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ORIGINAL ARTICLE

The Facial Autologous Muscular Injection (FAMI) Procedure: An Anatomically Targeted Deep Multiplane Autologous Fat-Grafting Technique Using Principles of Facial Fat Injection

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Abstract
Background As widely described in the medical literature, facial fat grafting has been limited to the subcutaneous plane, with only vague reference to the muscular plane and deeper tissues. Local infiltration, with or without general anesthesia, is commonly used. The challenges of maintaining volumetric correction, symmetry, and predictability have limited practitioners' confidence in obtaining a desirable result when fat grafting the face. The authors describe a technique for facial fat grafting that targets specific anatomic structures and tissue beds, in effect making the patient's underlying anatomy the template for rejuvenation. Engrafting the muscles of facial expression improves graft retention and therefore predictability and symmetry. The ability to target anatomic structures other than muscle lends itself to the prospect of greater therapeutic advances using adipose-derived stem cells (ADSCs). A set of principles guiding the technique intended to promote successful cellular engraftment is presented.
Methods Three illustrative cases are presented, each the result of a single session: two from a 10-year experience of 700 patients by the lead author and one by the corresponding author.
Results The majority of cases (80–90%) needed only a single session for creation of permanent improvement in facial volumes and contours.
Conclusions The facial autologous muscular injection (FAMI) technique offers an anatomically based approach to facial fat grafting with greater predictability and efficiency than current techniques. The principles of the technique put forth apply equally to volumetric enhancements obtained through successful fat grafting and to the promise of ADSCs.

Keywords Anatomy · Face · Fat grafting · Stem cells

Recent articles [1, 2] and publications have shown that current techniques still apply a topographic, fundamentally artistic approach to facial fat grafting. Areas to be augmented are marked out according to their surface contours in a fashion similar to that used for artificial fillers.

As described by Coleman and Mazzola [3], small amounts (0.05–0.10 ml) of fat are placed using multiple passes (hundreds) to enhance the viability of the fat cells and to ensure even distribution. The grafts are administered primarily in subdermal layers without specific regard for the anatomic structures encountered by the cannula when deeper planes are engrafted. Substantial loss of the graft can occur because the subdermal plane is relatively avascular, making large volumes necessary and often leading to unpredictable graft retention. This leads some practitioners to adopt a strategy of dividing the engraftment over separate sessions [4, 5].

Facial autologous muscular injection (FAMI) was first introduced by Dr. Roger Amar [6] in 1997 after favorable evidence [7–9] and demonstration of long-term survival of thinly infiltrated fat into rat skeletal muscle by

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Guerrerosantos et al. [10]. At its inception, the technique sought to take advantage of the rich vascular plexus within the facial muscles to improve graft retention and thereby predictability and symmetry. Subsequently, the technique was extended to target precisely the deep (Bichat), intermediate (suborbicularis oculi fat pad, SOOF; retro-orbicularis oculi fat pad, ROOF; superficial temporal fat pad, STF); the superficial fat pads (Charpy's and malar); the superficial musculo-aponeurotic system (SMAS)/platysma; and the subperiosteum, in addition to the muscles of facial expression.

By systematically targeting the specific underlying anatomy responsible for the surface contours, in effect using the patient's underlying anatomy as a template, a natural restoration of youthful volumes can be achieved. Engrafting the facial muscles places the graft within a rich vascular plexus and may allow improved graft survival while requiring lower total volumes of autologous fat. In our experience, the result is that 80–90% of patients require only a single session to achieve a desirable result.

The use of sensory trigeminal and upper cervical branch block avoids the inevitable distortion of the anatomy that occurs with local or regional infiltration of anesthetic and obviates the need for general anesthesia. Motor nerve anesthesia can also induce a flaccidity that potentially contributes to muscle injury during cannulation.

Graft survival depends as much on the nature of the graft bed as on the viability of the cells to be seeded there. This has consequences for the techniques of graft implantation as much as for their harvesting and has led to a statement of principles regarding autologous fat grafting to the face that may apply to future stem cell therapies.

