Autologous Fat Transfer: Techniques, Indications, and Future Investigation

Jeremy R. Etzkorn, MD; Jennifer M. Divine, BS; Jonathan J. Lopez, BS; George Cohen, MD

Correction of contour irregularities through autologous fat transfer has been successfully performed at various body sites. As a filler, autologous fat possesses many ideal properties, including its lack of immunogenicity, abundant and inexpensive supply, and potential for durable results; however, there is controversy concerning the most effective techniques for harvesting, processing, and injecting donor fat into recipient sites. In this article, we review the techniques, indications, and evidence of efficacy and risks for autologous fat transfer. We also provide recommendations for future investigation. *Cosmet Dermatol.* 2011;24:470-476.

Autologous fat possesses many qualities of an ideal filler, including its lack of immunogenicity, abundant supply, relatively low cost, and potential for durable results. The practice of transferring fat to repair body contour irregularities is more than a century old. Initial fat transfer techniques utilized excised whole grafts, and injectable grafts soon followed.[1] With the advent of liposuction, many clinicians saw an opportunity in utilizing the fat they removed as a graft to correct other irregularities elsewhere in the body. Several investigators have reported short-term and long-term viability of transferred fat.[2-7] Despite promising results, however, there are still concerns regarding the overall viability of transferred fat.[8-10] Although autologous fat grafting remains a valuable technique for volume and contour correction, there is justifiable caution due to the paucity of evidence-based literature that addresses optimal techniques and long-term outcomes.

From the University of South Florida, Tampa. Drs. Etzkorn and Cohen are from the Department of Dermatology. Ms. Divine and Mr. Lopez are from the College of Medicine.

The authors report no conflicts of interest in relation to this article.

Correspondence: George Cohen, MD, University of South Florida, Department of Dermatology, 12901 Bruce B Downs Blvd, MDC 79, Tampa, FL 33612 (gcohen@health.usf.edu).

TECHNIQUES

Harvesting

There are a number of considerations in determining the donor site for a fat transfer procedure, such as the availability of adipose tissue, patient and surgeon preference, and ease of accessibility. Common sites for harvesting donor tissue include the abdomen, thighs, and buttocks. A survey of practice patterns shows that the most common harvest site is the abdomen[11]; however, available experimental evidence indicates that no site offers significantly improved survival over another.[12,13]

Syringe aspiration, vacuum extraction, and surgical excision of fat have all been promoted in the literature as effective harvesting techniques. Syringe aspiration frequently is chosen because it minimizes trauma to adipocytes during extraction. Using this technique, practitioners can manually control the vacuum suction pressure that is employed. Various types of cannulas in a

variety of sizes have been used,[14-18] primarily selected to minimize mechanical damage to the graft; however, none have been demonstrated to be superior.

The evidence concerning conventional liposuction for grafting is inconclusive. Nguyen et al[19] found that the high pressure in conventional liposuction caused up to 90% of adipocytes to rupture, and Pu et al[20] reported that adipocytes from conventional liposuction aspirates demonstrated decreased cellular function. However, von Heimburg et al[21] found that liposuction aspirates demonstrated a higher rate of viable preadipocytes, which may play an important role in the viability of the graft.

Harvesting fat cores by cutting off the tip of a 1-cc syringe (with an internal diameter of 4.5 mm) and attaching a sharp steel sleeve has been endorsed.[22] Although no physiologic mechanism has been elucidated, it has been speculated that this method minimizes mechanical damage to the fat cells and their associated vasculature. An animal model demonstrated that the fat cores had a better overall survival rate than aspirated fat.[22] Fat cores may be employed in numerous areas of the face but not in areas where minimal volume replacement is required, such as the periocular region. When the diameter of the graft is greater than 3 mm, graft size is inversely proportional to survival, indicating the importance of using either small or aspirated grafts.[23]

Graft Handling and Preparation

Preparation of the graft prior to injection continues to be a matter of debate, largely subject to expert opinion. Even simple variables such as air exposure remain controversial. Aboudib Júnior et al[24] reported that up to 50% of lipocytes undergo lysis even with minimal exposure to air, while Ramon et al[25] reported that grafts exposed to air and towel drying exhibited similar, if not better, results than grafts not exposed to these variables.

Various procedures have been advocated to purify donor fat grafts prior to injection; some of the most popular are filtration and cleansing[26] as well as centrifugation.[4,27-30] Piasecki et al[31] noted a small but statistically significant ($P<.05$) improvement in adipocyte survival and viability in an in vitro mouse model after the combination of collagenase digestion, centrifugation, and washing; however, the clinical significance of this finding is uncertain, as others have shown a lack of subjective or objective improvement in vivo with centrifuged fat versus washed and filtered fat without centrifugation.[26] It remains unclear if these additional steps are necessary for optimal clinical outcome.

