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STRUCTURAL FAT GRAFTS

The Ideal Filler?

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Many materials can be forced percutaneously through a hollow tube to add volume to a human face; however, most of the materials with low enough viscosity or low enough parcel size to be forced through a small diameter hollow tube (e.g., needle, trocar, cannula, catheter) have potentially harmful effects, seem unnatural after implantation, interfere with function, or are temporary.

Autologous fat grafts, using a syringe and cannula for placement, have been used as a soft-tissue filler since the early part of the last century. Fat, an autologous tissue, is one of the most biocompatible soft-tissue fillers. Placement by separating the parcels one from the other encourages longevity, promotes stability, and integrates the fatty tissue into the host tissues so that it is minimally detectable as a separate entity after placement. Fat grafted in this way is presented as a safe, long-lasting, natural-appearing, soft-tissue filler.

HISTORY OF INJECTABLES

Since the nineteenth century, physicians have experimented with injections of various substances to alter the surface contours of the human face. The earliest substances to gain wide acceptance for soft-tissue augmentation through a syringe were hydrocarbons, especially paraffin. In 1899, Gersuny[14] first reported that he had injected the scrotum of a young man with paraffin to replace resected testicles. He later reported the use of paraffin to correct facial contour defects. By 1907, Miller[12] described numerous uses of paraffin for the correction of imperfections of the face. In 1911, Kolle[10] wrote the earliest text devoted entirely to plastic and cosmetic surgery. He devoted over one fourth of his 497 pages to subcutaneous injections of paraffin into the face and body.

As the many complications of paraffin injections became obvious, injecting paraffin fell into disfavor. Aesthetic surgeons continued to use injection techniques to inject other substances. Rubber and purified latex (i.e., gutta perch)[11] became popular as injectable fillers in the 1920s.[13]

With each new substance tried, the invention was touted as the answer to soft-tissue augmentation. Invariably, some good results were attained; however, over time, harmful side effects or limitations invariably were encountered.

HISTORY OF INJECTABLE FAT

In 1926, Miller[11] described his experiences with infiltration of fatty tissue through cannulas. He reported good results with the injected fat, but the technique he described never became popular. Although physicians widely

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accept autologous tissues as safer for implantation than alloplastic materials, autologous fatty tissue harvested en bloc can be difficult to place through a cannula because of the solid, nonparticulate nature of most of the tissues.

The arrival of the technique of liposuction in the 1980s solved that problem. A byproduct of liposuction, the suctioned semiliquid fat could be reinjected through cannulas and needles. Since this semiliquid condition of fat became readily available, surgeons have renewed their interest in the grafting of autologous fat through a cannula and have experimented with myriad techniques for placement of this autologous tissue back into the face.[4, 9, 15] As with most new techniques, their experiments yielded variable results and many failures.

In 1987, after early success with grafting fat into iatrogenic liposuction deformities, the author began to place fat in the face for aesthetic reasons. Some of his earliest attempts at fat grafting yielded long-term structural changes that have demonstrated every indication of permanence.[6] Major alterations of the technique from 1987 to 1992 yielded more integration and stability of the grafted fat.[5]

PREPARATION FOR STRUCTURAL FAT GRAFTING

Planning is essential to obtain predictable results in facial recontouring. Before a plan can be developed, the surgeon should appreciate the patient's psyche, medical history, surgical history, and goals and expectations for improvement. By listening carefully to the patient's desires and inspirations, by asking him or her to bring in photographs of faces they consider attractive, and by discussing photographs and tracings of the patient's face with him or her, the physician can understand the personal aesthetics of each patient. This understanding enables the physician to devise an individualized strategy for helping the patient realize his or her aesthetic goals.

Combining the knowledge of the patient's goals with a three-dimensional (3D) awareness of the patient's physical appearance allows the surgeon to develop a realistic 3D strategy to satisfy the patient's expectations. Because structural fat grafting involves 3D increments that can be as small as 0.5 mm (rarely more than 3 or 4 mm), there is little room for error.