Methods

Instrumentation

In 1998, 10 reusable blunt-tipped, 18-gauge cannulas (1–4, 4A, 5, 5A, 6, 7, 10) were designed for the 12 paired (plus the orbicularis oris, procerus, and mentalis) muscles of facial expression (Fig. 1, Table 1). The blunt-tipped cannulas have seven main curvatures and three different lengths. They follow the skull curvatures, allowing the muscles to be injected from their origin to their insertion, or conversely. Cannulas 2, 3, and 6A are used for the fat pads. More recently, disposable cannulas have been developed to ensure sterility and to be lighter and more precise.

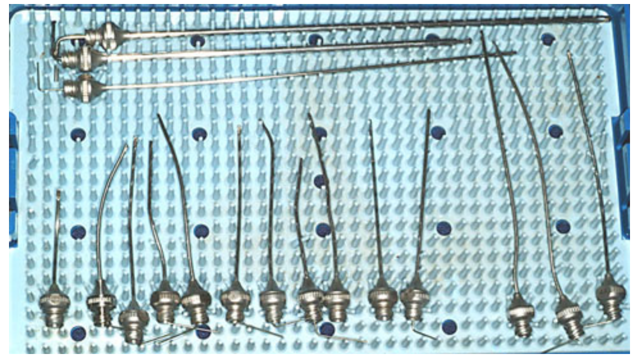

Fig. 1 Facial autologous muscular injection (FAMI) cannula set as listed in Table 1

Procedure

Most FAMI cases are managed as full-face procedures or otherwise divided into upper face, midface, or lower face procedures. The anatomic targets to be addressed are noted on a specially developed form that reflects the analysis of aging changes or other defects based on comparison with photographs from the patient's late 20s to early 40s. Facial movements that may reflect an anatomic variant are noted. A circulator records the graft volumes as they are administered. The injections are administered systematically level by level, from the deep fat pads to the facial muscles, followed by the intermediate fats pads and SMAS with the superficial fat pads, white roll, and finally, the philtrum.

Intramuscular fat injections use 1–2 ml per muscle in one to five passes, except for the procerus (0.5 ml), mentalis (up to 4 ml), platysma (up to 5 ml) muscles. Fat pads receive 1–5 ml in one to eight passes.

Harvesting

Diet-resistant donor areas are chosen with the patient in standing position. The most frequently chosen are the inner knees/lower inner thigh, outer thigh, and love handle regions. Klein's solution is infiltrated within the subcutaneous space and the deep supra-aponeurotic plane, leaving the central fat deposit relatively free of anesthetic solution. Lipo-harvesting requires a maximum of 200 ml to a net of 80–120 ml for engraftment, although most cases require less. Centrifugation at 3,000–5,000*g*, decantation, and transfer to 1-ml syringes is then carried out in standard fashion.

Anesthesia

Complete trigeminal sensory block using Naropin 0.5% (ropivicaine 5 mg/100 ml; Astra-Zeneca, Wilmington, DE, USA) is administered using no more than 10 ml. If platysmal bands are to be addressed, Klein's solution is infiltrated subcutaneously along the anterior border of the sternocleidomastoid muscle for 8 cm below the jawline to block the cervical nerve branches. Oral sedation alone can be sufficient for some patients (lorazepam PO and

Table 1 List the cannulas developed for a full-face facial autologous muscular injection (FAMI)

14 Cannulae	Target
Cannula no. 1	Levators labii superioris
Cannula no. 2	Orbicularis oculii and ROOF/Charpy's
Cannula no. 3	Risorius muscle and SOOF
Cannula no. 3A	Pillars of the cheeks
Cannula no. 4	Zygomaticus minor cheek part
Cannula no. 4A	Zygomaticus minor lip part and Cupid's bow
Cannula no. 5	Frontalis, buccinator, depressor anguli oris
Cannula no. 5A	Platysma and neck bands
Cannula no. 6	Corrugators and procerus
Cannula no. 6A	Temporal extension of the Bichat fat pad
Cannula no. 7	Depressor labii inferioris and mentalis, levator anguli oris (LAO)
Cannula no. 8	Malleable cannula for testing
Cannula no. 9	Dissecting solid tube for scar undermining
Cannula no. 10	Zygomaticus major and platysma origin

clonidine 0.1–0.2 mg are helpful adjuncts), but most patients require intravenous sedation to be comfortable. Sedation is needed primarily for administration of the blocks. The access port sites are given intradermal blebs of 1% lidocaine with epinephrine 1:200, 000.