Numerous exogenous factors, such as collagenase, thyroxine, insulinlike growth factor 1, and basic fibroblast growth factor, have been shown to improve graft viability in mouse models.[31,32] The application of these modifications to harvested fat in human subjects remains a matter of investigation. Although theoretically intriguing, the clinical impact of injecting growth factors into transplanted adipocytes in humans is uncertain.

Regardless of the purification techniques used, up to 50% of grafted fat will not survive.[33] For this reason, there have been numerous attempts to preserve harvested fat, allowing for repeated grafting without additional harvesting procedures. Although some methods for cryopreservation of fat have had reasonable experimental success,[34-38] others have demonstrated poor viability of adipose tissue after storage, particularly if cryoprotectants are not used.[39,40]

Recipient-Site Anesthesia

Anesthesia at the recipient site may be administered via local injection or nerve blocks. Nerve blocks usually are preferred because they do not substantially alter the contour of the recipient site prior to injection. If local injection is used for anesthesia, a ring block is preferred over direct injection in the recipient site. Local anesthesia with lidocaine and epinephrine does not appear to notably affect adipocyte viability.[41]

Recipient-Site Injection

To optimize graft survival, damage to recipient tissue should be minimized. Blunt-tipped cannulas or small needles typically are employed; some authors contend that injection with a blunt-tipped cannula minimizes the risk for hematoma formation, but others prefer use of a needle because no incision site is necessary for the injections.[5,14,42-45] Injection is performed only during withdrawal of the cannula or needle.

Common to virtually all techniques is an emphasis on maximizing the surface area of grafted fat so that its interaction with the vascular supply at the recipient site can be maximized. Injection of fat typically is performed with deposition of small amounts of fat via multiple passes.[44] A fanning-out technique also has been described.[1] As an alternative, Nordstrom et al[14] advocated the "spaghetti" technique, which involves depositing 3-mm grafts in tunnels that do not touch one another. Although volume loss is common after the procedure, the amount varies among patients and recipient sites; therefore, most clinicians do not advocate overfilling the recipient site in anticipation of future volume loss.

INDICATIONS AND EVIDENCE

At this time, indications for and evidence in favor of autologous fat transfer are mostly based on case series, case reports, and expert opinions.

Fat Graft Survival

Despite remarkable positive clinical experience with fat grafts, there is limited quality experimental evidence to prove that transferred fat survives. Peer[46] concluded more than 50 years ago that approximately half of the fat cells in grafted tissue survive. Fagrell et al[22] compared fat graft survival rates of various methods of harvesting fat in New Zealand white rabbits. In this study, aspirated fat grafts lost approximately 60% of their weight after 6 months.[22] Using a cell-labeling technique in rats, Rieck and Schlaak[47] demonstrated variable survival rates when fat was transferred to different recipient sites; when fat was injected into subcutaneous tissue, a 30% survival rate was noted at 6 months, but when fat was injected into muscle, only a 6% survival rate was noted at 6 months.

Case series often describe satisfactory results, but quantitative data addressing the percentage of short-term and long-term fat viability are lacking. Hörl et al[48] used magnetic resonance imaging to document volume changes after autologous fat graft survival for correction of facial defects. A reduction in graft volume of approximately 50% was demonstrated at 3 months, increasing to 55% at 6 months, and remaining stable thereafter until 12 months after reimplantation.[48] Meier et al[49] utilized 3-dimensional imaging to obtain quantitative volume measurements after autologous fat grafting to the midface. After a mean follow-up of 16 months, approximately 32% of the injected volume remained.[49]

Facial Augmentation

Facial augmentation through fat transfer dates back to 1926 when Miller[50] described cosmetic benefits in 36 patients; however, this method did not become an increasingly popular means of modifying the face until the 1980s. The aging face loses subcutaneous fat volume and adding volume to the face results in a more youthful appearance.[51] In addition, contour irregularities that are secondary to medical diseases are amenable to correction with autologous fat transfer. Positive clinical experiences have been reported in patients with Parry-Romberg syndrome[52,53]; lipoatrophy associated with human immunodeficiency virus (Figure 1)[54]; idiopathic hemifacial lipoatrophy (Figure 2)[55]; acne scarring[56]; and defects associated with trauma, infection, and surgery.[57]

Breast Augmentation and Reconstruction

Autologous fat transfer now is being explored as an alternate or adjuvant to breast implantation. Indications identified in the literature include micromastia, tuberous breasts, Poland syndrome,[58] postaugmentation deformity,[59] nipple reconstruction,[60] postlumpectomy or postmastectomy,[61] and postradiation deformity.[62] An evidence-based literature review performed by the American Society of Plastic Surgeons revealed that only 8 of 283 autologous fat grafting procedures for breast and nipple augmentation and reconstruction were deemed unsuccessful, and only 7 showed no improvement.[63]

Other Indications

Successful experiences with fat transfer for lip augmentation,[64] cleft lip and nose reconstruction/augmentation,[65] reversal of aging hands,[66,67] gluteal augmentation,[68-70] and penile enlargement[71,72] also have been published.