Improvement in the contours of a patient, however, is not enough for a successful result. If the patient is not prepared for the changes in his or her face or body, the postoperative course, or the possible complications, an otherwise successful procedure can become a disaster. Before the procedure begins, the patient should understand the details of the planned procedure, the expected outcome and postoperative course, his or her responsibilities during recovery, expected sequelae, and possible complications. The surgeon's investment in preparation can be equal to or more than the length of the procedure itself. Placement of any amount of structural fat into a patient's face or body should never be done spontaneously or as an afterthought.

STRUCTURAL FAT GRAFTING TECHNIQUE

The use of structural fat grafting for facial recontouring previously has been described and is explained in this article.[5, 7] This method harvests small intact parcels of fatty tissue and refines them to remove the nonviable components. Gentle positive pressure propels the harvested fatty parcels through a cannula much smaller than the harvesting cannula to place parcels of fatty tissue in a manner that allows nutrition and structural integrity in the host tissues.

Harvesting Technique

Strict sterile technique always is observed. Donor sites are selected to improve body contour and avoid deformities. Anesthesia is chosen depending on the individual case. With general anesthesia or epidural, Ringer's lactate solution with 1:400,000 of epinephrine is infiltrated bluntly into the sites for harvesting through a stab incision. If only a limited amount of tissue is to be harvested, local anesthesia is used with infiltration of 0.5% lidocaine (Xylocaine) with 1:200,000 epinephrine.

A two-holed blunt cannula is connected to a 10-mL disposable Luer-Lok (Becton Dickerson and Co., Franklin Lakes, NJ) syringe. The entry portal of the cannula is large enough to allow admittance of fatty tissue parcels of a size that then will pass through the lumen of the Luer-Lok syringe. Suction created by slowly withdrawing the plunger of the 10-mL syringe aids the curetting action of the cannula.

Transfer and Purification Technique

After disconnecting the Luer-Lok syringe from the harvesting cannula, the tip is covered with a cap. The plunger of the syringe is extracted, and the capped 10-mL syringe is placed into a sterilized sleeve in a sterilized central rotor of a centrifuge. Spinning the syringes at approximately 3000 rpm for 3 minutes separates the harvested material into three layers. The top layer primarily is composed of oil from ruptured parcels of fat. The lowest layer almost entirely is composed of blood and lidocaine (Xylocaine) or Ringer's lactate solution. The middle layer primarily consists of usable subcutaneous tissue.

By leaving the cap on the syringe after removing it from the centrifuge, the vacuum is maintained to allow decanting of the top oil layer. The cap then is removed, and the aqueous, dense lower level is allowed to drain. Nasal packing is placed into the remaining tissue layer to wick-off the remaining oil. After the oil and aqueous components have been removed, the remaining refined tissue is transferred into 1-mL Luer-Lok syringes.

Placement

Xylocaine (0.5%) with epinephrine is placed at the planned incision sites. One- to two-mm incisions are made with a No. 11 blade. If general anesthesia is used, no solutions are infiltrated into the recipient site. Otherwise, anesthesia is provided with a combination of regional nerve blocks and 0.5% lidocaine (Xylocaine) with 1:200,000 of epinephrine.

Infiltration of the local anesthesia into the recipient sites with a 25-gauge needle occasionally induces a hematoma. These hematomas dramatically can impede a surgeon's ability to place an appropriate volume smoothly. To avoid the formation of hematomas, the author uses blunt fat infiltration cannulas (e.g., Coleman infiltration cannulas [Byron Medical, Tucson, AZ]) for infiltration of local anesthesia.

The cannula used for placement of the fat is a 17-gauge cannula with an ejection aperture close to the distal end. The ejection portal is large enough to allow passage of the parcels of fatty tissue.

A cannula connected to a 1-mL syringe filled with refined fatty tissue is inserted through the incision site and is advanced to the target area. As the cannula is withdrawn, gentle digital pressure on the plunger of the syringe forces the fat out through the cannula. Only a small amount of the refined fat is expressed with each pass. At no time is strong positive pressure placed on the plunger. If any resistance is encountered, the cannula is disconnected from the syringe to inspect for the possibility of fibrous tissue or parcels too large to pass through the cannula. With appropriately designed harvesting and infiltration cannulas, this form of blockage rarely happens. The design of the cannulas also incorporates a blunt distal end to reduce the chance of damage to underlying structures (e.g., nerves, blood vessels, salivary glands). The length, shape, curvature, tip shape, and size of the cannula can vary to facilitate multiple technical considerations.

