(4).**

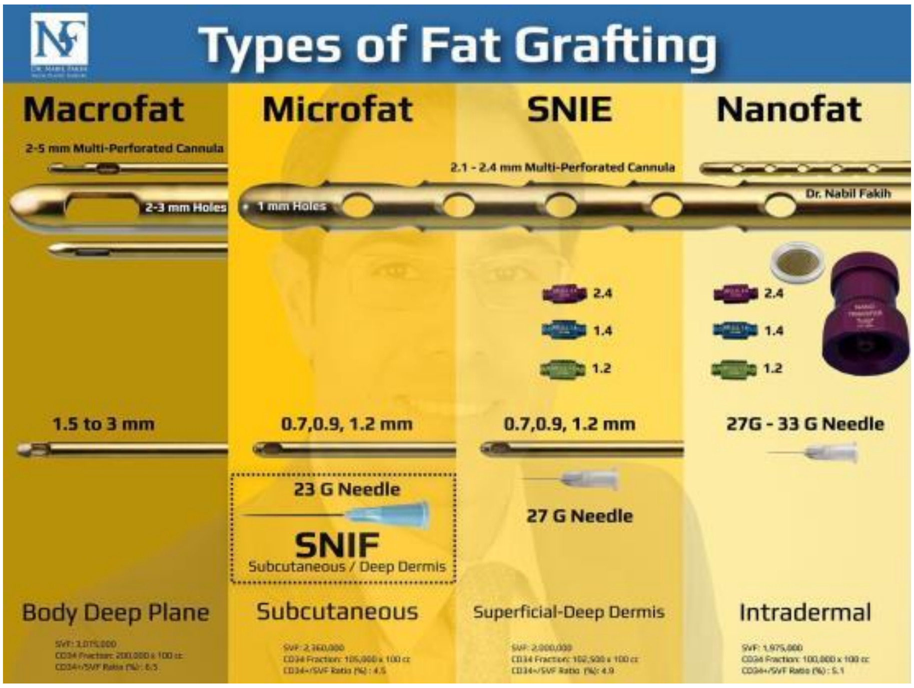

Figure (1): Types of fats grafting (5).

SNIF=Sharp needle intradermal fat

SNIE=Sharp needle intradermal emulsion

Fat harvesting:

Low negative-pressure lipoaspiration may yield fat faster than syringe aspiration and can be used when a large volume of fat is required, as in breast surgery. The high vacuum pressures of conventional liposuction may cause structural disruption in up to 90% of adipocytes. Cannula size may also affect the viability of harvested fat **(6).**

With a 3-mm, blunt-edged, 2-hole cannula connected to a 10-mL syringe, fat is suctioned manually by withdrawing the plunger. The cannula is pushed through the harvest site, as the surgeon uses digital manipulation to pull back on the plunger of the syringe and create a gentle negative pressure **(7).**

A combination of slight negative pressure and the curetting action of the cannula through the tissues allows parcels of fat to move through the cannula and Luer-Lok aperture into the barrel of the syringe. When filled, the syringe is disconnected from the cannula, which is replaced with a plug that seals the Luer-Lok end of the syringe. The plunger is removed from the syringe before it is placed into a centrifuge **(8).**

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. The harvesting of fat grafts can be performed via a "wet" method.**(9).**