Access Ports

Facial access ports are made with a tapered-tip awl, which minimizes any dermal bleeding and avoids the need for suture. These locations are relatively free of vessels and nerves, and from them, the clinician can enter the origin or the insertion of one or more muscle or fat pads (Fig. 2). They become invisible in 4–5 days.

Graft Placement

The appropriate cannula is attached to a 1-ml Luer-Lok syringe. Correct intramuscular placement after entrance of the muscle sheath is characterized by little or no resistance as the plunger is depressed. Injection is performed with each withdrawal for one to five passes in the plane and direction of the muscle fibers.

Cannulation of the zygomaticus major, for example, begins at its insertion in the modiolus by entry through the access port placed 2–3 mm lateral to the lateral oral commisure. A no. X straight (7.3 cm from tip to hub) cannula is advanced superolaterally within the muscle to its origin on the inferior aspect of the lateral maxilla, with injection of 1–2 ml during withdrawal in one to two passes.

The corrugator is approached from a port created at the central meridian of the hairline using a no. 6 cannula (10.5 cm with a bend near the tip) advanced in the subgaleal plane to enter the origin of the corrugator inferomedially to the superior orbital rim. Next, 0.5 ml of fat is

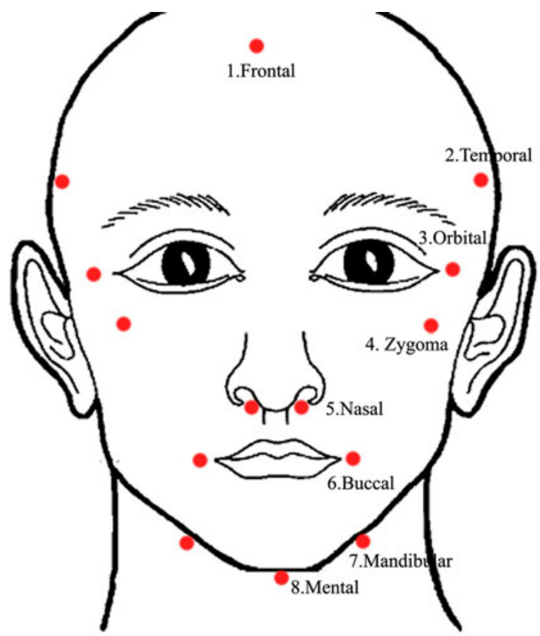

Fig. 2 Standard access port locations

injected before withdrawal and rotation of the tip along its axis approximately 100° laterally to inject 0.5 ml into its insertion in the medial brow. The access port for this injection is placed remotely to avoid introducing a sharp instrument near the supraorbital and supratrochlear vessels.

The depressor labii inferioris is accessed through a port at the inferior border of the mandible at the vertical oral commissural meridian. The cannula is double angled and 6.3 cm long. Angled down, the tip is pressed to the periosteum before it is advanced and rotated along its axis 180° to enter the depressor labii inferioris (DLI) deep to the origin of the depressor anguli oris, then advanced to its insertion in the vermilion. It is a broad and flat muscle that can accommodate up to 2 ml injected in three to five passes, distributing the fat evenly in the superomedial direction of its fibers.

Engrafting of the DLI is one step in restoring the volume of the lower lip that helps to address marionette lines. From the same access port, the depressor anguli oris can be engrafted using a curved no. 5 cannula. It enters the muscle in a more superficial plane relative to the DLI, and advancing superiorly and slightly lateral to the oral commissure before turning medially and superiorly deep to the superficial portion of the orbicularis oris; it deposits up to 2 ml in the lower part and up to 1 ml above the commissure, depending on volumetric indications. The objective is to lay down long, thin 2-mm-diameter threads of fatty tissue consistent with theoretical perfusion limits [11] and following the guidance of animal studies [12–14].

