

Applications of Fat Grafting in Facial Aesthetic Skeletal Surgery

Matthew R. Endara, MD; Lindsay Jones Allred, BS;
Kevin D. Han, MD; and Stephen B. Baker, MD, DDS

Aesthetic Surgery Journal
2014, Vol. 34(3) 363–373
© 2014 The American Society for
Aesthetic Plastic Surgery, Inc.
Reprints and permission:
[http://www.sagepub.com/
journalsPermissions.nav](http://www.sagepub.com/journalsPermissions.nav)
DOI:10.1177/1090820X14525964
www.aestheticsurgeryjournal.com



Abstract

Background: Aesthetic skeletal surgery of the face is a powerful tool to alter the facial skeleton; the facial form is enhanced through the use of alloplastic implants and osteotomies of the facial bones. However, the ultimate aesthetic appearance is dictated by how the soft tissue envelope drapes over the altered skeletal foundation. Intraoperative and postoperative fat grafting enhances the final aesthetic result in patients who undergo skeletal aesthetic procedures.

Objectives: The authors describe cases in which selective fat grafting has been successful in optimizing facial soft tissue symmetry in patients undergoing skeletal aesthetic surgery of the face.

Methods: A retrospective chart review of all patients who underwent aesthetic skeletal surgery of the face between November 1, 2003, and October 31, 2011, in the Department of Surgery at Georgetown University Hospital was performed, and any patient who required fat grafting either at the time of aesthetic facial skeletal surgery or in the postoperative period was identified (n = 21). Common indications for fat grafting and the surgical plans are reviewed and presented in this article.

Results: Twenty-one patients were identified who required 37 fat grafting procedures either at the time of aesthetic skeletal surgery of the face or in the postoperative period. The procedures most frequently requiring fat grafting were genioplasty, facial shape modifications, and facial symmetry improvement. Fat grafting most commonly corrected irregularities or asymmetries and improved the soft tissue contour overlying repositioned bone or alloplastic implants. Most patients were female (72%) with a mean age of 42 years (range, 4–58 years). There were 4 complications in total: 3 surgical site infections (managed conservatively in 1 patient and with incision and drainage in the remaining 2) and 1 hematoma requiring drainage and closure on the day of surgery.

Conclusions: Knowledge of which procedures are likely to require fat grafting and the techniques for doing so can improve the plastic surgeon's ability to provide optimal aesthetic results following facial skeletal alterations.

Keywords

genioplasty, fat grafting, aesthetic skeletal surgery, facial plastic surgery, facial implants

Accepted for publication July 29, 2013.

Aesthetic skeletal surgery of the face involves the use of alloplastic implants, autologous tissues, and/or osteotomies to alter the appearance of the underlying skeletal foundation. These techniques can be quite powerful, and their effects have been shown to play a profound role in soft tissue facial aesthetics.^{1–10} Studies have demonstrated that skeletal expansion can have a positive effect on the aesthetics of the overlying soft tissues. It has been shown that as the facial skeleton expands, overlying creases and folds are reduced, leading to a rejuvenated appearance of the overlying soft tissue envelope.¹¹ Conversely, when the

osseous component of the face decreases, as with aging, detrimental effects on the overlying facial soft tissues, including an increased propensity toward sagging and

From the Department of Plastic Surgery, Georgetown University Hospital, Washington, DC.

Corresponding Author:

Dr Stephen B. Baker, Department of Plastic Surgery, Georgetown University Hospital, 3800 Reservoir Road, NW, Washington, DC 20007, USA.
E-mail: SBB6@gunet.georgetown.edu

Table 1. Patient Demographics

Characteristic	Value
No. of patients	21
Total No. of procedures	37
Age, mean (range), y	42 (25-58)
Sex, No. (%)	
Male	5 (24)
Female	16 (76)

wrinkles due to loss of the underlying structural support, are evident, resulting in the typical stigmata of aging. The result of these observations is that improvement of both the hard and soft tissues of the face is considered when planning optimal facial rejuvenation procedures.¹²⁻¹⁵

