# 89. Fat Grafting

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## GENERAL PRINCIPLES

- Fat grafting is the free nonvascularized transfer of adipose tissue.
- It is used to correct soft tissue contour deformities.
- Successful long-term volume maintenance is the goal.
- The main drawback is **unpredictable long-term results** from graft volume loss over time.
- Current efforts investigate methods to minimize graft resorption and provide more long-term predictability.

**TIP:** Peer's "cell survival theory": The number of viable adipocytes at the time of transplantation correlates with ultimate fat graft survival volume.[1]



## FAT CHARACTERISTICS

- Fat grafting transfers adipocytes, preadipocytes, and surrounding stroma
- Adipocytes: Mature fat cells
- Preadipocytes:
  - Adipogenic precursor cells (stem cells)
  - Tolerate ischemia better than mature adipocytes[2]
  - Have the potential to differentiate into adipocytes and proliferate after grafting[2]

## INDICATIONS[3]

### BREAST[4] (Fig. 89-1)

- Contour irregularity after reconstruction or augmentation
- Primary breast augmentation with or without external tissue expansion[3]
- Micromastia, tuberous breast, or other congenital breast deformity
- Poland's syndrome

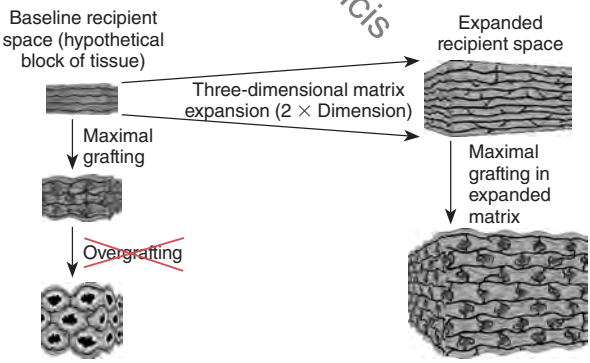


**Fig. 89-1** Megavolume grafting after expansion. The block of tissue is maximally filled with fat grafts, and then overfilled to crowding *(left).* The block is three-dimensionally stretched to show how many more grafts can be placed in the expanded and hypervascular space *(right).*

- Deformity following partial mastectomy
- Damaged skin resulting from radiotherapy[5]
  - Decreases collagen deposition
  - Attenuates thickened epidermis
  - Improves hyperpigmentation
- Nipple reconstruction

### FACE
- Lipoatrophy (HIV, drug-related, facial aging)
- Posttraumatic contour deformity
- Lip augmentation
- Malar augmentation
- Periorbital rejuvenation
- Nasolabial fold augmentation
- Depressed acne scars

### TRUNK
- Iatrogenic liposuction deformities

### GLUTEAL REGION
- Gluteal crease augmentation
- Buttock augmentation

### HAND REJUVENATION
- Dorsal hand rejuvenation[6]
- Dupuytren's contracture release[7]

### OTHER INSTRUCTIONS
- Penile enlargement
- Burn scar contractures
- Radiation damage[8,9]
- Congenital constriction bands



## PREOPERATIVE EVALUATION
- Patient expectations: Patient must be informed of the tenuous nature of fat grafting and the possible need for multiple procedures for desired cosmetic result.[10]
- **Extrinsic factors** can affect graft viability.
  - Smoking, nutritional status, sympathomimetic drugs, obesity, diabetes, COPD

## ADVANTAGES
- Safe
- Biocompatible, nonimmunogenic
- Avoids synthetic fillers
- Abundant, readily available
- Natural appearance

- Inexpensive
- Soft tissue contouring at donor site
- Low donor site morbidity

## DISADVANTAGES

- No uniform technique has proved superior for maximizing long-term results.[11]
- Amount of graft resorption is unpredictable.
  - A result of acute graft ischemia and failure of graft nutrition
- Results are highly technique dependent.
- Graft volume fluctuates with weight change.