The most important single maneuver of this method is placing the fat in extremely small amounts with each pass and using multiple passes, which is the key to consistent results. The author rarely places more than 0.10 of a mL with a single pass, and for most passes, he deposits from 0.20 to 0.50 of a mL, which maximizes survival, integration, and anchoring of the transplanted fat.

POSTOPERATIVE CARE

Postoperative edema is the most consistent sequela of this technique. Hundreds of passes of a blunt cannula are needed for placement of the harvested tissue. The trauma of these passes results in remarkable tissue edema. For 36 to 48 hours postoperatively, cold compresses or ice packs are applied on all infiltrated sites. The patient is instructed to keep his or her head elevated above the heart. Three days after the procedure, the patient is instructed to massage selected areas.

Even with elevation, cold therapy and massage as aids in the recovery process, postoperative edema is still a major impediment. Two years ago, the author began using electromagnetic energy applied four or five times a day for 3 to 7 days postoperatively, which empirically has reduced the recovery time significantly.

DISCUSSION

Rationale For Technique

Harvesting, Refinement, and Transfer

The two most important factors for the harvesting and transfer phases of fat grafting are

to recognize the fragile nature of fatty tissue and to respect and maintain the tissue architecture of fat. The surgeon must acknowledge the fragile nature of human fatty tissue during every step of the procedure. Without human skin, fat easily can be damaged by mechanical maneuvers. For instance, fat tissue is not well equipped to handle the high negative pressures of extraction with a vacuum or the high positive pressures of placement. Exposure to dry air also rapidly causes the fat to desiccate.[1] The technique the author uses for harvesting, refining, and transferring fat was developed to minimize mechanical trauma to the delicate parcels of fat and to limit exposure to air during the harvesting and transfer phases. These activities potentially can violate the fragile fatty tissue that was never intended to survive unprotected by a human envelope.

Successful tissue transplantation of most tissues (e.g., skin, cartilage, corneas, bone) in humans requires that tissue architecture be maintained. With fatty tissue transplantation, tissue architecture must be respected. The fat should be harvested as an intact parcel that already is a size that can pass easily through a small cannula lumen to allow placement. The mechanical activities needed for reducing large parcel sizes so that they move through a smaller needle (e.g., straining, chopping, washing) potentially and fatally disrupt the fragile tissue architecture.

Placement of fat with a high percentage of nonviable components reduces the potential for accurate volume estimation. Most of the oil, blood, and lidocaine (Xylocaine) should be removed gently from the harvested tissue by sedimentation or centrifugation.

Placement

This technique emphasizes integrated placement of fat so that each parcel is separated as much as possible from the other transplanted parcels. The rationale for this separation of fatty parcels one from the other is that, first, it encourages the viability of transplanted fat. Secondly, this separation allows integration of the fat into the host tissues so that it is not palpable as a discrete entity. The method of placement also encourages anchoring of the fat parcels to the host tissue to discourage migration and to encourage structural changes.

Studies have demonstrated that as little as 40% of grafted fatty tissue is viable 1 mm from the graft edges at 60 days.[2, 3] Every parcel of the transplanted fatty tissue should be touching or within at least 1 mm of living, vascularized tissue to ensure a larger surface area of fatty tissue contact with vascularized recipient tissues. To maximize this area of surface contact, the parcels of fat should be as small as possible while maintaining tissue architecture and should be separated by a miniscule amount. Capillaries are small, so the distance between fat parcels does not need to be great. By placing small parcels in many passes, the surface area of contact is maximized, as is the potential for successful diffusion respiration, nutrition, and eventually vascularization of the fatty tissues.

Structural fat should be placed so that the desired shapes are formed during the placement of the fat. Because of the integrated manner of placement described, attempts at significant molding of the fat after placement are usually futile and can cause undesirable irregularities.