While techniques in skeletal facial surgery are capable of achieving very good aesthetic results, facial form ultimately is determined by how the soft tissue envelope drapes over the underlying skeletal foundation. In patients requiring asymmetric or significant skeletal changes, the overlying soft tissue may appear asymmetric, irregular, or hypoplastic. When subtle surface irregularities are visible or palpable, correcting them through fat grafting is a simple, reproducible procedure with permanent results.^{16,17}

In this article, we discuss fat grafting as an adjunctive procedure to aesthetic skeletal surgery and present applications for autologous fat grafting in skeletal aesthetic surgery, since we believe that fat grafting allows for more precision and greater attainment of intended aesthetic goals. Cases representative of common skeletal aesthetic problems and procedures requiring the addition of fat grafting are presented, accompanied by the treatment plans used to optimize the final result.

METHODS

A retrospective chart review was performed for all patients who underwent aesthetic skeletal surgery with the senior surgeon (S.B.) between November 1, 2003, and October 31, 2011. Twenty-one consecutive patients who had supplemental fat grafting performed for the purposes of improving the aesthetic outcome of facial skeletal surgery were included.

Once the decision was made to pursue fat grafting, the donor site was chosen preoperatively based on patient preference and location of fat deposits. Prior to fat harvesting, the donor site was infiltrated with tumescent solution, consisting of 1:1 000 000 epinephrine and 0.01% lidocaine in lactated Ringer's solution. All patients underwent fat harvesting with 1 of 2 methods. If the fat grafting was performed in the operating room, a Tulip (San Diego, California)

Table 2. Distribution of Sites for Fat Grafting

Characteristic	No. (%)
Total No. of harvests	46
Abdomen	28 (60.9)
Medial thigh	8 (17.4)
Lateral thigh	2 (4.3)
Hip	4 (8.7)
Groin	2 (4.3)
Arm	1 (2.2)
Submental region	1 (2.2)

harvesting cannula attached to a 60-mL syringe aspirated fat from the recipient site. For in-office procedures, a 10-mL syringe was used along with a Coleman (Mentor, Santa Barbara, California) aspiration cannula. All harvested fat was processed by the same method: the fat was gently moved across Telfa (Covidien, Mansfield, Massachusetts) sheets with a blunt scalpel handle. Care was taken to gently move the fat without injuring fat cells by pressing them into the Telfa. After the oil was removed from the fat and it had attained a gelatinous consistency, the fat was placed into either a 1- or 3-mL syringe, depending on the volume to be injected. The injection cannulae were then attached to the syringes. Stab incisions were made at the recipient site with a scalpel, and the fat was injected in a controlled manner from deep to superficial. The first injection was placed just over the periosteum, and subsequent grafting was incrementally layered superficially to structurally lift the overlying tissue. This technique reduces irregularities and is analogous to the liposuction cannula: superficial enough to be palpable but deep enough that its movement does not create dermal displacement. To minimize the chance of a fat embolism, care was taken to inject the fat only while the cannula was withdrawn.

RESULTS

Five of the 21 consecutive patients included in this study (24%) were men, and 16 were women (76%). Average patient age was 42 years (range, 25-58 years) (Table 1). There were a total of 37 procedures with 46 fat harvests from various donor sites: abdomen (n = 28, 60.9%), medial thigh (n = 8, 17.4%), hip (n = 4, 8.7%), lateral thigh (n = 2, 4.3%), groin (n = 2, 4.3%), arm (n = 1, 2.2%), and submental region (n = 1, 2.2%) (Table 2). Seven of 22 patients (18.9%) underwent multiple fat grafting procedures; 6 required 3 grafts, and 1 required 4 grafts.

Of the 37 total procedures, there were 4 complications (11%): 3 surgical site infections (75%) and 1 hematoma

(25%). One of the infections resolved with oral antibiotics alone while the other 2 required incision and drainage with oral antibiotics. The hematoma was infraorbital and developed in the postanesthesia care unit; it was drained and closed on the day of surgery without further complication. Significantly, all 4 complications occurred during skeletal surgeries combined with intraoperative fat grafting. Secondary fat grafting as a staged procedure incurred no complications.