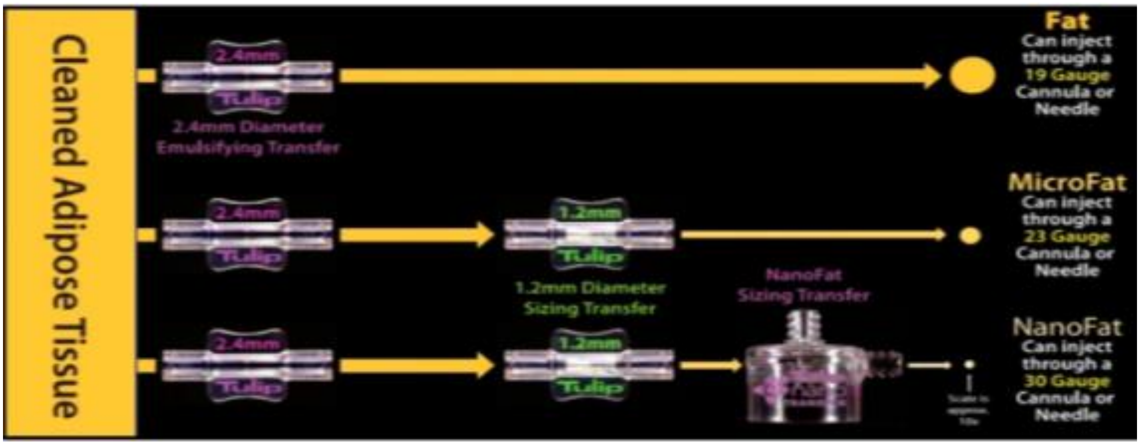

Figure (2): Harvested fat processing procedure sequence (10)

It has been observed that low shear stress leading improves graft survival; in fact, the shear stress exerted on harvested fat has been determined to be a factor affecting adipocyte viability. **(11).**

Fat processing:

The most commonly used methods to prepare fat grafts are sedimentation, filtering, washing, and centrifugation. Fat processing is necessary because lipoaspirate contains not only adipocytes but also collagen fibres, blood, and debris. These elements can cause inflammation at the recipient site, which can be detrimental for the fat graft **(12).**

Blood must be extracted because blood accelerates the degradation of the transplanted fat. Moreover, the injection of debris gives an erroneous impression of the volume of correction because the debris will be absorbed after a few hours **(13).**

Aspirated fat in syringes is spun at 3000 rpm for 3 min to isolate the fat. 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 anaesthetic and is ejected from the base of syringe **(9).**

The middle layer is routinely used for adipose tissue grafting. The identification of an optimal processing method will increase the number of viable cells and ultimately increase fat engraftment and retention over time **(7).**

Cotton gauze rolling is another commonly used method of isolating harvested fat graft, with Telfa (Medtronic) being the most popular choice of cotton gauze. Alternatives to Telfa include blue surgical towels or 4 × 4 gauze pads to absorb the undesired oil and aqueous components of the lipoaspirate. In this technique, the harvested fat is placed on top of the gauze. The back of a forceps, scalpel, or tongue depressor is used to roll the fat back and forth over the gauze. The excess tumescent and oil is absorbed in the gauze, leaving the cellular components of the fat graft behind. The harvested fat becomes more “gold” in color as the blood and other components of lipoaspirate are removed. **(14).**

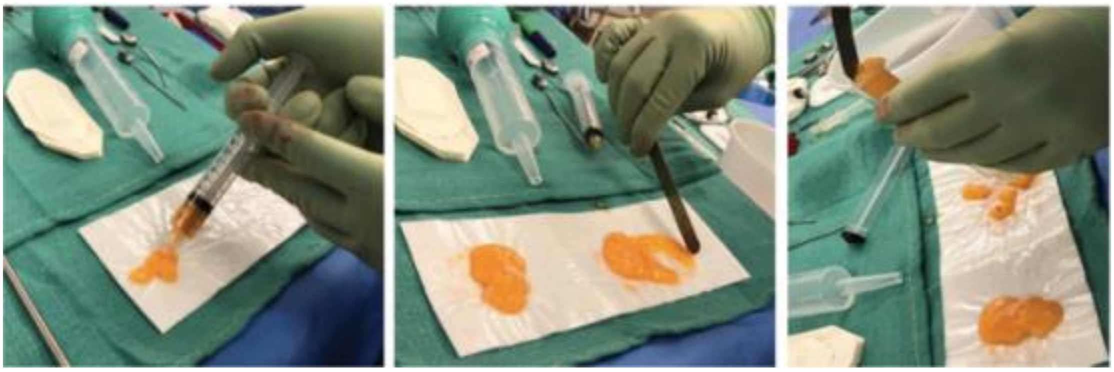

Figure (3): (Left) Placing the harvested fat onto Telfa. (Middle) Removing debris by rolling the harvested fat onto cotton gauze. (Right) Placing the processed fat into a syringe for fat injection. (14).

