Assessing the Long-Term Viability of Facial Fat Grafts: An Objective Measure Using Computed Tomography

Joan Fontdevila, MD, PhD; Jose Maria Serra-Renom, MD, PhD; Mauricio Raigosa, MD; Joan Berenguer, MD; Eva Guisantes, MD; Eduardo Prades, MD; Jesus Benito-Ruiz, MD, PhD; and Esteban Martinez, MD, PhD

Background: Autologous fat transplantation for soft tissue augmentation is a commonly used technique without a universally accepted approach. The literature includes a variety of reports describing varying degrees of success or failure.

Objective: To evaluate the behavior of facial fat grafts in humans with the use of an objective measuring tool.

Methods: A prospective randomized study, comparing patients pre- and postoperatively, was designed to evaluate the long-term viability of fat grafting. Participants were 18 men and 8 women between 34 and 59 years of age (mean, 45.07 yrs; standard deviation, 6.54 yrs). A total of 52 hemifaces in 26 patients diagnosed with HIV and demonstrating facial lipoatrophy were treated with fat transplantation using Coleman's technique. HIV-positive patients were chosen as study participants because their nearly total lack of subcutaneous fat diminishes the bias in the evaluation of fat volume. Fat graft viability was evaluated by measuring the volume of adipose tissue evolution via computed tomography scan before fat grafting, at the second month after fat grafting, and 1 year after fat grafting. Descriptive statistical analysis was performed.

Results: The mean volume on the right and left cheeks before fat grafting was 1.57 cc. The mean volume 2 months after the procedure was 2.93 cc with a statistically significant mean increase of 1.36 cc ($P < .001$) between baseline and the second month after the procedure. The mean volume after 12 months was 3.29 cc ($P < .001$), with a mean increase compared with the baseline of 1.72 cc, and of 0.36 cc between months 2 and 12. The statistically significant posttreatment improvement ($P < .001$) was maintained until month 12 of the follow-up period.

Conclusions: Using objective measurement, this study demonstrates that with one fat grafting procedure a durable result can be achieved, persisting for a minimum of 12 months without any trend towards reabsorption. (*Aesthetic Surg J 2008;28:380–386.*)

After more than a century of using fat grafts for soft tissue augmentation in a diverse range of reconstructive and aesthetic procedures since the first attempts by Neuber in 1893,[1] there are still plastic surgeons and other medical professionals who remain skeptical about fat transplantation. The lack of objective measurements of fat graft viability may be one of the reasons. The literature provides a variety of reports with varying degrees of success or failure. Recent publications show a resorption rate of 20% to 90%,[2–7] but these statistics are not based on objective measurement.

The mechanisms responsible for resorption are not completely clear. The most accepted theory is the "cells survival theory" postulated by Peer[8] in 1955, which states that the number of viable adipocytes at the time of transplantation correlates with the ultimate fat graft survival volume. Smahel[9] demonstrates that implanted fat does not remain intact because fat resorbs in a 2-stage fashion. In the first stage, there is an acute reduction in cell numbers. The second stage of volume loss occurs with resorption of the oil cyst from nonviable adipocytes. A multitude of variables can affect graft integration, such as the harvesting technique (conventional lipoplasty vs. low pressure harvesting with syringe); tis-

The authors are from the Hospital Clinic, University of Barcelona, Barcelona, Spain. Drs. Fontdevila, Serra-Renom, Raigosa, Guisantes, and Benito-Ruiz are from the Department of Plastic Surgery. Dr. Berenguer is from the Department of Radiology. Dr. Prades is Statistic Evaluator. Dr. Martinez is from the Infectious Disease Unit.

sue processing (decantation, centrifugation, or tissue washing to eliminate the blood and other impurities); injection technique; type of cannula; harvesting area; and the anatomic features of the patients.

There are numerous publications reporting on histologic measures of fat graft viability in animals,[10–24] but there are few such reports in humans[2,25–35] because of the invasive evaluation methods. Therefore, a very limited number of patients have been evaluated, and it has not been possible to perform a statistical analysis of the results. The results of studies using noninvasive methods are merely descriptive. It is difficult to quantify the long-term volumetric effects of fat grafts given baseline soft tissue atrophy, descent, and bony changes over time.[36–40]

To support our positive clinical experience using facial fat grafts,[41] we designed this study to evaluate the behavior of fat grafts using an objective method of measurement and an adequate human model.