The fat pads can be grafted with more passes to distribute the volume of fat evenly into larger structures such as the Bichat and malar fat pads, or with as few as only a single pass for Charpy's fat pad. The angle and relative depth of the cannula can be variable in the fat pad, compatible with the idea of a more diffuse, layered infiltration. The superficial temporal fat pad, for example, is accessed via a port placed at the hairline marked by drawing of a horizontal line from the arch of the brow.

The no. 7 cannula is 7.2 mm long and double angled. As it is entered tip down, a pop is felt (and heard) as the superficial layer of the deep temporal fascia is pierced. The cannula is rotated 180° on its axis, and injection of 1–3 ml of fat can be placed in two to six passes. By using the longer no. 4 cannula (7.5 cm curved), the SOOF can be accessed by advancing in the same plane around the lateral orbital rim below the orbicularis oculi. The medial extent of the SOOF is encountered at the malar septum. A larger amount (up to 4 ml) can be distributed at this point. This is an important maneuver for malar and periocular rejuvenation.

The fibrofatty SMAS can be accessed from a preauricular port, with advancement in a more superficial plane heading inferiorly down toward the mandible. Generally speaking, the lower face provides relatively more muscle and the upper face relatively more fat compartments for anatomic targeting. Overcorrection could be acceptable for some patients with injection of the fat pads but is never used with the muscles. Acquired technical skill and a detailed knowledge of the anatomy are necessary for successful placement of the grafts using the FAMI technique.

Postoperative Care

Benzoin solution is applied to the access ports after the procedure, and the patient is asked not to wash his or her face for 3 days. The patient leaves the facility with gauze dressing on the donor sites but no dressing on the face. Bruising, if it does appear, is apparent on the first postoperative day, most commonly around the access ports and lower eyelids. Swelling reaches a peak on postoperative day 3 before subsiding rapidly over a variable period of 1–3 weeks. Patients take a 5-day course of antibiotics. Valtrex is used if indicated. Typically, only acetominophen or ibuprofen is needed for a day or two.

Results

A 12-year experience of 700 cases by the lead author has resulted in satisfactory to very good results for about 85% of the cases after a single session. Most of the remaining 15% have been disappointing due to factors that may have led to a better preselection of candidates for fat grafting including more laxity than desired (e.g., persistence of jowls), factors that interfered with harvesting of sufficient fat [e.g., low body mass index (BMI) or extensive prior liposuction], or differences in judgment of the result between the surgeon and the patient. One patient had persistent malar edema and festoons, and another patient experienced persistent facial swelling after an insect bite elsewhere on the body (a history of allergic sensitivity to insect bites had not been elicited before the procedure in this case). No infections occurred and no more than occasional minor bruising.

Case 1

Figure 3a shows a 58-year-old woman with atrophic aging changes. She had undergone subcutaneous malar fat augmentation 2 years before by another surgeon and was concerned that this procedure had not made her look any younger. She also regarded her cheek volumes to be out of balance with the remainder of her face.

Figure 3b shows the patient 2 days after a single full-face procedure that specifically spared the malar fat pads. No bruising is seen, and the amount of swelling is typical for the patient's age. Figure 3c shows the result 3 months afterward. The facial volumes are balanced around the prior augmentation, with filling of the temples, zygoma, upper lid sulcus, lid–cheek junction, jawline, perioral area, and lips. Reinflation of the brow fat pad has seemed to relax the frontalis muscle activity.

Restoration of the fossa temporalis and upper face volumes made the bizygomatic diameter larger than the bimaxillary angle diameter as in a younger person. Figure 3d shows the persistence of the result at 2 years.

Case 2

Figure 4a shows a 39-year-old woman with a left cheek deformity after a deep facial cellulitis of dental origin.