Lipoaspirate can be prepared through washing and/or filtration, which is usually performed through a closed system. Washing and filtration are not mutually exclusive and can be performed together or individually. Washing is generally performed multiple times with normal saline or lactated Ringer's solution (LR), whereas filtration occurs across membranes of various pore sizes, depending on the product used. As with the previously described techniques, the goal of washing and/or filtration is to eliminate contaminants such as oil, debris, and nonviable components while obtaining the highest concentration of viable ASCs and adipocytes possible. Some hypothesize that filtration is less traumatic compared with centrifugation and better able to remove free lipid and undesired cellular content from the fat graft. **(14).**

Figure (4): Fat graft washing and filtration using the Puregraft (left) and REVOLVE (right) systems. (14).

Puregraft (Cytori Therapeutics Inc.) and REVOLVE (LifeCell Corp.) are two commercially available, closed-system processors that combine filtration and washing for fat graft processing (Fig. 2). The Puregraft system comes in a rectangular dual filtration bag (50, 250, and 850 mL) with multiple afferent and efferent ports.The manufacturer's recommended LR wash volume as well as drain time increase as harvested lipoaspirate volume increases. The fat is harvested directly into the bag and washed with LR. The bag is then inverted to allow all corners of the bag to be infiltrated; drain fluid is then egressed through a pinch clamp. Approximately 250 mL of lipoaspirate can be harvested and processed within 15 minutes. **(14).**

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 **(11).**

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 **(12).**

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 **(15).**

Studies on fat-graft maintenance have demonstrated that mobile areas of the face, such as the glabella and lips, are less amenable to correction than are less-mobile areas, such as the malar and lateral cheek areas. Regarding the cannula size, several authors use different caliber cannulas for fat injection, and the nature of the recipient site is the major determinant in the choice of cannula size **(6).**