Benefits

Harvesting fat from areas such as the abdomen, buttocks, or thighs provides an inexpensive filler material for correction at other sites, which compares favorably with the

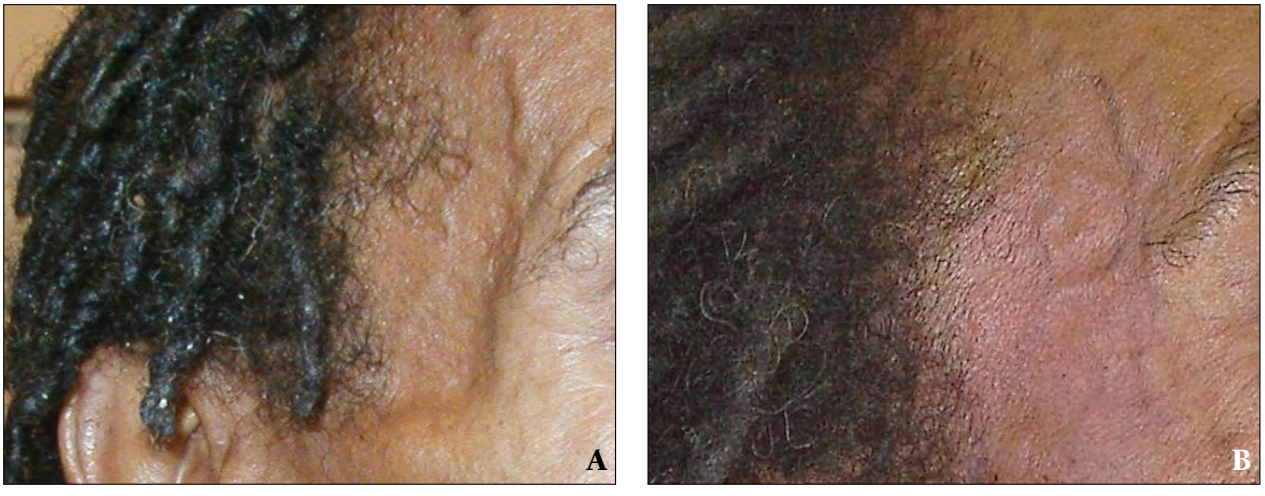

Figure 1. Lipoatrophy associated with human immunodeficiency virus with substantial temporal fat loss before treatment (A). Improvement is noticeable immediately after autologous fat transfer (B).

relatively costly fillers that are commercially available. There also is the secondary benefit of fat removal from sites with unwanted excess. Additionally, there is no risk for allergenicity or foreign body reactions,[73] and transferred adipose tissue may become integrated with the tissue at the recipient site, with the potential for permanence.

Risks

Similar to other surgical procedures, the risks and complications of autologous fat transfer appear to be related to the surgeon's technique and experience. Documentation of adverse events from autologous fat transfer is largely limited to scattered case reports and a few case series.