The author makes only a minimal compensation for fat that may be resorbed if damaged during transplantation; however, the injected material is not composed of fat entirely. Even after refinement, some quantities of blood, lidocaine (Xylocaine), or oil are present in the refined fatty tissue. The physician must take into account the volume of lidocaine (Xylocaine) used for local anesthesia, the edema caused by forcing a blunt cannula through living tissue, and the possibility of small hematomas. Some recipient areas of extreme motion, such as the mouth and glabella, may have a percentage of the infiltrate forced out postoperatively by motion. Initially, it is best to use small amounts of the infiltrate and to increase gradually with experience. Of particular importance is the use of 1-mL syringes initially to prevent overzealous augmentation. After becoming familiar with the technique, larger amounts can be placed in many areas.

The key to accurate volume placement is familiarity with the technique and the goals of the patient. After experience, the surgeon knows what 5 mL of refined fatty tissue do when placed into the cheek, lip, or chin. Five mL into a cheek may be too much for one patient and too little for another patient with the same defect.

Fat grafting is best suited for percutaneous placement into the subcutaneous and intramuscular layers. A layer also may be placed immediately superficial to the periosteum or perichondrium. Intradermal placement with

this blunt cannula technique is difficult and can cause unsightly visible isolated deposits of fat.

Complications

Complications with structural fat grafting mainly are related to aesthetic appearance. They most often are associated with the location, manner, and volume in which the fat tissue has been placed into recipient areas. These complications include overcorrection, undercorrection, visible irregularities, and migration of the placed fat.

Structural fat grafting shares potential complications with other surgical procedures. Infections usually are associated with intraoral contamination or breaks in technique. Although the cannula is blunt, damage to underlying structures, such as nerves, muscles, glands, blood vessels, and so forth, is possible. Complications associated with incisions and with the harvesting sites are also possible. The complication rate with fat grafting is low compared with most open surgical techniques, however, and the complication rate lessens dramatically with experience.

Indications

Fat grafting can be used for restoration of facial tissues that have atrophied from aging, acne, or disease and also can be used for replacement of tissues lost by accident, infection, or surgery. Fat grafting is particularly suitable for correction of some depressed scars (Fig. 1) and the depressed element of chronic acne scarring. Fat grafting can adjust facial proportion to increase the size of one facial part relative to the rest of the face. The lips (Fig. 2) or the cheeks, eyelid, and forehead (Fig. 3) can be increased in size.

The combination of well-shaped facial components that have a harmonious proportion with each other makes a face attractive. These are the differences in our society between aged, youthful, healthy, sickly, attractive, and not so attractive faces.

Ideal Soft-Tissue Substitute

Fat harvested, refined, and placed in the fashion described in this and other articles has many qualities that make it appropriately considered by a physician as the best choice for a soft-tissue filler.

Biocompatible (Safe)

A material for implantation must not endanger the health of the patient in whom it is injected. A patient's own fat that has not been contaminated by the addition of other substances or microbes should be nontoxic to the patient and to the local tissues. It should be resistant to infection after a period of implantation. Fat relies on its own volume for the volume displacement it accomplishes, unlike many other implants that rely on reactions such as tissue edema (e.g., collagen[8]) or scar formation (silicone) for their augmentation effect. Care should be taken concerning the areas into which the fat is placed because any volume placed into a muscle can alter function, such as muscle movement. Attention to the manner of placement and to the instruments involved in attaining the implant or the implantation should pose minimal threat to the health of the patient.

Nondetectable as a Seperate Entity (Natural)

Fat can be nondetectable as a separate entity after placement. Although a volume correction from structural fat augmentation should be obvious on photographic documentation, the changes fat grafts make when placed in the manner described usually appear and feel natural. Usually, the patient's face appears normal at rest and during motion. Many implants can be placed only next to bone or deep in a muscle but become obvious as a separate entity with superficial placement. Structural fat can be placed superficially and deeply into most levels of the face. The major advantage that injectable soft-tissue substitutes have over implants placed through an open incision (e.g., solid silicone, proplast, Gore-Tex [W.L. Gore and Associates, Flagstaff, AZ], hydroxyapatite) is that they have more potential to be integrated. If the injected substance is small enough to pass through a needle or cannula, it potentially may disperse into the host tissues, enough to be nondetectable as a separate entity.