## FAT HARVEST

- Atraumatic harvesting, handling, and transplantation correlates with higher long-term volume maintenance.
- Manual harvest (Coleman technique) results in higher percentage of viable adipocytes compared with conventional liposuction.
- Graft viability increases with the use of large-bore harvest cannulas and low pressure.
- **Coleman technique: Harvest**[6,12]
  - Small incision (~5 mm) placed strategically for broad access to donor site (Fig. 89-2)
  - Infiltration of donor site with 1:1 wetting solution (if under local anesthesia, 0.5% lidocaine with 1:200,000 epinephrine; if under general anesthesia, 1:400,000 epinephrine in lactated Ringer's solution)
  - Harvesting cannula[12] (Fig. 89-3): 3 mm diameter, 17-gauge lumen, 15 or 23 cm length, blunt tip; connected to a 10 cc Luer-Lok syringe
  - Cannula is introduced through the same incision made for infiltration.
  - Gentle back-pressure on the 10 cc syringe plunger creates a light negative pressure.
  - Cannula is advanced and retracted in long, even radial strokes through subcutaneous tissue.
  - After syringe is filled with subcutaneous tissue, cannula is removed from syringe, and a Luer-Lok plug is placed to prevent leakage.

**Fig. 89-2**

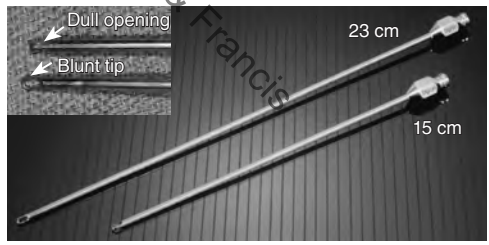


**Fig. 89-3** The harvesting cannula is usually 15 cm long. A longer cannula increases torque on the Luer-Lok aperture and can break the syringe tip during extraction.

- Suction-assisted fat harvest[13,14]
  - Fat harvest with liposuction has been reported as successful.[4]
  - A larger oil layer is often observed after suction-assisted fat harvest, indicating fat cell rupture.[13]
  - Fat cell viability correlates with amount of shear trauma, but does not correlate with pressure amount used to harvest.[15]
    - Therefore fat cell rupture is likely caused by mechanical shear trauma from travel through the suction circuit.
  - Suction provides a more efficient method of fat harvest in large-volume fat grafting, and larger lipoaspirate volumes can be harvested.

**TIP:** Maintain continuous negative pressure in the harvest syringe, with the plunger pulled back to the 2 or 3 cc mark.



## INFILTRATION TECHNIQUE BEFORE FAT HARVEST

- There is no benefit of donor site infiltration with epinephrine or local anesthetic on fat cell viability.[16]
- Infiltration with epinephrine-containing solution reduces blood loss and reduces blood fraction of harvested tissue.
- Wait 7-10 minutes after infiltration before harvest to allow maximal epinephrine effect.
- Some report reduced preadipocyte viability and impaired differentiation into mature adipocytes with use of local anesthetics.[17,18]

## DONOR SITE SELECTION

- Adipocyte viability not affected by choice of donor site.[19]
- Consider convenience of access and patient positioning.
- Consider possible need to enhance body contour at donor site.
- Consider patient request.
- Be aware of **zones of adherence** (Fig. 89-4).
  - Distal iliotibial tract
  - Gluteal crease
  - Lateral gluteal depression
  - Middle medial thigh
  - Distal posterior thigh

**Fig. 89-4**

**TIP:** Donor site selection depends mostly on positioning.

- Supine: Abdomen and medial thigh
- Prone: Back, flank, and buttock

## FAT PROCESSING

*Refinement of the harvested subcutaneous tissue into pure fat is crucial for predictable fat grafting.*

- **Three methods:** Centrifugation, washing, or sedimentation
  - All three techniques have shown equivalent results.[20]

### CENTRIFUGATION

- Ideal centrifugation is approximately 1500-3000 rpm for 2-3 minutes, but significantly lower G force centrifugation (15-20 G) has been reported as successful.[6,20,21]
- After 2-3 minutes no further separation occurs, and fat cell destruction takes place.[22]
- **Coleman technique: Refinement**[8]
  - The plunger is removed from capped 10 cc syringe, and syringe is placed in central-rotor centrifuge.
  - Syringe is centrifuged at approximately 3000 rpm for 3 minutes.
  - The harvested material is now separated into three layers (Fig. 89-5).
    1. **Upper layer:** Oil from ruptured fat cells
    2. **Middle layer:** Parcels of adipose tissue
       - Most viable adipose cells are consistently found at bottom of the fat layer.[22]
    3. **Lower layer:** Blood, water, lidocaine
  - The upper (oil) layer is decanted using a cotton pledget.
  - The lower (aqueous) layer is drained through bottom of the syringe.
  - Exposure to air is minimized to prevent dessication and fat cell lysis.