The mean follow-up time was 687 days. We did not directly survey patients for satisfaction; we retrospectively reviewed clinic notes for evidence of patient self-appraisals during postoperative visits. Thirteen of 21 (62%) patient charts had documented comments relating to satisfaction. Six of the 13 patients on whom we had outcomes data (46%) were “happy” with the results and did not request additional fat grafting. Six (46%) were “happy” but desired additional volume at the last follow-up appointment, and 1 (7.6%) patient felt he had excess lateral fullness following malar augmentation. No formal measurement of fat graft “take” was obtained beyond patient self-appraisal and surgeon assessment.

Clinical results are shown in Figures 1 to 4.

DISCUSSION

Performing complementary surgeries following skeletal surgery of the face to achieve optimal aesthetic results is not a novel concept, but no previous studies have specifically focused on fat grafting as an adjunctive procedure to aesthetic skeletal surgery of the face, as we did in our study. When the underlying skeletal foundation is altered more than several millimeters, the iatrogenic stigmata of an osteotomy or alloplastic implant may be visible. Fat grafting presents an excellent opportunity to use the patient’s own tissue to correct soft tissue asymmetries that may result or persist after altering the skeletal foundation. The 3 most common applications involve surgery of the chin, facial reshaping, or facial asymmetry correction.

Genioplasty

Techniques that alter chin appearance fall into the category of genioplasty and can be divided into either osseous or alloplastic categories. An osseous genioplasty is a powerful tool to improve the appearance of the lower face and neck. Smaller advancements and minor asymmetrical corrections are usually well tolerated by the soft tissue envelope and result in a natural look. However, in larger advancements or asymmetrical corrections, overlying soft tissues may be less forgiving. A “pharaoh deformity” occurs when the chin is advanced to the point that it loses a natural transition with the posterior jawline and has an overprojected look. This deformity is accentuated by unsupported

soft tissue in the parasymphyseal region that results in parasymphyseal hollowing, thus exaggerating the prominence of the chin. Additionally, when large asymmetric movements are necessary to achieve skeletal symmetry of the lower face, soft tissue irregularities may become apparent. Depending on how the soft tissue drapes, noticeable angles or palpable deformities may result and be of significant concern to the patient.

Another popular option for chin augmentation involves the implantation of alloplastic materials, thus eliminating the need for bony movements. Numerous implants exist for this purpose. Their dimensions range from being directly over the chin to extending posteriorly along the inferolateral border of the mandible. Multiple studies have demonstrated that, depending on the implant shape and size, the borders of the implant may be visible under the soft tissue.^{4,9} The larger the implant size relative to the soft tissue envelope into which it is placed, the more unnatural it will appear.

In both osseous and alloplastic genioplasty, autologous fat grafting can camouflage irregularities by enabling precise augmentation of the soft tissue envelope. Autologous fat allows the surgeon to simultaneously correct both the underlying asymmetric skeletal foundations and the overlying soft tissue envelope. Soft tissue asymmetry or irregularity after genioplasty is most commonly found in the parasymphyseal region. The graft sites are either determined by the preoperative examination or evaluated after the skeletal movement or implant placement. Typically, after any osteotomy used for sliding osseous genioplasty, some edema is present, but soft tissue irregularities can still be visible and identified for fat grafting. In our experience, approximately 4 mL of fat per side has been necessary to achieve symmetry and minimize the pharaoh deformity sometimes seen after a large advancement genioplasty. Four of our patients (21%) required a second fat grafting treatment 3 months after the first injection, but none required a third graft to achieve patient satisfaction.

In alloplastic genioplasty patients requiring larger implants for skeletal deformity correction, fat grafting softens the interface between implant and bone and reduces the visibility of the edge of the implant. Traditionally, alloplastic implants have not been recommended for asymmetric chin deformities because they are difficult to use for this purpose. However, for a patient who refuses an osteotomy, fat grafting can improve the final symmetrical result after implant placement by modifying the soft tissue to compensate for residual asymmetry. For asymmetric deformities, fat grafting is deposited in the deficient portion and feathered laterally and medially. Fat grafting also can be placed in the perioral region for soft tissue rejuvenation at the time of implant placement.