Solid implants, whether autologous or foreign, are more distinctly palpable, especially when not fixed to bone.

Predictably Stable

Although fat appears to be stable in most cases after placement, care should be taken

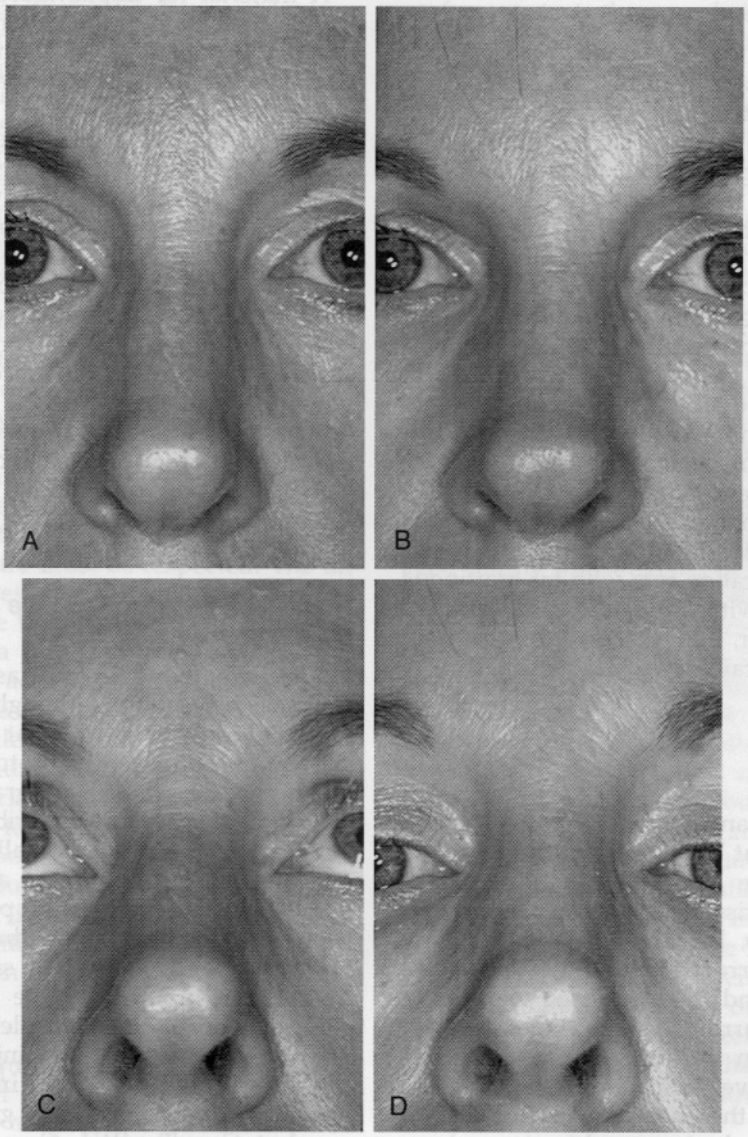

Figure 1. A 46-year-old woman with a depressed nasal scar. *A* and *C,* Before surgery. Note an old traumatic depressed scar running down the dorsum to the supratip. Two cm^2 of refined fatty tissue was infiltrated over the glabella, nasion, and down onto the dorsum of the nose. *B* and *D,* Twenty-one months after surgery. Note the widening of the glabella, nasion, and cephalad dorsum compared with the caudal nose. The depressed dorsal scar is almost invisible after subcutaneous filling. Structural fat can correct depressed scars and change the proportional relationship of facial parts.