**Fig. 89-5** Harvested graft is separated into three layers by centrifugation.



### WASHING[23]

- Cleansing of the harvested graft removes cellular debris that invokes inflammatory response.
- Washing solution options are normal saline, 5% glucose, lactated Ringer's, or sterile water.
- Fat aspirate is mixed with washing solution in washing syringes.
- Syringes are placed upright until the fat layer separates from the aqueous layer, which contains blood and debris.
- Aqueous layer is removed, and procedure is repeated until supernatant is clear.
- Osmotic gradient created by the washing solution may affect adipocyte viability.[24]

### SEDIMENTATION, DECANTATION, AND STRAINING[24]

- Least traumatic method
- Harvested tissue allowed to sediment in the harvest syringe
- Can take up to 1 hour
- Can be combined with decanting of harvested tissue on an absorbent surface
- Aspirate can be strained through a cotton towel or finely meshed wire basket.

### COTTON-GAUZE ROLLING[25]

- Low trauma method of fat processing.
- Lipoaspirate is poured from the harvest syringe onto a nonstick, absorbent gauze.
- The fat is gently rolled and kneaded along the gauze with an instrument handle for 5 minutes.
- Aqueous and oil layers are removed nearly completely, but the stromal component is largely retained with this method.
- Reported as having the highest graft retention in vivo.

## FAT INJECTION

- **Cannula selection**[4,13] (Fig. 89-6)
  - 7 or 9 cm injection cannula
  - 17-gauge lumen
  - 1 cc or 3 cc Luer-Lok syringe
  - Tip types:
    - Blunt
    - Sharp: "Pickle fork"
      - Used to break up fibrous tissue

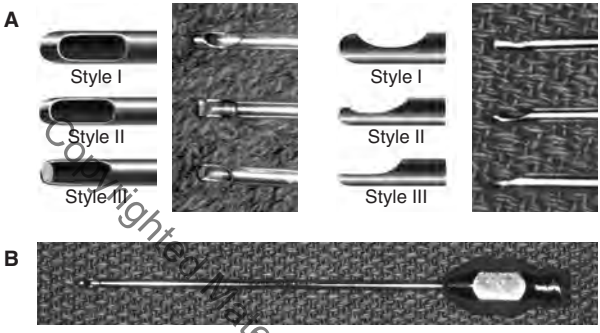




**Fig. 89-6** **A,** The Coleman style I cannula is completely capped on the tip and has a lip that extends 180 degrees over the distal aperture. The Coleman style II cannula is similar, with a lip that extends 130 to 150 degrees over the distal aperture. The Coleman style III cannula is flat on the end to allow dissection of tissues in specific situations, for example, when pushing through scars or fibrous tissue. **B,** Structural fat placement is usually achieved using a blunt 17-gauge cannula with one distal aperture just proximal to the tip.

- **Injection technique**
  - **"Structural" fat placement**[12]
    - Transfer refined fat tissue from the 10 cc harvest syringes into 1 cc (face) or 3 cc (body) syringe by injection into open barrel of injection syringe.
    - Place incisions for wide access to recipient site.
    - Advance cannula and inject on withdrawal.
    - Deposit in 0.1 cc aliquots to maximize surface area of contact with surrounding tissue.
    - Place fat in cross-hatched pattern using long radial passes from multiple directions.
    - Use digital manipulation to flatten clumps and minor irregularities.
- **Large-volume fat injection**[4,26]
  - Up to 4-6 L of regional fat grafting can be performed safely, but more commonly performed volumes include 200-300 cc per site.
  - 10 cc and 60 cc syringes are used for large-volume injections to increase efficiency.
  - Multiplanar radially oriented passes performed, but larger aliquots are deposited.
  - Large aliquot fat injections have better survival when injected intramuscularly.
  - Volumetric studies using Vectra imaging have shown better long-term fat retention when a larger volume of fat is injected.[27]
  - Survival of large-volume fat grafts is higher when combined with external tissue expansion.[3]