Even in cases where no irregularities exist and there are no palpable step-offs with either an implant or osteotomy,



Figure 1. (A, C, E) This 50-year-old woman presented for facial feminization. (B, D, F) Twelve months after facial reshaping. The surgical plan (G) required a narrowing genioplasty, bilateral gonial angle reduction, facelift, and rhinoplasty, which successfully reshaped the facial skeletal structure. Autologous fat (8 mL in the right cheek and 6 mL in the left; 4 mL in the right nasolabial crease and 3 mL in the left; 5 mL in the parasymphyseal region) softened the appearance of the new facial shape.

fat grafting optimizes the effects of genioplasty by softening the surrounding perioral region and creating a more natural appearance; in such circumstances, regions targeted for fat grafting usually include marionette lines and the paramandibular region. This procedure can be done at

the same time as genioplasty, provided the patient and surgeon properly anticipate the effects chin alteration will play on the surrounding perioral region.

In patients with ideal lower facial height and retrogenia who cannot tolerate the increased acuity of the



Figure 1. (continued) (A, C, E) This 50-year-old woman presented for facial feminization. (B, D, F) Twelve months after facial reshaping. The surgical plan (G) required a narrowing genioplasty, bilateral gonial angle reduction, facelift, and rhinoplasty, which successfully reshaped the facial skeletal structure. Autologous fat (8 mL in the right cheek and 6 mL in the left; 4 mL in the right nasolabial crease and 3 mL in the left; 5 mL in the parasymphyseal region) softened the appearance of the new facial shape.