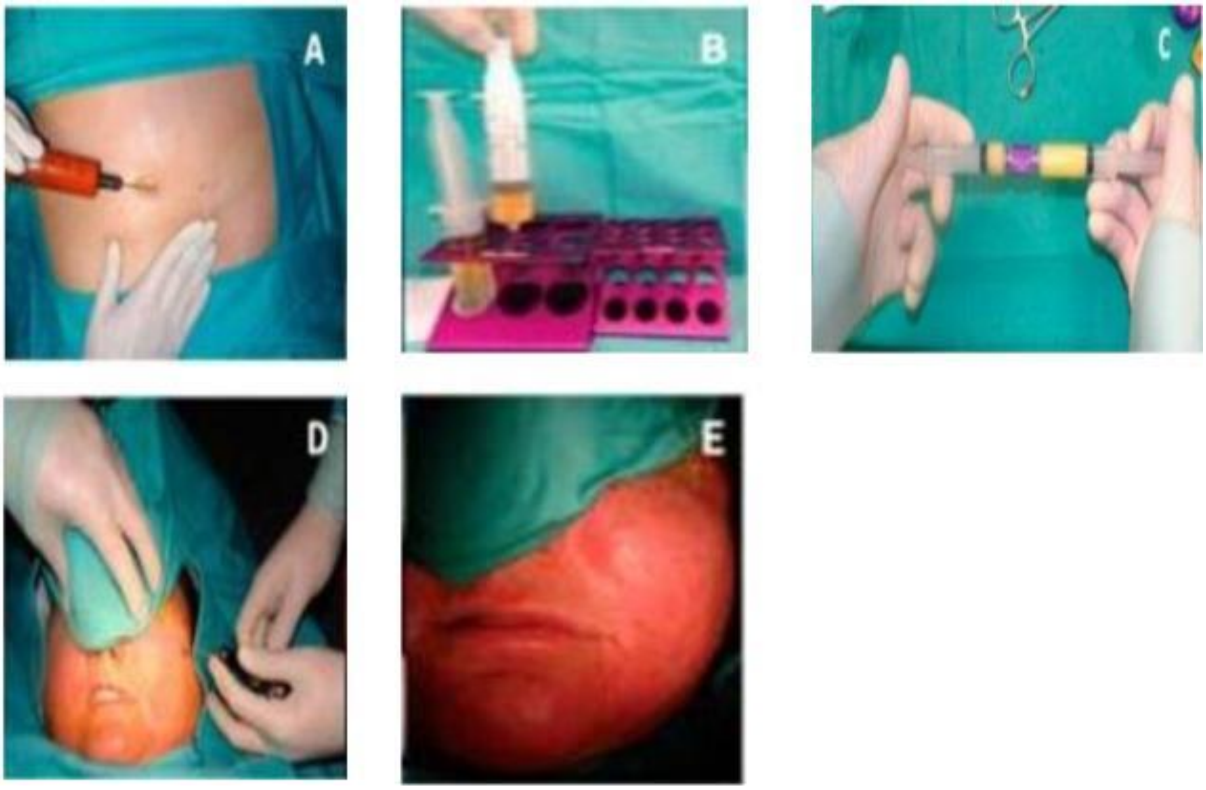

Figure (5): Fat collection from the abdominal region (A), fat decanting (B), fat processing (C), fat grafting (D), and the immediate postoperative state (E). (10)

Figure (6): This picture shows how adipose tissue is mechanically emulsified to obtain nanofat (4).

In 2013, Tonnard introduced the nanofat technique for skin rejuvenation. The technique can involve injecting nanofat grafts into various areas, including breast cleavage, glabellar skin, and perioral skin, as well as to treat dark lower eyelids, scars, and other conditions **(4).**

A 27-gauge needle is used for superficial intradermal and subdermal injection, and injection continued until a yellowish tint appeared. Discoloration typically resolves within a few hours after injection, and clinical outcomes improve progressively over time, peaking between 4 and 6 months after surgery **(16).**

No significant complications, granulomas, infections, fat cysts, or other adverse effects, although brief erythema lasting 1.5 to 2 days occurs when larger areas, such as the face or décolletage, are injected **(17).**

- **The Three Phases of preparing Nanofat:**

The most common method for obtaining nanofat involves shuffling lipoaspirate between syringes and filtering it to produce the nanofat product. The process of obtaining nanofat can be divided into three phases. The first phase is the fat harvesting procedure, which involves collecting fat from the lateral side of the thigh (preferably in females) (micro-nanofat), the medial side of the thigh, and the abdomen (the most reliable collection site in males) **(18).**

The collection site is treated by infiltrating a solution of 1% lidocaine and 1:100,000 adrenaline. The fat is collected using a liposuction cannula with 1 mm side ports, taking approximately 40–50 mL of aspirate. The second phase involves the emulsification of the fat, which is achieved by shifting the fat between two 10-cc syringes connected to each other **(19).**

Once the emulsification and filtering phase is complete, the resulting product is a translucent liquid that is rich in high-quality mesenchymal stem cells but devoid of any viable adipocytes. The final phase involves the injection of the nanofat product into the desired areas of the patient **(20).**