MATERIALS AND METHODS

A prospective study was designed to evaluate the long-term viability of fat grafting in the cheeks, including 52 hemifaces of 26 patients with HIV who demonstrated facial lipoatrophy secondary to antiretroviral therapy. The study was approved by the Ethics Committee of the Hospital Clinic of the University of Barcelona. Participants included 18 men and 8 women between 34 and 59 years of age (mean, 45.07 yrs, standard deviation [SD], 6.54 yrs). The nearly complete absence of subcutaneous facial fat in these patients with lipoatrophy minimized bias in evaluating fat thickness. Moreover, a spontaneous improvement in lipoatrophy is simply not expected.

General anesthesia or deep intravenous sedation plus local anesthesia were used. The harvesting areas were first injected using the superwet technique for hemostatic fat aspiration. Wetting solution infiltration in patients under general anesthesia consisted of normal saline solution with epinephrine 1:1,000,000. In patients under deep sedation, 60 mL of 2% lidocaine and 10 mEq sodium bicarbonate were added to this epinephrine solution. Fat was harvested from the cervicodorsal region in 11 subjects, the abdomen in 11, the masculine breast area in 3, and the pubic area in 1, using a 10-cc Luer Lok syringe and a blunt tipped cannula COL-ASP15 (Byron Medical Inc., Tucson, AZ). Once the fat was harvested, it was purified by means of centrifugation at 3000 rpm for 3 minutes and the top and bottom layers—containing blood, serum, and fatty acids—were discarded. The fat was implanted according to the Coleman technique[42–44] with the use of a 1-mL Luer Lok syringe with a blunt tipped cannula COL-19 (Byron Medical).

The cannula was used to create subcutaneous and subdermal tunnels into which the fat cells were deposited when the cannula was withdrawn. By injecting the fat during the withdrawal phase, less pressure is required, and therefore less potential damage is inflicted upon the adipocytes. The tunnels were executed in a fanlike distribution at various planes over the atrophic area of the cheeks, with the cannula entering from the lateral aspect of the malar bone and from the lower aspect of the nasolabial fold. At the beginning of the procedure, it was not known how much fat would be injected. Similar to other filling procedures, such as in the lips, cheeks, or nasolabial folds, injection was completed when a satisfactory correction was achieved. At the end of the procedure, the volume of fat injected and other technical data of interest were recorded.

In order to determine fat graft viability, computed tomography (CT) scans were used to volumetrically measure fat tissue as it evolved in the treated area (over time). CT scans can distinguish fat density from all other tissues, and was chosen over magnetic resonance imaging (MRI) because CT measurements are more exact than those of MRI. Fat tissue was measured before fat grafting and again at 2 months, and 1 year postprocedure. The radiologist delimited the same area in 3 slices of CT (from the first slice in which the nasal spine was identified to the next 2 inferior slices), using specific software (VOLUME in a Leonardo VD30B workstation) provided by the manufacturer of the CT device (Siemens AG, Berlin, Germany; Figure 1). This is a straightforward procedure that requires minimal intervention; the observer simply specifies permanent anatomic points via computer, which minimizes subjectivity.

The volume of fat studied by CT in these 3 slices was between the skin (superficially) and the surface of the bone and deep facial muscles, and between the nasolabial fold medially and the anterior edge of the masseter muscle laterally (Figures 2 and 3).

Photographs of the patients were taken when the CT evaluations were performed. They were then evaluated using a validated severity scale (developed by the authors) that classifies patients according to 4 grades of facial atrophy (Figures 4 to 6).[41,45–46] Grade 0 is normal with convexity in the malar area; grade 1 is mild atrophy with a flattening of the malar area; grade 2 is moderate with a sinking of the skin under the inferior rim of the cheekbone; and grade 3 is severe with a skeletonization

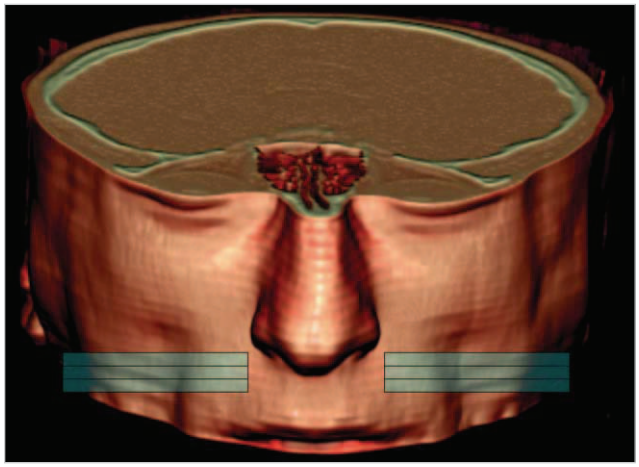

Figure 1. The computed tomography scan explores a facial area 9 mm below the nasal spine (3 slices, each 3 mm).