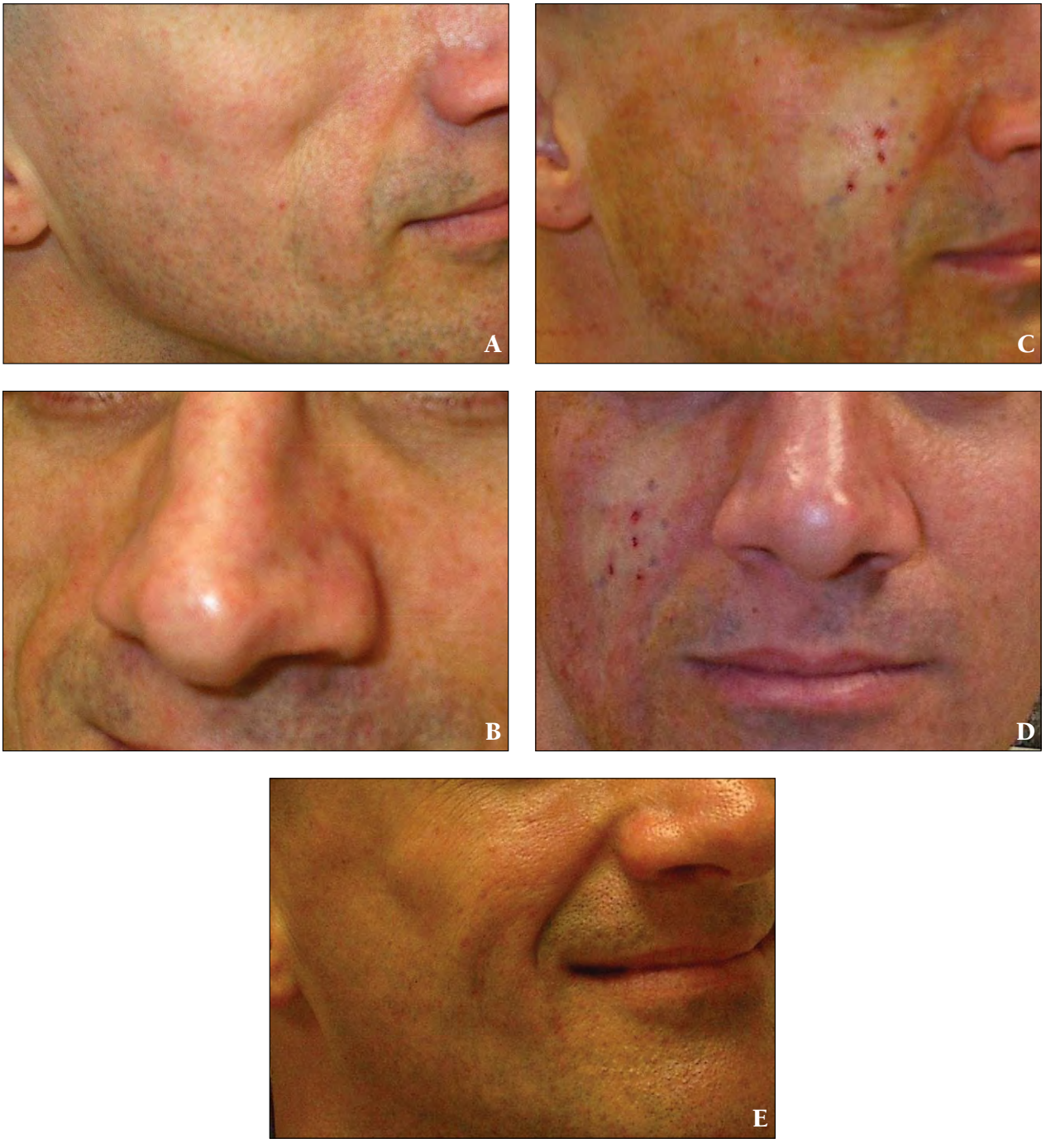

Figure 2. Idiopathic hemifacial lipoatrophy before (side view, A; front view, B) and immediately after autologous fat transfer with marked improvement in symmetry (side view, C; front view, D). Twelve months postprocedure, persistent improvement was demonstrated but with mild volume loss compared to immediately postprocedure (E).

Infection—As with all invasive procedures, there is a risk for infection. Most reported cases have been bacterial in nature, predominantly of the staphylococcal species, and have resolved with antibiotic therapy alone.[74-76] However, a case of septic shock was reported following fat transfer.[75] Rare cases of delayed mycobacterial infection also have been documented,[77] which may occur from inoculation of open incisions at the donor site with contaminated tap water.

Bleeding—Cases of both hematoma and seroma have been reported in association with autologous fat transfer[70,74,78]; however, no cases of unusual or severe bleeding have been reported.

Loss or Hypertrophy of Volume and Contour Irregularities—Suboptimal cosmetic outcomes may occur during removal or placement of fat grafts. Contour irregularities can develop at both harvest and graft sites. For this reason, it is preferred that donor sites are in exercise-resistant areas so that exercise-induced fat loss does not exacerbate or uncover contour irregularities in the remaining adipose tissue. Graft volume loss secondary to necrosis or reabsorption is a leading cause of suboptimal results; however, hypertrophy of grafts also has been reported in several case studies, occurring as late as 10 years after the initial procedure.[1,79]

Interference With Breast Cancer Detection—The use of autologous fat transfer as a means of breast augmentation initially was taboo from fear induced by a statement issued by the American Society of Plastic and Reconstructive Surgeons in 1987[80] based on concerns that calcifications and lumps, which can occur from fat necrosis in autologous fat grafts, would obscure breast cancer detection; however, it should be noted that these same changes can occur with other breast surgeries, including breast biopsy,[81] implant procedures,[82-84] breast reduction,[85] breast reconstruction,[86,87] liposuction,[86] and radiation therapy.[88] A recent study by Veber et al[89] concluded that post–fat grafting changes were noted in less than 50% of mammograms and overall breast density was not significantly changed. The study also showed that radiographic follow-up was not more difficult after fat transfer, causing them to conclude that radiographic follow-up of breasts following fat grafting is not problematic and should not be a hindrance to autologous fat transfer procedures. They also encouraged further study of the issue in larger groups of patients.[89]

Other Complications—Few serious complications from autologous fat transfer have been published. Most notable is a case of cerebral fat embolism resulting in the death of a 39-year-old patient immediately after facial fat injection.[90] Cases of central retinal artery fat embolism and blindness following fat injection also have been reported[91,92] as well as a single case of lipoid meningitis.[93]

FUTURE INVESTIGATION

Randomized controlled trials in humans to evaluate different technical aspects of fat grafting are sorely needed; the optimal technique for fat grafting remains an issue dominated by expert opinion rather than reported evidence. Further research also is needed on improving the viability of transferred adipocytes, possibly via the addition of growth factors, as well as long-term storage of donor tissue for future implantation.