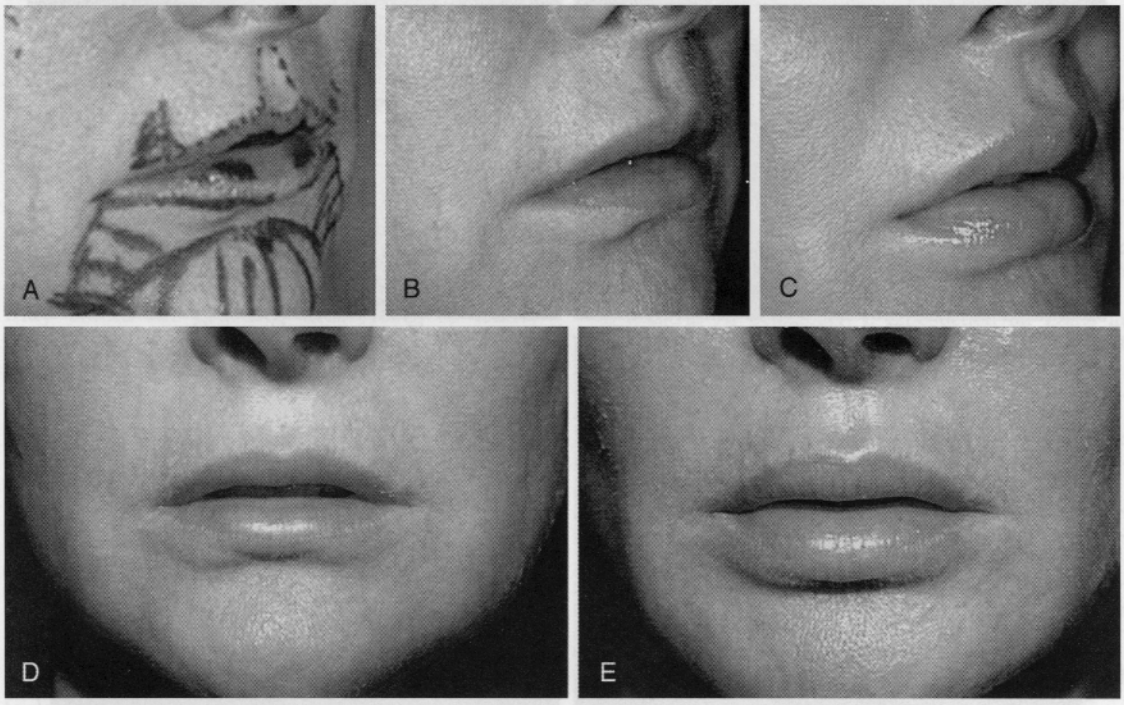

Figure 2. A 54-year-old woman desiring lip augmentation. *A,* Markings show placement of refined fatty tissue into the upper and lower lips. The surgical plan included injection with 2 cm^2 under the upper lip vermilion and mucosa, 1.1 cm^2 under the white roll, 1.4 cm^2 into the philtrum, and 6 cm^2 into the lower lip. Note the concentric circles demarcating the structural placement of the fatty tissue in specific shapes. Fatty tissue was also placed into the chin (30 cm^2) and nasolabial folds (2.5 cm^2 on each side). *B,* Before surgery (side view). *C,* Three years and 7 months after one infiltration. *D,* Before surgery (front view). *E,* Three years and 7 months after surgery. The only additional treatment the patient used was tretinoin (Retin-A Cream) beginning 1 year after the procedure. The fatty tissue changed not only the volume of the lip but also the shape.