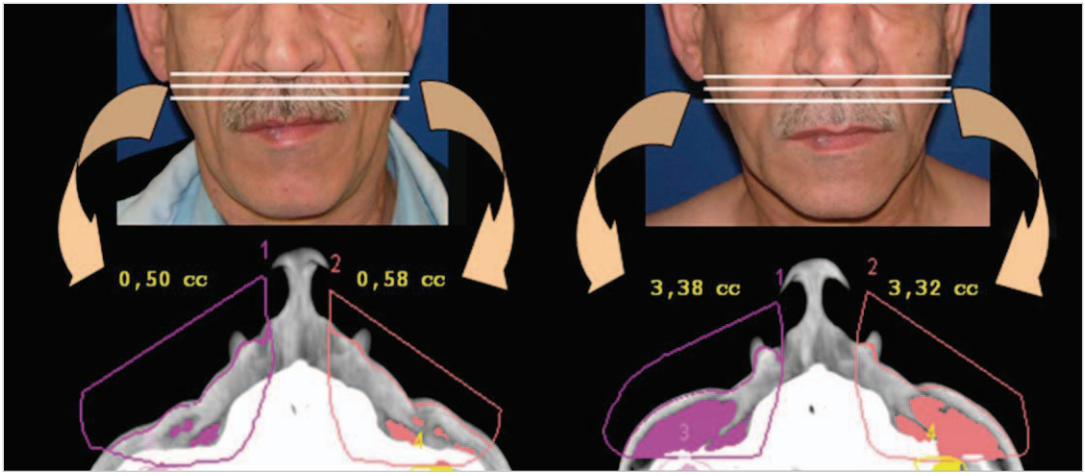

Figure 2. A graphical representation of how the computer processes the data. The radiologist indicates fixed anatomic points to delimit an area from the anterior rim of the masseteric muscles to the nasolabial fold in width, and from the skin to the bone surface in depth. The computer then calculates the volume of fat within this area. Because human intervention in this process is minimal, we can consider this method almost automatic. The yellow numbers show the volume of fat detected in each side of the face by the CT scan.

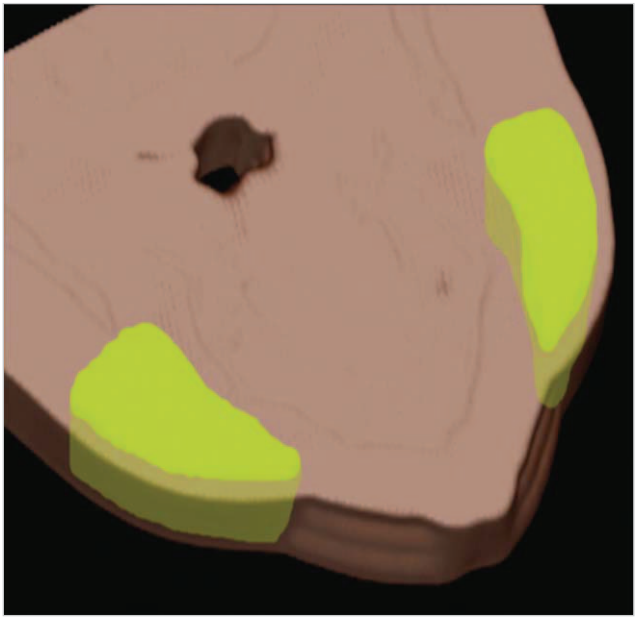

Figure 3. Three-dimensional simulation of the area of fat measured by the CT scan.

of the cheeks with easily noticeable superficial muscles of the face and the bony structures (Figure 7).

Descriptive statistics were gathered for all variables. A nonparametric Wilcoxon rank sum test for paired data was also done to test for the significance of the observed changes.

RESULTS

A total of 52 hemifaces in 26 patients were studied. According to our validated severity scale, 5 patients were included in grade 1 of facial atrophy, 15 patients in grade 2, and 6 patients in grade 3. The mean volume of fat grafted in the cheek area, depending on the grade of atrophy, was 6.53 cc in grade 1, 9.45 cc in grade 2, and 11.46 cc in grade 3.