Trials assessing short-term and long-term volume improvement ideally should be conducted with quantitative measurements of volume changes; quantifying patient satisfaction also would be desirable. These trials should seek to provide safety information as well as efficacy data. Concern about interference with breast cancer detection also requires further investigation. Finally, comparative trials with commercial fillers would be of substantial interest to clinicians who engage in the correction of contour irregularities on the face and elsewhere on the body.

CONCLUSION

Autologous fat has been described as an ideal filler.[4,8] Numerous case series and case reports have documented successful outcomes, and fat transfer procedures continue to show promise in reconstructive and cosmetic areas, especially for the aging face and breast augmentation. This technique is a valuable tool for both plastic surgeons and dermatologists; however, there is the need to investigate how to optimize the safety and efficacy of autologous fat grafting.

REFERENCES

1. Kaufman MR, Miller TA, Huang C, et al. Autologous fat transfer for facial recontouring: is there science behind the art? *Plast Reconstr Surg.* 2007;119:2287-2296.
2. Ellenbogen R. Free autogenous pearl fat grafts in the face—a preliminary report of a rediscovered technique. *Ann Plast Surg.* 1986;16:179-194.
3. Carraway JH, Mellow CG. Syringe aspiration and fat concentration: a simple technique for autologous fat injection. *Ann Plast Surg.* 1990;24:293-296; discussion 297.
4. Coleman SR. Structural fat grafts: the ideal filler? *Clin Plast Surg.* 2001;28:111-119.
5. Guerrerosantos J. Long-term outcome of autologous fat transplantation in aesthetic facial recontouring: sixteen years of experience with 1936 cases. *Clin Plast Surg.* 2000;27:515-543.
6. Dasiou-Plakida D. Fat injections for facial rejuvenation: 17 years experience in 1720 patients. *J Cosmet Dermatol.* 2003;2:119-125.
7. Ersek RA, Chang P, Salisbury MA. Lipo layering of autologous fat: an improved technique with promising results. *Plast Reconstr Surg.* 1998;101:820-826.
8. Calabria R, Hills B. Fat grafting: fact or fiction? *Aesthet Surg J.* 2005;25:55.
9. Illouz YG. Present results of fat injection. *Aesthetic Plast Surg.* 1988;12:175-181.