## GRAFT VIABILITY

- Grafted fat relies initially on plasmatic imbibition from surrounding tissue before neovascularization takes place.
- If graft aliquots are too large, central necrosis will occur.
- Maximum viable percentage of graft at 1.5 mm from vascularized margin is 40%.[28]
- Ideal fat graft aliquot is 3 mm diameter.
- Histologic zones of grafted fat[16]
  - **Peripheral zone:** Viable adipocytes
  - **Intermediate zone:** Inflammatory cells
  - **Central zone:** Necrosis
- **Graft success may correlate with the number of viable preadipocytes transferred with the graft.**
- Infusion of platelet-rich plasma (PRP) improves fat graft survival and neovascularization.[29,30]
- PRP reduces inflammatory reaction and reduces rate of oil cyst formation.[31]

## FAT STORAGE

- Tissue viability drops significantly with cryopreservation.[32]
- At room temperature, aspirated fat should be transplanted as quickly as possible.
- Fat cells begin to degenerate rapidly at 4 hours after harvest.[33]
- Controlled rate of freezing reduces cell destruction.
- Addition of a cryopreservative agent to improve adipocyte viability is controversial.
  - Most agents are cytotoxic.
  - Effect on metabolic activity is variable.
  - Adipose-derived stem cell yield is significantly less in cryopreserved fat than that obtained from fresh fat.[33]



## CLINICAL TECHNIQUES

- **The Coleman technique** (see pp. 1103-1104)
  - Popular method of atraumatic fat harvest, processing, and injection
  - Goal of this technique is to maximize graft take
- Breast augmentation with external tissue expansion[3,26]
  - The Brava system is an external tissue expansion system used in conjunction with fat grafting for primary breast augmentation.
    - External tissue expanders worn for 4 weeks preoperatively
    - Brava worn for 7 days postoperatively
    - Breasts are infiltrated with lipoaspirate through 10-14 needle puncture sites and fanned over a 3D pattern
    - Brava worn for 7 days postoperatively
    - Breast volumes increased by 233 cc per breast
    - Graft survival substantially higher when external tissue expander used (82% vs. 55%)
- **Facial fat grafting**[34]
  - Useful for rejuvenation of the aging face and correction of craniofacial disorders such as hemifacial atrophy
  - Facial volume loss is primarily due to loss of facial fat, therefore fat represents the ideal filler for the aging face
  - When combined with other facial rejuvenation procedures, superior cosmetic outcomes can be obtained

- Atraumatic manual fat harvest is performed with a 10 cc syringe and blunt cannula
- Purification is performed by rolling fat on absorbent nonstick gauze to minimize injury to adipocytes.
- Injection is performed using the Coleman technique.

■ Percutaneous aponeurotomy and lipofilling (PALF)[21]
- Used for subdermal scar release, congenital constriction band, radiation scarring, Dupuytren's contracture[7]
- Percutaneous "Rigottomies" (4-5 nicks/cm$^2$) with 18g needle releases the scar in a scaffold manner and the 3D matrix interstices are filled with lipoaspirate in microliter aliquots.
- Open, broad fasciotomies should be avoided to avoid large cavities where fat may collect and fail to revascularize
- Multiple stages required

■ Gluteal augmentation[4]
- Gluteal augmentation with fat grafting
- Harvest lipoaspirate with 4-5 mm liposuction cannula
- Strain fat through large metal strainer
- Large aliquot fat injections do better when injected intramuscularly than subcutaneous
- Inject fat with 2.4 mm cannula on a 10 cc syringe in subcutaneous space and a 3 mm cannula on a 60 cc syringe for intramuscular injection
- Total fat graft amount = up to 6-8 L
- Compression garment for 4-6 weeks, no sitting for 10 days, no pressure on buttock for 6 weeks
- 75%-80% fat survival