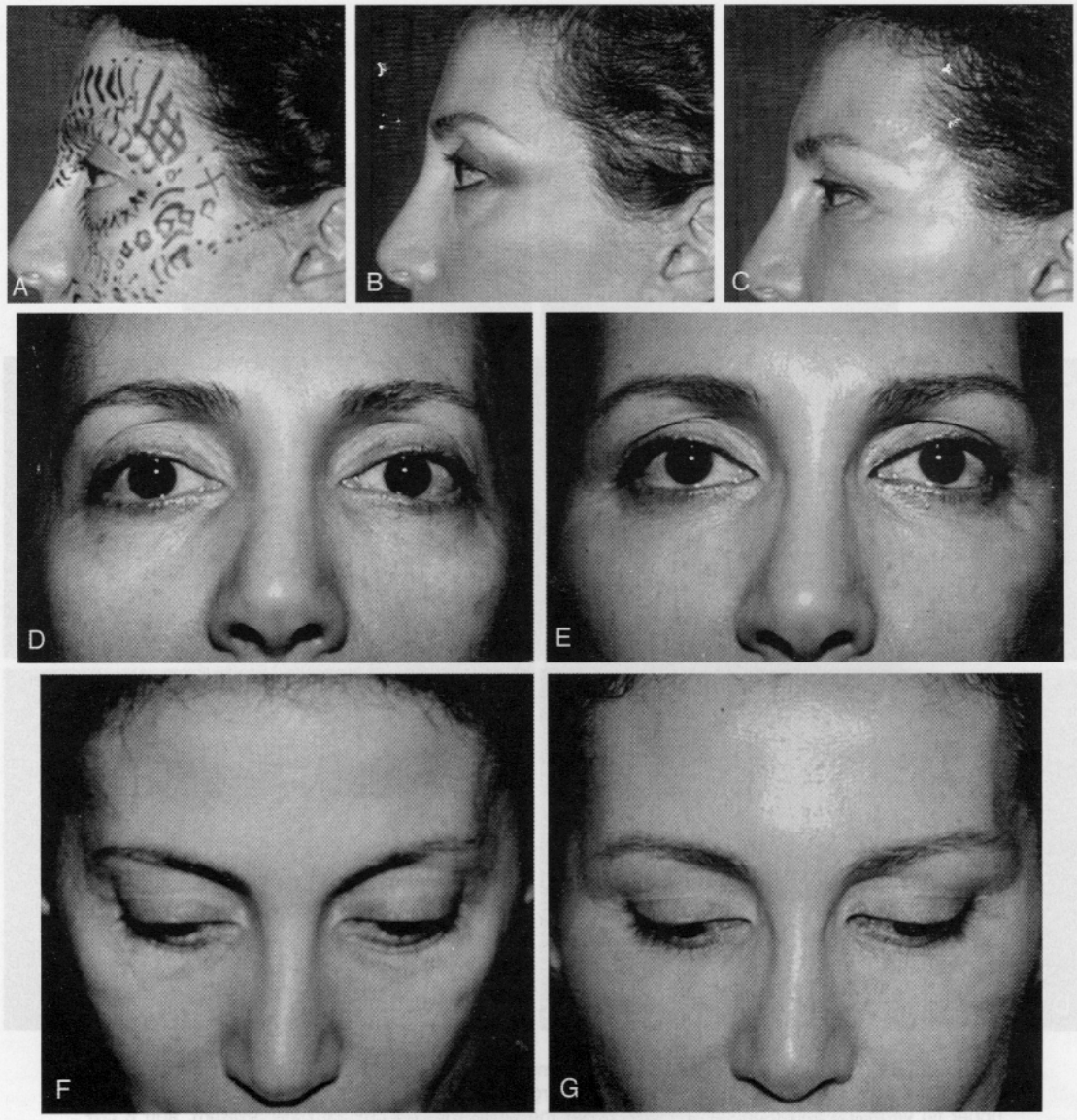

Figure 3. A 52-year-old woman with a remarkably proptotic appearance 2 years after an upper-lid blepharoplasty. *A,* Markings show the actual area of placement of fatty tissue into the following areas: 1 cm^2 of refined fatty tissue was placed into the glabella; 2 cm^2 into each upper eyelid; 2.5 cm^2 into each lower eyelid; 50 cm^2 over the entire forehead; and 15 cm^2 into each malar cheek. *B,* Before surgery (side view). *C,* Three years and 6 months after one procedure. Note raising of the cheek and lowering of the supraorbital contents. *D,* Before surgery (front view). *E,* Three years and 6 months after one procedure. Note the raising of the cheek into the orbital area and restoration of fullness to the supraorbital area. Filling of the entire periorbital region lessens the isolation of the globe from the orbital rims. *F,* Before surgery. *G,* Three years and 6 months after one procedure (tilted-down view). Note obvious filling of the skin below the eyebrow.

during the procedure and in the immediate postoperative period to avoid migration of the fatty tissue into surrounding tissues. Forcing too much of the fatty tissue into any area may cause it to move into an area with less pressure. Placing fat into some areas of intrinsic muscular motion, such as lateral to the corrugators, may precipitate migration from the area of placement. Large fluctuations in weight also may be reflected in the implanted tissue with increases or decreases in size of the transplant. With the exception of the previously mentioned situations, in the author's experience, fat placed stably maintains its

shape and consistency over time and has every indication of permanence.