10. Ersek RA. Transplantation of purified autologous fat: a 3-year follow-up is disappointing. *Plast Reconstr Surg.* 1991;87:219-227; discussion 228.
11. Kaufman MR, Bradley JP, Dickinson B, et al. Autologous fat transfer national consensus survey: trends in techniques for harvest, preparation, and application, and perception of short- and long-term results. *Plast Reconstr Surg.* 2007;119:323-331.
12. Rohrich RJ, Sorokin ES, Brown SA. In search of improved fat transfer viability: a quantitative analysis of the role of centrifugation and harvest site. *Plast Reconstr Surg.* 2004;113:391-395; discussion 396-397.
13. Ullmann Y, Shoshani O, Fodor A, et al. Searching for the favorable donor site for fat injection: in vivo study using the nude mice model. *Dermatol Surg.* 2005;31:1304-1307.
14. Nordstrom RE, Wang J, Fan J. "Spaghetti" fat grafting: a new technique. *Plast Reconstr Surg.* 1997;99:917-918.
15. Tzikas TL. Lipografting: autologous fat grafting for total facial rejuvenation. *Facial Plast Surg.* 2004;20:135-143.
16. Rubin A, Hoefflin SM. Fat purification: survival of the fittest. *Plast Reconstr Surg.* 2002;109:1463-1464.
17. Karacalar A, Orak I, Kaplan S, et al. No-touch technique for autologous fat harvesting [published online ahead of print July 30, 2004]. *Aesthetic Plast Surg.* 2004;28:158-164.
18. Trepsat F. Periorbital rejuvenation combining fat grafting and blepharoplasties. *Aesthetic Plast Surg.* 2003;27:243-253.
19. Nguyen A, Pasyk KA, Bouvier TN, et al. Comparative study of survival of autologous adipose tissue taken and transplanted by different techniques. *Plast Reconstr Surg.* 1990;85:378-386; discussion 387-389.
20. Pu LL, Cui X, Fink BF, et al. The viability of fatty tissues within adipose aspirates after conventional liposuction: a comprehensive study. *Ann Plast Surg.* 2005;54:288-292; discussion 292.
21. von Heimburg D, Hemmrich K, Haydarlioglu S, et al. Comparison of viable cell yield from excised versus aspirated adipose tissue. *Cells Tissues Organs.* 2004;178:87-92.
22. Fagrell D, Eneström S, Berggren A, et al. Fat cylinder transplantation: an experimental comparative study of three different kinds of fat transplants. *Plast Reconstr Surg.* 1996;98:90-96; discussion 97-98.
23. Carpaneda CA, Ribeiro MT. Percentage of graft viability versus injected volume in adipose autotransplants. *Aesthetic Plast Surg.* 1994;18:17-19.
24. Aboudib Júnior JH, de Castro CC, Gradel J. Hand rejuvenescence by fat filling. *Ann Plast Surg.* 1992;28:559-564.
25. Ramon Y, Shoshani O, Peled IJ, et al. Enhancing the take of injected adipose tissue by a simple method for concentrating fat cells. *Plast Reconstr Surg.* 2005;115:197-201; discussion 202-203.
26. Botti G, Pascali M, Botti C, et al. A clinical trial in facial fat grafting: filtered and washed versus centrifuged fat. *Plast Reconstr Surg.* 2011;127:2464-2473.
27. Coleman SR. Long-term survival of fat transplants: controlled demonstrations. *Aesthetic Plast Surg.* 1995;19:421-425.
28. Coleman SR. Facial recontouring with lipostructure. *Clin Plast Surg.* 1997;24:347-367.
29. Fulton JE, Parastouk N. Fat grafting. *Dermatol Clin.* 2001;19:523-530, ix.
30. Kononas TC, Bucky LP, Hurley C, et al. The fate of suctioned and surgically removed fat after reimplantation for soft-tissue augmentation: a volumetric and histologic study in the rabbit. *Plast Reconstr Surg.* 1993;91:763-768.
31. Piasecki JH, Gutowski KA, Lahvis GP, et al. An experimental model for improving fat graft viability and purity. *Plast Reconstr Surg.* 2007;119:1571-1583.
32. Yuksel E, Weinfeld AB, Cleek R, et al. Increased free fat-graft survival with the long-term, local delivery of insulin, insulin-like growth factor-I, and basic fibroblast growth factor by PLGA/PEG microspheres. *Plast Reconstr Surg.* 2000;105:1712-1720.
33. Billings E Jr, May JW Jr. Historical review and present status of free fat graft autotransplantation in plastic and reconstructive surgery. *Plast Reconstr Surg.* 1989;83:368-381.
34. Atik B, Oztürk G, Erdoğan E, et al. Comparison of techniques for long-term storage of fat grafts: an experimental study. *Plast Reconstr Surg.* 2006;118:1533-1537.
35. Pu LL, Cui X, Li J, et al. The fate of cryopreserved adipose aspirates after in vivo transplantation. *Aesthet Surg J.* 2006;26:653-661.
36. Cui X, Pu LL. The search for a useful method for the optimal cryopreservation of adipose aspirates: part I. in vitro study. *Aesthet Surg J.* 2009;29:248-252.
37. Pu LL, Coleman SR, Cui X, et al. Cryopreservation of autologous fat grafts harvested with the Coleman technique. *Ann Plast Surg.* 2010;64:333-337.
38. Shoshani O, Ullmann Y, Shupak A, et al. The role of frozen storage in preserving adipose tissue obtained by suction-assisted lipectomy for repeated fat injection procedures. *Dermatol Surg.* 2001;27:645-647.
39. Moscatello DK, Dougherty M, Narins RS, et al. Cryopreservation of human fat for soft tissue augmentation: viability requires use of cryoprotectant and controlled freezing and storage. *Dermatol Surg.* 2005;31(11, pt 2):1506-1510.
40. Wolter TP, von Heimburg D, Stoffels I, et al. Cryopreservation of mature human adipocytes: in vitro measurement of viability. *Ann Plast Surg.* 2005;55:408-413.
41. Shoshani O, Berger J, Fodor L, et al. The effect of lidocaine and adrenaline on the viability of injected adipose tissue—an experimental study in nude mice. *J Drugs Dermatol.* 2005;4:311-316.
42. Cook T, Nakra T, Shorr N, et al. Facial recontouring with autogenous fat. *Facial Plast Surg.* 2004;20:145-147.
43. Eremia S, Newman N. Long-term follow-up after autologous fat grafting: analysis of results from 116 patients followed at least 12 months after receiving the last of a minimum of two treatments. *Dermatol Surg.* 2000;26:1150-1158.
44. Coleman SR. Structural fat grafting: more than a permanent filler. *Plast Reconstr Surg.* 2006;118(suppl 3):108S-120S.
45. Ozsoy Z, Kul Z, Bilir A. The role of cannula diameter in improved adipocyte viability: a quantitative analysis. *Aesthet Surg J.* 2006;26:287-289.
46. Peer LA. The neglected free fat graft, its behavior and clinical use. *Am J Surg.* 1956;92:40-47.
47. Rieck B, Schlaak S. Measurement in vivo of the survival rate in autologous adipocyte transplantation. *Plast Reconstr Surg.* 2003;111:2315-2323.
48. Hörl HW, Feller AM, Biemer E. Technique for liposuction fat reimplantation and long-term volume evaluation by magnetic resonance imaging. *Ann Plast Surg.* 1991;26:248-258.
49. Meier JD, Glasgold RA, Glasgold MJ. Autologous fat grafting: long-term evidence of its efficacy in midfacial rejuvenation. *Arch Facial Plast Surg.* 2009;11:24-28.
50. Miller CG. *Cannula Implants and Review of Implantation Techniques in Esthetic Surgery.* Chicago, IL: Oak Press; 1926.
51. Glashofer M, Lawrence N. Fat transplantation for treatment of the senescent face. *Dermatol Ther.* 2006;19:169-176.
52. Clauser LC, Tieghi R, Consorti G. Parry-Romberg syndrome: volumetric regeneration by structural fat grafting technique [published