Fig. 3 **a** A 59-year-old woman with age-related facial atrophy. She had grafting to both malar fat pads 2 years previously by another surgeon and felt this left her with overly prominent malar mounds in relation to the remainder of her face. She received 70 ml of injected fat delivered as follows: frontalis 2 ml, procerus 1 ml, superficial temporal fat pad 4 ml, SOOF 6 ml, ROOF 2 ml, superior orbital orbicularis oculi 2 ml, corrugator 2 ml, zygomaticus major 4 ml, masseter 6 ml, Bichat fat pad 6 ml, zygomaticus minor 2 ml, levator anguli oris 3 ml, levator labii superioris 2 ml, philtrum 1 ml, depressor anguli oris 5 ml, depressor labii inferioris 3 ml, orbicularis oris 2 ml, platysma/submucosal aponeurotic system (SMAS) 11 ml, mentalis (including the transverse mentalis) 6 ml. **b** Postprocedure day 2 showing typical symmetric swelling with almost no bruising. **c** View 3 months after a single session showing filling of temporal hollows and upper lid sulci, with resolution of the "witch's chin." The bizygomatic diameter has been expanded to a more youthful dominance of the bimaxillary diameter. **d** View 2 years afterward showing persistence of the result, with less sun exposure than in **c**

Figure 4b shows the patient 1 year after grafting to the area with lower face augmentation. Figure 4c is a photo of the patient 2 years afterward. Some of the volume effect between 4a and b and c is due to generalized weight gain after restoration of normal dentition and the patient's ability to overcame depression related to her deformity.

Case 3

Figure 5a shows a 39-year-old woman who presented for revolumization to improve facial hollowing of her temples and cheeks. She had undergone Thermage treatment 5–6 months previously. Figure 5b shows her 2 days after her procedure, primarily targeting the temple and cheek anatomy. Figure 5c shows her result 8 months after her single session. She is smiling slightly. Figure 5d shows the persistent result at 2 years.

Figure 6 shows the effect of injecting the lip levators and depressors in the plane and direction of their fibers. Reestablishment of lip projection is shown without injection of the orbicularis oris or submucosal injection. In Fig. 6a, three of four quadrants have been injected,

Fig. 4 **a** 37 year-old woman with a cheek depression due to cellulitis of dental origin involving the Bichat fat pad, buccinator, and buccinator fat pad. **b** View 12 months after a single session. The woman received 23 ml of injected fat including: 1 ml to the right, and 3 ml to the left buccinator muscle; 1 ml to the mentalis; 1 ml to the left labii superioris; 1 ml to each rizorius; 1 ml to each zygomaticus major; 1 ml to each zygomaticus minor; 1 ml to the right Bichat, and 4 ml to the left Bichat fat pads; 1 ml to the right buccinator fad pad, and 3 ml to the left buccinator fat pad. Some of the general fullness of the face after the procedure is due to weight gain. **c** View 2 years after facial autologous muscular injection (FAMI) sent by the patient. Some loss of facial fullness has occurred due to moderation of her body weight, but the restoration of symmetry is intact

Fig. 5 **a** A 39-year-old woman who presented with hollowing of the cheeks and temples. She had received Thermage treatment 5–6 months previously. **b** View on postprocedure day 2 showing minimal bruising and swelling typical for a younger person. Characteristically, the bruising is in the lower lids. The woman received 50 ml of injected fat delivered as follows: corrugator 1 ml each, procerus 0.5 ml, Charpy's fat pad 2 ml each, frontalis 3 ml total, lateral brow and temple 2 ml each subcutaneously, SOOF 3 ml each, Bichat fat pad 3 ml each, levator labii origins 2 ml each, levator labii insertions 1 ml each, depressor labii inferioris 2 ml each, buccinator 3 ml each, white roll 0.5 ml for each quadrant, nasal tip 0.5 ml, masseter 1 ml each, and lateral platysma/submucosal aponeurotic system (SMAS) 2 ml each. **c** Result at 8 months showing a natural, symmetric fullness to the face. **d** Result at 2 years showing that the correction present at 8 months is substantially intact