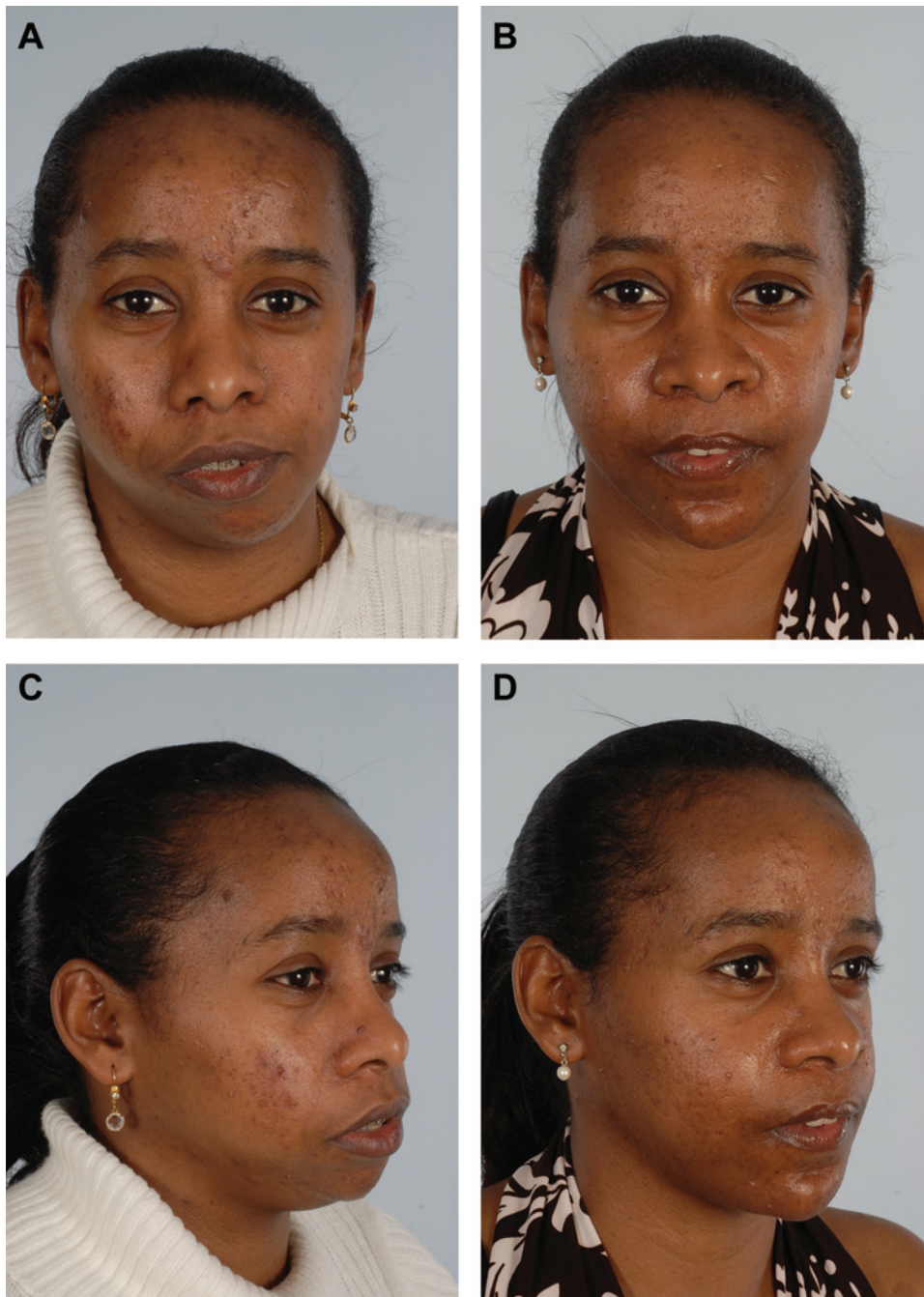


Figure 2. (A, C, E) This 29-year-old woman presented with severe facial asymmetry and an occlusal cant following an early traumatic injury to her left condyle. (B, D, F) Twelve months after facial reshaping. The surgical plan (G) required a Le Fort I osteotomy with correction of transverse cant by inferior positioning of 7 mm on the left and superior positioning of 2 mm on the right, left intraoral vertical ramus osteotomy, right sagittal split osteotomy, and genioplasty along with a left mandibular bone graft to achieve skeletal symmetry. Despite restoring symmetry to the skeletal tissues, it was anticipated that the patient would have a persistent facial asymmetry, so 26 mL of fat was injected into the malar prominence, buccal soft tissue, and the mandibular angle of her left face. Her result was stable, and she required only 1 additional fat graft.

labiomental angle that occurs with chin advancement, fat grafting of the labiomental crease has been used to soften the crease and allow anterior chin positioning without detrimental changes to the crease. A pickle fork is used to release the tissue deep to the crease; then fat is injected to create a more obtuse angle in this region. Typically, 2 mL of fat is necessary, and care must be taken to keep in the

region of the fold. OnabotulinumtoxinA (5-7 units in a single injection) centering at 2 cm cephalad from the apex of the chin is also a useful adjunct for fat grafting into the labiomental crease. This minimizes mentalis activity during graft incorporation, which is thought to reduce graft loss. Fat grafting thus has expanded the indication for sliding osseous genioplasty.



Figure 2. (continued) (A, C, E) This 29-year-old woman presented with severe facial asymmetry and an occlusal cant following an early traumatic injury to her left condyle. (B, D, F) Twelve months after facial reshaping. The surgical plan (G) required a Le Fort I osteotomy with correction of transverse cant by inferior positioning of 7 mm on the left and superior positioning of 2 mm on the right, left intraoral vertical ramus osteotomy, right sagittal split osteotomy, and genioplasty along with a left mandibular bone graft to achieve skeletal symmetry. Despite restoring symmetry to the skeletal tissues, it was anticipated that the patient would have a persistent facial asymmetry, so 26 mL of fat was injected into the malar prominence, buccal soft tissue, and the mandibular angle of her left face. Her result was stable, and she required only 1 additional fat graft.