## APPLICATIONS IN IRRADIATED TISSUE

■ Fat grafting can alleviate the sequelae of radiation damage to skin and soft tissue.
■ Although not fully elucidated, the most likely mechanism is the effect of adipose-derived stem cells present within the stromal vascular fraction of the graft.[8]
■ After fat grafting, irradiated skin becomes softer and more pliable, with resolution of ulceration and improvement in scar index.[8]
■ Histologic and electron micrographic evaluation reveals progressive regeneration of tissue ultrastructure.[8,9,35]
- Reduction of epidermal thickening
- Decrease in vascular density
- Down-regulation of fibrotic response to radiation
- Restoration of collagen organization

## APPLICATIONS IN REGENERATIVE MEDICINE

■ Adipose tissue is a rich source of multipotent stromal cells that can be applied towards regenerative cellular therapy.
■ Two cell fractions containing multipotent cell lines can be derived from lipoaspirate[36]:

1. **Stromal vascular fraction (SVF)**
   - Heterogeneous mesenchymal cell population that includes adipose stromal cells, hematopoietic stem cells, endothelial cells, fibroblasts, macrophages, and pericytes

2. **Adipose tissue-derived stem cells (ASCs)**
   - ASCs have been shown to contain cell lines that can differentiate into adipocytes, chondrocytes, osteoblasts, myocytes, and cardiomyocytes.[37,38]
   - When compared with conventional lipotransfer, fat containing supraphysiologic concentrations of ASCs (cell-enriched lipotransfer) have a higher survival rate and more prominent microvasculature on histologic evaluation.[39-41]
   - The potential applications of cell-enriched lipotransfer are extensive. In addition to soft tissue augmentation, these include involutional disorders, radiation damage, and chronic wound-healing problems.[8]
   - Applications in other fields of medicine include treatment of inflammatory disorders, diabetes, neurologic disorders, and cardiovascular disease.
   - The ASAPS/ASPS joint position on cell-enriched lipotransfer is that scientific evidence on both safety and efficacy is limited.[42]

## POSTOPERATIVE CARE

- Compression garment at all times for 2 weeks, then at night for 2 weeks
- Edema minimized to prevent fat migration and resorption
  - Elevation and application of cold packs
- Swelling and bruising possible up to 4-5 months[6]
- Permanent results not seen until 6 months postoperatively
- Activity limitation
  - Massage or manipulation of grafted area is minimized for at least 1 week to prevent graft migration.
  - Full activity is resumed 3 weeks after procedure.



## COMPLICATIONS[43]

- **Fat resorption**
  - Reports of varying amounts of volume resorption over time
  - Six months needed to determine permanent results before repeating fat grafting
- **Aesthetic deformity**
  - Recipient or donor site
- **Graft size fluctuation with weight changes**
- **Fat necrosis and formation of calcifications**
  - Fat grafting to the breast may result in microcalcifications, which can be misinterpreted as sign of malignancy on subsequent mammogram.
  - This does not interfere with detection of malignancy if evaluated by an experienced radiologist.[44]
- **Pseudocyst formation**
- **Fat emboli**
- **Lipoid meningitis**
- Arterial **occlusion** leading to blindness, stroke, and skin necrosis[45,46]
  - Incidence is 7% of partial- or full-thickness skin loss.
  - Do not use sharp cannulas and needles when injecting the face.
  - Inject face with epinephrine to vasoconstrict surrounding arteries.
  - Limit volume of each injection to 0.1 cc per pass.

## Key Points

- ✓ Counsel patients regarding long-term unpredictability of fat grafting and the need for multiple procedures to obtain the desired cosmetic result.
- ✓ Graft success correlates with the number of viable adipocytes and preadipocytes transferred.
- ✓ Use an atraumatic fat harvest technique with a large-bore cannula and low-pressure system.
- ✓ Graft must be injected in small aliquots (0.1 cc) to maximize surface area contact with surrounding tissue.
- ✓ Avoid manipulation of grafted site postoperatively to minimize graft migration.
- ✓ Compression garments are essential to prevent graft migration, contour deformity, and seroma.
- ✓ Fat grafting to the breast does not interfere with malignancy detection if subsequent mammograms are evaluated by an experienced radiologist.



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