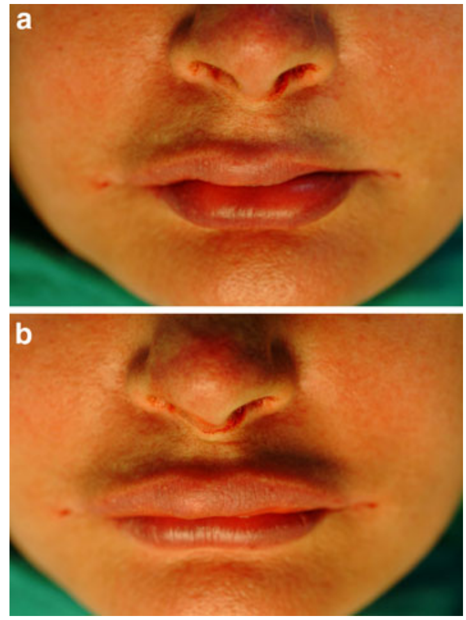

Fig. 6 **a** Lip injection by following the plane of the lip levators and depressors without injection of the orbicularis oris or the white roll. The left upper lip remains to be injected. The injected muscles included the levator anguli oris (LAO), levator labii superioris (LLS), levator labii and alaque nasi (LLSAN), and zygomaticus minor. **b** View showing result after injection of the left upper lip quadrant with a natural lip eversion

whereas in Fig. 6b, the left upper quadrant has been added. Revolumization of the anatomic structures that create the lip contours restores youthful projection.

Discussion

The most widely adopted fat-grafting technique is that popularized by Coleman [15]. Planning with this approach appears to be fundamentally "artistic" in that analysis considers only the surface topography in the decision on the areas and volumes to be grafted. Similar markings are made during preparation to inject artificial fillers.

The engraftment procedure is characterized by multiple passes (in the hundreds), depositing 0.1 ml of fat with each pass ("microcannulation") to ensure even distribution and to aid in graft retention. Most of the fat is placed subdermally, and descriptions of injection into deeper tissue planes such as the intramuscular and periosteal planes are vague. It is not unexpected that passing a blunt cannula many times through the facial muscles results in substantial bruising, prolonged edema, and loss of the graft due to damaged capillary networks, with potential for muscle damage unless care is taken to engraft within the fascial sheath between the muscle fibers in their plane and direction using a minimum of passes.

Conversely, overreliance on engrafting of the subcutaneous plane can lead to a distended, unnatural appearance. Local infiltration of lidocaine, with or without general anesthesia or nerve block, inevitably alters the very contours that the operator is trying to correct [16, 17], adds more fluid to the interstitial space, and risks hematoma formation with deep injection, posing the possibility of repeat injections to maintain anesthesia if the procedure lasts longer than 2 h. It is a logical consequence that practitioners describe the need for staged sessions and thus increased total volumes of fat to achieve a desired result [4, 5].

In contrast, the FAMI technique seeks to target the underlying anatomic structures that create the surface contours. The preoperative analysis correlates atrophic areas according to the underlying fat pads and bony regressions and uses the rich vascular plexus of the facial muscles to improve graft retention and thereby the predictability and efficiency of the volume correction.

That the muscles of facial expression can be cannulated accurately and injected has been demonstrated in a cadaver study [18]. The shapes of the cannulas developed for FAMI are more varied than those used for the Coleman technique. They are designed to work along the contours of the skull and make it easier to reach a targeted structure from a minimum of access points.

In life, fat coexists easily within muscle. It is soft, flexible, and occurs naturally in skeletal muscle with age, obesity, and disuse. It has been engrafted into other muscles—gluteus and pectoralis muscles [19, 20]—without reports of functional impairment. In the ten plus years of clinical experience with the FAMI technique, there has been no limitation of facial muscle function after the subsidence of postprocedure edema. The risks for embolization of fat from injection into the facial muscles with a blunt cannula are theoretically no more than for other tissues, and none have materialized in the 700 cases to date.