Convenience

Compared with other implants, fat grafts can be less convenient. The fat must be obtained through a surgical procedure. Like any technique in surgery, a certain amount of technical facility is necessary for the placement of fatty tissue, which may not be necessary with other injectables. There is a steep learning curve, and some patience is necessary to learn the new technique. A 3D ability to visualize structures is necessary, because the surgeon has no preformed implant that he or she can choose to decide the shape or volume of placement.

Fat grafting in this manner usually requires an enormous investment in planning, execution, and postoperative care of the patient. This investment in time for a soft-tissue filler may make fat grafting uninviting to many surgeons.

SUMMARY

In the search for injectable subcutaneous fillers, fat harvested, transferred, and placed in the manner previously described has most of the characteristics of an ideal filler. It is biocompatible, versatile, stable, long-lasting, and natural-appearing.

The key to successful fat grafting lies in the technique. Harvesting, refinement, and transfer of subcutaneous tissue to provide pure, intact parcels of fat are essential for successful fat grafting. The surgeon also must infiltrate the refined fat parcels into the recipient site so that they survive predictably and uniformly, become integrated into the host tissues, and accomplish the desired structural alteration. The key to attaining these goals is the placement of minuscule amounts of fatty tissue with each withdrawal of the infiltrating cannula. This maneuver maximizes the surface area of contact between the newly transplanted tissues and the recipient tissues.

Applying this technique to enact structural volume alteration of the face can result in subtle or striking improvements in the appearance of patients. The ideal substance for soft-tissue augmentation still eludes physicians, but fat grafting through a blunt cannula seems to be the safest of all of the fillers used; in the hands of an experienced surgeon, it can provide long-lasting, natural-appearing structural changes.

References

1. Aboudib JHC, Cardoso de Castro C, Gradel J: Hand rejuvenescence by fat filling. Ann Plast Surg 28:559–564, 1992
2. Carpaneda CA, Ribeiro MT: Percentage of graft viability versus injected volume in adipose autotransplants. Aesth Plast Surg 18:17–19, 1994
3. Carpaneda CA, Ribeiro MT: Study of the histologic alterations and availability of the adipose grafts in humans. Aesth Plast Surg 17:43–47, 1993
4. Chajchir A, Benzaquen I: Liposuction fat grafts in face wrinkles and hemifacial atrophy. Aesth Plast Surg 10:115–117, 1986
5. Coleman SR: Facial recontouring with lipostructure. Clin Plast Surg 24:347–367, 1997
6. Coleman SR: Long-term survival of fat transplants: Controlled demonstrations. Aesth Plast Surg 19:421–425, 1995
7. Coleman SR: The techniques of periorbital lipoinfiltration. *Operative Techniques in Plastic and Reconstructive Surgery* 1:120–126, 1994
8. Fagien S: Facial soft-tissue augmentation with injectable autologous and allogeneic human tissue collagen matrix (autologen and dermalogen). Plast Reconst Surg 105:362–373, 2000
9. Illouz YG: The fat cell graft: A new technique to fill depressions. Plast Reconstr Surg 78:122–123, 1986
10. Kolle FS: Plastic and Cosmetic Surgery. New York, Appleton & Company, 1911, pp 209–338
11. Miller CG: Cannula Implants and Review of Implantation Techniques in Esthetic Surgery. Chicago, Oak Press, 1926, p 15
12. Miller C: The Correction of Featural Imperfections. Chicago, Oak Printing, 1906, pp 56–59
13. Miller CG: Experiments with Rubber and Gutta Perch in Esthetic Surgery. Oak Press, Chicago, 1926
14. Spira M, Rosen T: Injectable soft-tissue substitutes. Clin Plast Surg 20:181–188, 1993
15. Teimourian B: Repair of soft-tissue contour deficit by means of semiliquid fat graft. Plast Reconstr Surg 78:123–124, 1986

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