online ahead of print June 11, 2010]. *J Craniomaxillofac Surg.* 2010;38:605-609.
53. Sterodimas A, Huanquipaco JC, de Souza Filho S, et al. Autologous fat transplantation for the treatment of Parry-Romberg syndrome [published online ahead of print August 15, 2008]. *J Plast Reconstr Aesthet Surg.* 2009;62:e424-e426.
54. Cohen G, Treherne A. Treatment of facial lipoatrophy via autologous fat transfer. *J Drugs Dermatol.* 2009;8:486-489.
55. Liu SW, Cohen GF. Idiopathic hemi-facial lipoatrophy treated with autologous fat transfer. *J Cosmet Dermatol.* 2010;9:226-229.
56. Sardesai MG, Moore CC. Quantitative and qualitative dermal change with microfat grafting of facial scars. *Otolaryngol Head Neck Surg.* 2007;137:868-872.
57. Cárdenas JC, Carvajal J. Refinement of rhinoplasty with lipoinjection [published online ahead of print July 25, 2007]. *Aesthetic Plast Surg.* 2007;31:501-505.
58. Del Vecchio DA, Bucky LP. Breast augmentation using preexpansion and autologous fat transplantation: a clinical radiographic study. *Plast Reconstr Surg.* 2011;127:2441-2450.
59. Yoshimura K, Sato K, Aoi N, et al. Cell-assisted lipotransfer for cosmetic breast augmentation: supportive use of adipose-derived stem/stromal cells [published online ahead of print September 1, 2007]. *Aesthetic Plast Surgery.* 2008;32:48-55; discussion 56-57.
60. Bernard RW, Beran SJ. Autologous fat graft in nipple reconstruction. *Plast Reconstr Surg.* 2003;112:964-968.
61. Amar O, Bruant-Rodier C, Lehmann S, et al. Fat tissue transplant: restoration of the mammary volume after conservative treatment of breast cancers, clinical and radiological considerations [in French] [published online ahead of print October 23, 2007]. *Ann Chir Plast Esthet.* 2008;53:169-177.
62. Rigotti G, Marchi A, Galiè M, et al. Clinical treatment of radiotherapy tissue damage by lipoaspirate transplant: a healing process mediated by adipose-derived adult stem cells. *Plast Reconstr Surg.* 2007;119:1409-1422; discussion 1423-1424.
63. Gutowski KA; ASPS Fat Graft Task Force. Current applications and safety of autologous fat grafts: a report of the ASPS fat graft task force. *Plast Reconstr Surg.* 2009;124:272-280.
64. Bertossi D, Zancanaro C, Trevisiol L, et al. Lipofilling of the lips: ultrastructural evaluation by transmission electron microscopy of injected adipose tissue. *Arch Facial Plast Surg.* 2003;5:392-398.
65. Duskova M, Kristen M. Augmentation by autologous adipose tissue in cleft lip and nose. final esthetic touches in clefts: part I. *J Craniofac Surg.* 2004;15:478-481; discussion 482.
66. Butterwick KJ. Lipoaugmentation for aging hands: a comparison of the longevity and aesthetic results of centrifuged versus noncentrifuged fat. *Dermatol Surg.* 2002;28:987-991.
67. Coleman SR. Hand rejuvenation with structural fat grafting. *Plast Reconstr Surg.* 2002;110:1731-1744; discussion 1745-1747.
68. Harrison D, Selvaggi G. Gluteal augmentation surgery: indications and surgical management [published online ahead of print March 26, 2007]. *J Plast Reconstr Aesthet Surg.* 2007;60:922-928.
69. Murillo WL. Buttock augmentation: case studies of fat injection monitored by magnetic resonance imaging. *Plast Reconstr Surg.* 2004;114:1606-1614; discussion 1615-1616.
70. Roberts TL 3rd, Toledo LS, Badin AZ. Augmentation of the buttocks by micro fat grafting. *Aesthet Surg J.* 2001;21:311-319.
71. Panfilov DE. Augmentative phalloplasty [published online ahead of print March 17, 2006]. *Aesthetic Plast Surg.* 2006;30:183-197.