Using an anatomically based approach, layering from deep to superficial planes spreads the fat grafts over a larger graft bed volume. Incorporating the vascular muscle plexi allows more access to capillary beds per total volume injected while minimizing disruption of capillary networks and errors in the clinical judgment of the volume correction. When this is combined with the use of the patient's own anatomy as the template for rejuvenation, a natural result can most often be achieved in a single session, with 10–20% of patients requiring a second session, no earlier than 6 months after the first session. Consequently, only freshly harvested fat is used, eliminating stored frozen fat that likely is, in the absence of elaborate cryoprotective protocols, dead tissue [21, 22].

The use of the trigeminal block for anesthesia is another distinction. It permits comfortable engraftment without the distorting effects of tissue infiltration [8] and, theoretically, with less edema to interfere with fat engraftment. Ropivicaine (Naropin 0.5%, Astra Zenica) has a duration of action (4–6 h) similar to that of Marcaine but with a lower neuro- and cardiotoxic profile at equivalent volumes [23]. This provides a more than adequate window for completion of full face and neck engraftment without the need for repeat injections of anesthetic. Its lower toxicity profile is an important consideration where sensory trigeminal nerves exit the foramina with blood vessels. A typical face and neck FAMI requires 2½ to 3 h. General anesthesia is never used.

A paradigmatic distinction from the Coleman technique arises in the approach to the mouth and lips, an area at least as challenging as the eyelids. The Coleman technique specifically avoids intramuscular injections in this area [3], whereas FAMI embraces them.

A total of 12 muscles (ten paired plus the mentalis and the orbicularis oris) insert in the vermilion or near the commissure, with some variation in detail [24, 25]. All these muscles are suitable targets for fat grafting provided the cannulation is performed in the plane and direction of the muscle fibers and within them (Fig. 6a, b). The lip levators cross under the nasolabial fold and thus help with correction of nasolabial contours. Following these muscles individually to their insertions in the vermilion helps the operator maintain a correct plane for volume augmentation [26–28] and avoids errors such as an overly distended vermilion, obliteration of the philtrum, distension of the lips away from the teeth, and subsequently impaired articulation. Accurate and even engrafting of these muscles restores natural projections and contours such as Cupid's bow, reducing the risk of a distorted, asymmetric, or unnatural result without masking or retarding muscle motility [29]. It also is distinct from the approach used for fillers.

In Fig. 6a, all the lip levators and depressors that insert into the vermilion have been injected except the left upper lip. Figure 6b shows the effect after injection of the levator anguli oris, levator labii superioris, levator labii et alaque nasi, and zygomaticus minor of the left upper quadrant. The orbicularis oris was not injected in this case. Engrafting of the lips, then, is a lower face procedure that, except for the zygomaticus major muscle, includes cannulation from the muscle origins along the superior aspects of the maxillary bone to their lip insertions. The inferior muscles are engrafted from their origins on the mandible. The buccinator and platysma are special cases (like the corrugator) in that they are most easily grafted from a middle access point—the oral commissure for the former and the inferior border of the mandible for the latter.

Just as important as optimizing graft cell vitality [30, 31], successful engraftment adapts its techniques to the tissue into which it is implanted: the graft bed. Capillary density and blood flow, stromal scaffolds and tissue pressure gradients, endogenous stem cell populations, cell–cell and cell–matrix communications, and humoral influences all contribute to a microenvironmental milieu, or niche [32].

In vivo, microenvironmental factors may have deterministic influences for differentiation of precommitted mesenchymal stem cells [33, 34]. The concept of engrafting fat simply for volumetric effect considers graft retention as a percentage of graft volume placed to be the primary criterion of success. The dynamic nature of facial muscles, however, demands that their contractile fibers and elastic characteristics, encased in a thin fascia, be preserved if the dense, branching, capillary plexus they provide is to be used to advantage and if their freedom to act alone and in concert is to be maintained. Overcorrection is not used for the muscular tissue beds.