Figure 3. (A, C, E) This 26-year-old woman presented with significant facial asymmetry. (B, D, F) Ten months after facial reshaping. The surgical plan (G) required osseous genioplasty, a left-sided gonial angle reduction (green), and a rhinoplasty. She had fat grafted to each paramandibular region: 4 mL on the right and 8 mL on the left. In total, 12 mL was also injected into the left cheek region.

Facial Shaping

Facial shape is critical in determining overall aesthetics. Studies have shown that for women, the most ideal shape is an oval.¹⁸ In the general population, however, a wide variety of facial shapes can be seen, including long, narrow, square, heart shaped, or tapered.¹⁹ Patients may desire

a change in facial shape to soften or accentuate sex characteristics or alter facial dimensions associated with their ethnicity.

Procedures we have used to reshape the face primarily focus on the skeletal structures of the malar complex, the mandible, and the chin. Gonial reduction, malar reduction, and genioplasty are the procedures frequently performed



Figure 4. (A, C, E) This 25-year-old woman presented with facial asymmetry secondary to Goldenhar syndrome. (B, D, F) Nine months after facial reshaping. The surgical plan (G) required placement of a polyethylene implant modified for contour at the posterior left mandibular angle. The patient also received 22 mL of injected fat at the interface between the implant and the underlying facial skeleton. She received subsequent in-office fat injections at 3 and 9 months after surgery.

to soften the chin and taper the jaw in women, for a more feminine appearance.²⁰ In men, genioplasty and mandibular angle augmentation are the procedures used most frequently to masculinize the face.²¹

Fat grafting is used in the mandibular angle region to optimize facial symmetry after gonial angle reduction in women and to smooth the implant-bone transition zone in

men. Although men typically desire enhanced jawline angularity, fat grafting has been used to reduce an iatrogenic or “implant” look by softening sharp edges that may become apparent after edema subsides. By augmenting soft tissue, fat grafting has been optimal for improving both the surface contour and the texture of soft tissue surrounding the bones. When a genioplasty is performed as

part of a facial reshaping procedure in women, fat can be injected intraoperatively at the region of the parasymphysis to further enhance a gently tapered chin. Additional fat can be layered along the inferior border of the mandible to create a soft-flowing tapered mandibular border. Fat grafting used in the mandibular angle region can optimize facial symmetry after gonial angle reduction in women and smooth the edges of any visible osteotomy sites.

Patients of Asian descent commonly request procedures to narrow the malar eminence and soften or reduce the gonial angle of the mandible. In malar reduction surgery, the zygomaticotemporal osteotomy allows medialization of the posterior arch; thus, anterior narrowing of the zygoma is achieved. Due to the tight adherent tissue overlying the arch in this region, a visible depression may be evident after zygoma medialization. Overaggressive dissection to release the tissue may place the temporal branch of the facial nerve at risk. The addition of autologous fat in this depression is ideal to camouflage the deformity without adding undue morbidity.

Asymmetry

Facial asymmetry frequently results from both skeletal and soft tissue abnormalities, the etiology of which can be congenital, genetic, traumatic, or iatrogenic from previous surgery. Skeletal asymmetry may be addressed with alloplastic implants, bone grafts, osteotomies, or skeletal recontouring. After the skeletal asymmetry is corrected, a persistent soft tissue asymmetry may overlie the new skeletal foundation. Fat grafting has proven to be a useful adjunct procedure to enhance the soft tissue symmetry over the skeletal foundation; the results can be tailored for optimal symmetry and texture.

Osteotomies are indicated in major cases of facial asymmetry and include orthognathic procedures, lateral mandibular decortication, and genioplasty. When large asymmetric movements of bone occur, the soft tissue response is unpredictable and does not necessarily translate into soft tissue symmetry despite underlying skeletal symmetry. Autologous fat is injected at the time of surgery in areas where soft tissue asymmetry is anticipated, or as part of a revision procedure after swelling subsides and soft tissue asymmetries become evident.