72. Spyropoulos E, Christoforidis C, Borousas D, et al. Augmentation phalloplasty surgery for penile dysmorphophobia in young adults: considerations regarding patient selection, outcome evaluation and techniques applied [published online ahead of print March 16, 2005]. *Eur Urol.* 2005;48:121-127; discussion 127-128.
73. Condé-Green A, de Amorim NF, Pitanguy I. Influence of decantation, washing and centrifugation on adipocyte and mesenchymal stem cell content of aspirated adipose tissue: a comparative study [published online ahead of print August 12, 2009]. *J Plast Reconstr Aesthet Surg.* 2010;63:1375-1381.
74. Hang-Fu L, Marmolya G, Feiglin DH. Liposuction fat-fillant implant for breast augmentation and reconstruction. *Aesthetic Plast Surg.* 1995;19:427-437.
75. Valdatta L, Thione A, Buoro M, et al. A case of life-threatening sepsis after breast augmentation by fat injection. *Aesthetic Plast Surg.* 2001;25:347-349.
76. Kuran I, Tumerdem B. A new simple method used to prepare fat for injection [published online ahead of print March 10, 2005]. *Aesthetic Plast Surg.* 2005;29:18-22; discussion 23.
77. Murillo J, Torres J, Bofill L, et al. Skin and wound infection by rapidly growing mycobacteria: an unexpected complication of liposuction and liposculpture. The Venezuelan Collaborative Infectious and Tropical Diseases Study Group. *Arch Dermatol.* 2000;136:1347-1352.
78. Ellenbogen R, Youn A, Yamini D, et al. The volumetric face lift. *Aesthet Surg J.* 2004;24:514-522.
79. Miller JJ, Popp JC. Fat hypertrophy after autologous fat transfer. *Ophthal Plast Reconstr Surg.* 2002;18:228-231.
80. Report on autologous fat transplantation. ASPRS Ad-Hoc Committeee on New Procedures, September 30, 1987. *Plast Surg Nurs.* 1987;7:140-141.
81. Sickles EA, Herzog KA. Mammography of the postsurgical breast. *AJR Am J Roentgenol.* 1981;136:585-588.
82. Huch RA, Künzi W, Debatin JF, et al. MR imaging of the augmented breast. *Eur Radiol.* 1998;8:371-376.
83. Handel N, Jensen JA, Black Q, et al. The fate of breast implants: a critical analysis of complications and outcomes. *Plast Reconstr Surg.* 1995;96:1521-1533.
84. Leibman AJ, Kruse BD. Imaging of breast cancer after augmentation mammoplasty. *Ann Plast Surg.* 1993;30:111-115.
85. Danikas D, Theodorou SJ, Kokkalis G, et al. Mammographic findings following reduction mammoplasty. *Aesthetic Plast Surg.* 2001;25:283-285.
86. Abboud M, Vadoud-Seyedi J, De Mey A, et al. Incidence of calcifications in the breast after surgical reduction and liposuction. *Plast Reconstr Surg.* 1995;96:620-626.
87. Mandrekas AD, Assimakopoulos GI, Mastorakos DP, et al. Fat necrosis following breast reduction. *Br J Plast Surg.* 1994;47:560-562.
88. Cyrlak D, Carpenter PM. Breast imaging case of the day. fat necrosis of the breast. *Radiographics.* 1999;19:80S-83S.
89. Veber M, Tourasse C, Toussoun G, et al. Radiographic findings after breast augmentation by autologous fat transfer. *Plast Reconstr Surg.* 2011;127:1289-1299.
90. Yoon SS, Chang DI, Chung KC. Acute fatal stroke immediately following autologous fat injection into the face. *Neurology.* 2003;61:1151-1152.
91. Feinendegen DL, Baumgartner RW, Schroth G, et al. Middle cerebral artery occlusion and ocular fat embolism after autologous fat injection in the face. *J Neurol.* 1998;245:53-54.
92. Dreizen NG, Framm L. Sudden unilateral visual loss after autologous fat injection into the glabellar area. *Am J Ophthalmol.* 1989;107:85-87.
93. Ricaurte JC, Murali R, Mandell W. Uncomplicated postoperative lipoid meningitis secondary to autologous fat graft necrosis. *Clin Infect Dis.* 2000;30:613-615. ■