Systematic engrafting of the facial muscles has implications for technique. Although it is accepted that muscular injection enhances cellular retention, we believe that more attention should be focused on the nature of muscle tissue to avoid undue risk of hematoma and structural damage and to promote of graft retention better.

A minimally traumatic approach by necessity inserts a cannula parallel to the muscle fibers, does not infiltrate local anesthesia into the muscle, and enters the muscle where it is most fixed as a target—its origin or insertion—allowing the length of the muscle to be engrafted in one to five smooth motions.

Accepting that engraftment of muscular tissue ought to require a distinct approach leads to the idea that other anatomic structures also can be engrafted according to their characteristics. Fat pads, or compartments as described by Rorich and Pessa [35], have a looser, more netlike amorphous capillary structure and lower partial pressure of oxygen (p_{O_2}) requirements. Although FAMI does not use as many passes as described by Coleman, blunt cannula engraftment can proceed with more passes in fatty tissue beds, allowing for some overcorrection, as in engrafting of the breast, without disrupting functional elements or causing excessive concern with hydrostatic tissue ischemia. The challenge is not so much the orientation of the cannula as it is accurate location of the fat pad and even spreading of the grafts with a minimum of trauma (passes). Finding the superficial temporal fat pad or the SOOF, for example, means guiding the cannula through or past anatomic landmarks that are palpable to the operator and referenced by his or her knowledge of the anatomy.

The FAMI technique does not provide more stem cells than standard practice. It does describe a systematic, anatomically based approach for fat grafting that we believe leads to more predictable results from a single session and is extendable to future stem cell–based interventions.

The future of adult adipose stem cell therapies is promising. Adipose-derived stem cell (ADSC)-enriched fat grafting (cell-assisted lipo-injection, CAL) has shown early promise for augmenting volumetric results in the breast [36] and face [37] and has the advantage of not requiring exogenous induction factors or ex vivo expansion. This does not obviate the need for anatomic precision and targeting, however. Current stem cell therapies for more homogeneous tissues (bone marrow, myocardium) can be delivered by infusion, whereas precise injection is necessary for dealing with functionally heterogeneous anatomic structures such as the face. For example, therapeutically successful targeted placement of muscle stem cell–derived smooth muscle cells into the urinary sphincter for stress urinary incontinence has been reported [38, 39].

Although adipose-derived stem cells show remarkable plasticity for a multitude of cell types [40], they are not yet easily inducible along myogenic lineages. Nonetheless, examples of this potential have been reported [41–43]. These considerations go beyond the volumetric ambitions of facial fat grafting. With the ability to target specific facial anatomic structures comes the possibility of using the regenerative promise of adipose-derived (or other) stem cells as well as injectable biomatrices and cytokines in a way that is compatible with the concept of facial reconstruction and augmentation by "biosurgery," as described by Mao [44]. This supports our rationale for FAMI as it applies to future therapeutics.

Extending the principles relevant to any free-tissue graft, a set of procedural principles for cellular, cannula-based techniques can be suggested. First, consideration of the graft bed is as important as consideration of the graft. The anatomic target influences the pattern, number, and amount of each cannula injection. Using the patient's underlying anatomy as a template helps to guide planning and promote an individualized result.

Second, disruption of the tissues should be minimized. Intramuscular grafts should be injected within the muscle sheath and in the direction of the muscular fibers with a minimum of passes and more variation allowed for the fat pads. Access ports are chosen for entrance to more than one target, if possible, with regard to important neural, vascular, and glandular structures.

Third, distorting influences on the anatomy should be minimized. Sensory block is preferred over local infiltration, and the progression of engraftment is generally from deep to superficial planes.

Conclusion

The FAMI fat-grafting technique offers advantages over current methods for facial volume enhancement and lends itself to incorporating advances in stem cell–based cosmetic and reconstructive therapies.

Conflict of interest Dr. Roger Amar has a U.S. patent on the cannulas assigned to the FAMI Charitable Foundation. Dr. Amar has no financial interest in the cannula patent, and the authors have no other conflicts of interest to disclose.

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