When the asymmetry is not severe enough to warrant an osteotomy, bone grafts or alloplastic implants are used. In these situations, fat grafting has proved to be especially useful. In many asymmetry cases, the underdeveloped side is a combined skeletal and soft tissue hypoplasia. When an attempt is made to achieve facial symmetry with a bone graft or alloplastic implant alone, the overlying soft tissue may have an excessively angular appearance compared with the opposite side. An improvement in skeletal symmetry does not always lead to an improvement in facial symmetry. In fact, a mild disparity with normal contours and texture may actually be preferable over a seemingly

symmetric skeleton with an angular appearance on one side and a soft tapered appearance on the other. Masden and Baker⁸ have described the use of fat grafting for the purpose of improving the soft tissue appearance after placement of mandibular implants. For example, in cases of moderate to severe mandibular asymmetry, they recommend reducing the size of the alloplastic implant and feathering with fat over the top to create good 3-dimensional qualities as well as the right contour and texture under the overlying soft tissue. Madsen and Baker recommended using an implant about two-thirds of the size necessary to achieve skeletal symmetry and make up the additional volume discrepancy by fat grafting. This provides more precision in matching the shape, size, and soft tissue contour of the opposite side.

In patients with mild to moderate malar asymmetry, an alloplastic implant is usually used to create symmetry. Given the thin skin of the lid-cheek junction, fat can reestablish soft tissue volume, thereby enhancing a natural appearance. Visible or palpable edges of implants will compromise the result and give the patient an iatrogenic appearance that may be as unsatisfactory as the original deformity. Fat grafting in this region can be performed at the initial surgery and repeated as necessary in the office under local anesthesia. To minimize surface irregularities, rather than add the fat superficially, it should be layered deep to lift the overlying normal tissue. Our initial injections in this region tend to be just over the periosteum and incrementally proceed to the more superficial subcutaneous level.

Given the above described benefits of fat grafting, it alone may appear to be a reasonable strategy for correcting asymmetry. It is our belief, however, that this approach is usually flawed. When treating a patient with facial asymmetry, knowledge of all the components contributing to the deformity is critical. In almost all cases, both the skeletal and soft tissues contribute to the problem. It is misguided to think that fat grafting alone will correct asymmetry and provide the optimal aesthetic result for any but the mildest cases. Skeletal problems ultimately require skeletal solutions: replacing like with like. Attempting to correct facial asymmetry with soft tissue fillers alone may improve volumetric symmetry but will likely result in a soft and doughy appearance.

In revision surgery, fat grafting adds a level of precision unobtainable with skeletal surgery alone. Whether inserting an alloplastic implant, performing an osteotomy, or recontouring the facial skeleton, the clinician's intraoperative observations are limited in terms of the ultimate outcome. Preoperative planning is important in determining the final shape of an implant or osteotomy, but the ultimate soft tissue topography cannot be assessed until after the edema subsides. The soft tissues' response to altering the underlying skeletal foundation may be unpredictable, and variations in healing can affect the final result. After the edema subsides, fat grafting can precisely correct any remaining irregularities or asymmetry.

Our initial experience with fat grafting in skeletal aesthetic surgery was to correct postoperative irregularities that were present on follow-up visits. As we acquired experience using fat grafting as an adjunct therapy to optimize the soft tissue envelope, we expanded to intraoperative grafting in areas where we anticipated soft tissue discrepancies. The anticipated regions of fat grafting were based on previous procedures where soft tissue irregularities necessitated postoperative fat grafting following the original skeletal procedure. Based on these initial experiences, we are now able to predict where fat grafting is typically necessary in order to optimize results and minimize postoperative revisions.

Choice of Fillers

Although other permanent or semipermanent fillers are commercially available, we prefer autologous fat because it is less expensive to graft, biocompatible, and, to a degree, permanent.

We are aware that the small number of subjects and lack of randomization and controls limit this study, but we believe our methodology engenders the design of a prospective study with appropriate controls to assess objectively the usefulness of fat grafting.

CONCLUSIONS

Aesthetic skeletal surgery is the practice of altering facial bones to improve the overall appearance of the face. The ultimate result depends on how the soft tissue drapes over the new skeletal foundation. Fat grafting is a powerful tool to optimize the soft tissue envelope and gives the surgeon another level of control over the result. The goal of aesthetic skeletal surgery is not merely a good outcome but rather the best possible outcome, and this can be more easily achieved with supplemental fat grafting.