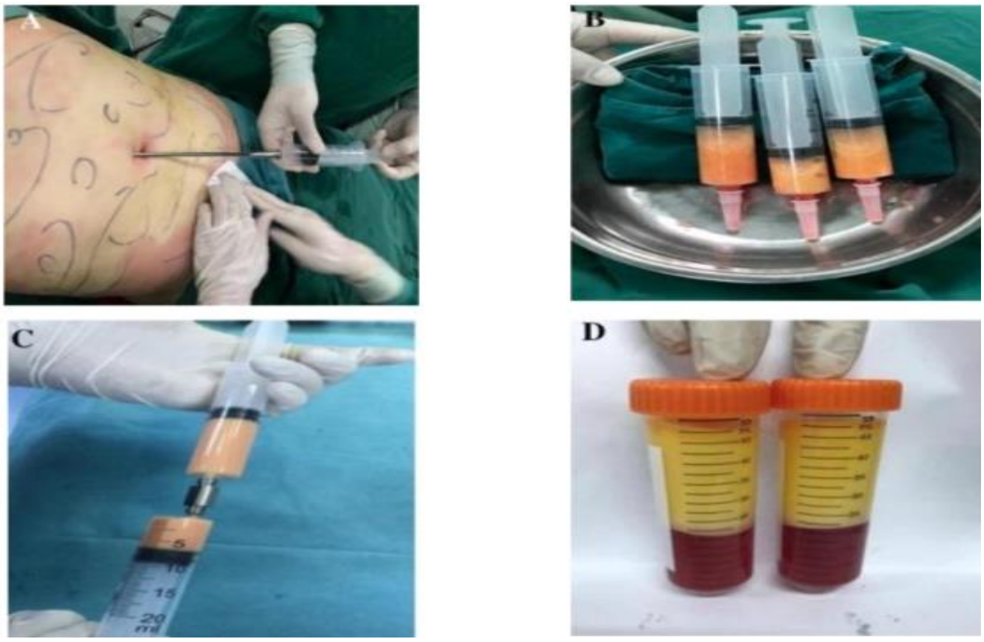

Figure (7): Process of extracting nanofat (21)

A- Harvesting of abdominal fat under negative pressure.

B- Vertical positioning of the fat to remove the underlying blood–water mixture.

C- Two 20-ml syringes connected through a Luer connector and passed through No. 4, No. 3, No. 2 and No. 1 connectors in sequence to emulsify the fat mechanically.

D- The upper layer containing oil, the lower layer containing the blood–water mixture, and the middle layer containing nanofat.

Applications:

Table (1): Application of fat grafting. (6).

Reconstruction surgery	**Aesthetic surgery**
1-Alopecia. 2-Breast reconstruction: Autologous fat transplantation is widely used in reconstructive breast surgery. Lipofilling represents a simple solution to restore the correct profile of the breast after reconstruction. 3-Scars. 4-Burns. 5-Radiodermatitis 6-HIV-associated lipodystrophy	1-Facial rejuvenation. 2-Hand rejuvenation. 3-Rhinoplasty. 4-Breast augmentation and asymmetry. 5-Gluteal augmentation.

Complications:

Every step-in fat transplantation, i.e., harvesting, processing, and transplantation, is important, but viability of the harvested fat cells is crucial. The chances of survival are higher the less the fat graft is manipulated and the more quickly it is reinjected. Donor-site complications appear to be minimal and related to the liposuction technique **(12).**

The possible complications include bruising, swelling, haematoma formation, paraesthesia or donor-site pain, infection, hypertrophic scarring, contour irregularities, and damage to the underlying structures for example due to the intraperitoneal or intramuscular penetration of the cannula **(13).**

Lipofilling could cause in the recipient site fat necrosis, oil cyst formation, and calcification if large volumes of fat are injected into a single area or if fat is injected into poorly vascularized areas. These changes result in the failure of "graft take" and lead to palpable masses due to fat necrosis. Post-lipofilling calcification can be found on mammograms **(7).**

The complications of lipofilling for hand rejuvenation may include cellulitis at the donor site, transient digital numbness, infections at both the recipient and harvest sites, cyst formation, temporary dysaesthesia, fat necrosis, and reabsorption of the grafted fat, which is the most common complication **(12).**

The major complications of facial rejuvenation by lipofilling are possibly attributable to the injection of fat grafts in "dangerous" areas such as the glabella and nasolabial folds. In fact, fat grafts may cause cerebral or ocular artery thrombosis, with an increase in local pressure, resulting in a reflux of the fat into the ophthalmic artery and the internal carotid artery **(22).**

To limit this risk and the risks of fat embolism and serious consequences, verification of an absence of blood reflux into the syringe prior to the injection, slow injection at low pressure, and the use of a blunt-tip cannula are recommended **(9).**

When lipofilling is used to correct the dorsum of the nose, surgeons should prevent a spike in local pressure that could propel a fat parcel upstream to the ophthalmic artery where it could occlude the central retinal artery and cause visual disturbance or blindness **(12).**

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