Disclosures

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

Funding

The authors received no funding for the research, authorship, and publication of this article.

REFERENCES

- Binder WJ. Facial rejuvenation and volumization using implants. *Facial Plast Surg*. 2011;27(1):86-97.
- Chisholm BB. Facial implants: facial augmentation and volume restoration. *Oral Maxillofac Surg Clin North Am*. 2005;17(1):77-84, vi.
- Elsalanty ME, Genecov DG, Genecov JS. Functional and aesthetic endpoints in orthognathic surgery. *J Craniofac Surg*. 2007;18(4):725-733.
- Gui L, Huang L, Zhang Z. Genioplasty and chin augmentation with Medpore implants: a report of 650 cases. *Aesthetic Plast Surg*. 2008;32(2):220-226.
- Hoenig JF. Sliding osteotomy genioplasty for facial aesthetic balance: 10 years of experience. *Aesthetic Plast Surg*. 2007;31(4):384-391.
- Jones BM, Vesely MJ. Osseous genioplasty in facial aesthetic surgery <@151>a personal perspective reviewing 54 patients. *J Plast Reconstr Aesthetic Surg*. 2006;59(11):1177-1187.
- Louis PJ, Cuzalina LA. Alloplastic augmentation of the face. *Atlas Oral Maxillofac Surg Clin North Am*. 2000;8(2):127-191.
- Masden D, Baker S. A novel approach for correcting mandibular asymmetry with a combination of autologous fat and alloplastic implants. *Aesthetic Surg J*. 2010;30(4):513-515.
- Yaremchuk MJ. Improving aesthetic outcomes after alloplastic chin augmentation. *Plast Reconstr Surg*. 2003;112(5):1422-1434.
- Yaremchuk MJ, Doumit G, Thomas MA. Alloplastic augmentation of the facial skeleton: an occasional adjunct or alternative to orthognathic surgery. *Plast Reconstr Surg*. 2011;127(5):2021-2030.
- Rosen HM. Facial skeletal expansion: treatment strategies and rationale. *Plast Reconstr Surg*. 1992;89(5):798-808.
- Shaw RB Jr, Kahn DM. Aging of the midface bony elements: a three-dimensional computed tomographic study. *Plast Reconstr Surg*. 2007;119(2):675-683.
- Shaw RB Jr, Katzel EB, Koltz PF, Kahn DM, Giroto JA, Langstein HN. Aging of the mandible and its aesthetic implications. *Plast Reconstr Surg*. 2010;125(1):332-342.
- Shaw RB Jr, Katzel EB, Koltz PF, et al. Aging of the facial skeleton: aesthetic implications and rejuvenation strategies. *Plast Reconstr Surg*. 2011;127(1):374-383.
- Kahn DM, Shaw RB. Overview of current thoughts on facial volume and aging. *Facial Plast Surg*. 2010;26(5):350-355.
- Bucky LP, Kanchwala SK. The role of autologous fat and alternative fillers in the aging face. *Plast Reconstr Surg*. 2007;120(6)(suppl):89S-97S.
- Coleman SR. Facial augmentation with structural fat grafting. *Clin Plast Surg*. 2006;33(4):567-577.
- Baker SB, Dayan JH, Crane A, Kim S. The influence of brow shape on the perception of facial form and brow aesthetics. *Plast Reconstr Surg*. 2007;119(7):2240-2247.
- Ellenbogen R, Motykie G, Youn A, Svehlak S, Yamini D. Facial reshaping using less invasive methods. *Aesthetic Surg J*. 2005;25(2):144-152.
- Altman K. Facial feminization surgery: current state of the art. *Int J Oral Maxillofac Surg*. 2012;41(8):885-894.
- Ousterhout DK. Dr. Paul Tessier and facial skeletal masculinization. *Ann Plast Surg*. 2011;67(6):S10-S15.