Before fat grafting, the mean volume of fatty tissue in each side of the face in the area of CT scan assessment (not the entire treated area) was 1.57 cc (range, 0.22 cc to 3.52 cc; SD, 0.96 cc). The mean volume 2 months postprocedure was 2.93 cc (range, 1.07 cc to 4.64 cc; SD, 0.88 cc) with a statistically significant mean increase of 1.36 cc ($P < .001$) between baseline and month 2 of follow-up. The mean volume 12 months postprocedure was 3.29 cc (range, 1.16 cc to 5.17 cc; SD, 0.90 cc; $P < .001$), with a mean increase compared with the baseline of 1.72 cc and of 0.36 cc between postprocedure months 2 and 12. The statistically significant improvement ($P < .001$) observed posttreatment was maintained until month 12 of follow-up.

No significant differences were observed in volume increase when the different fat donor areas were compared (cervicodorsal, abdomen, and masculine breast). Complications included asymmetry in 3 patients, undercorrection in 2 patients, and skin irregularities in 1 patient. These complications were corrected with a new fat grafting procedure performed 1 year after the initial procedure in case of undercorrection and lipoplasty in case of overcorrection.

DISCUSSION

Autologous fat has many of the ideal properties for tissue augmentation: it is readily available, easily obtained, inexpensive, host-compatible, and can be harvested repeatedly. Nevertheless, the literature fails to provide definitive objective evidence of fat survival, instead providing varied reports with different degrees of success or failure, which is why autologous fat is actually not considered the ideal soft tissue filler. Many authors remain skeptical about fat transplantation even though the plastic surgeons most experienced with fat-filling procedures have reported clinical results suggesting both short- and long-term persistence of transferred grafts and promote autologous fat as the ideal soft tissue filler.[41,44,47–49] The difficulty of quantifying long-term volumetric effects of the fat transfer may be the reason for the controversy.

Hörl et al[50] used MRI to study the long-term retention volume of fat and concluded that imaging together with

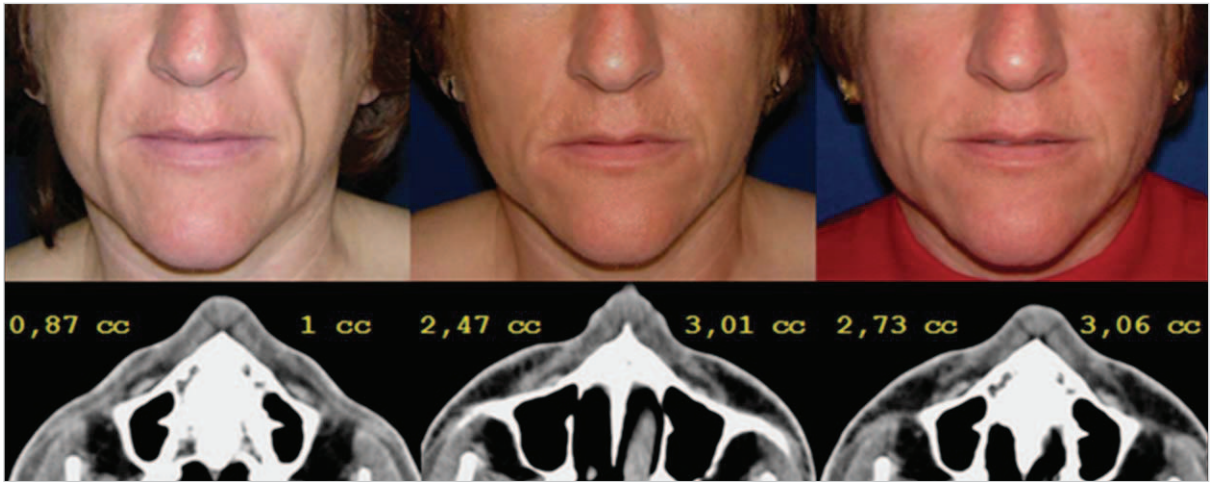

Figure 4. This 41-year-old woman demonstrates grade 2 facial lipoatrophy. In each side of her face, 9.6 cc of fatty tissue was injected. The numbers indicate the volume of fat detected by CT scan in a fixed cheek area before treatment and 2 and 12 months postinjection.

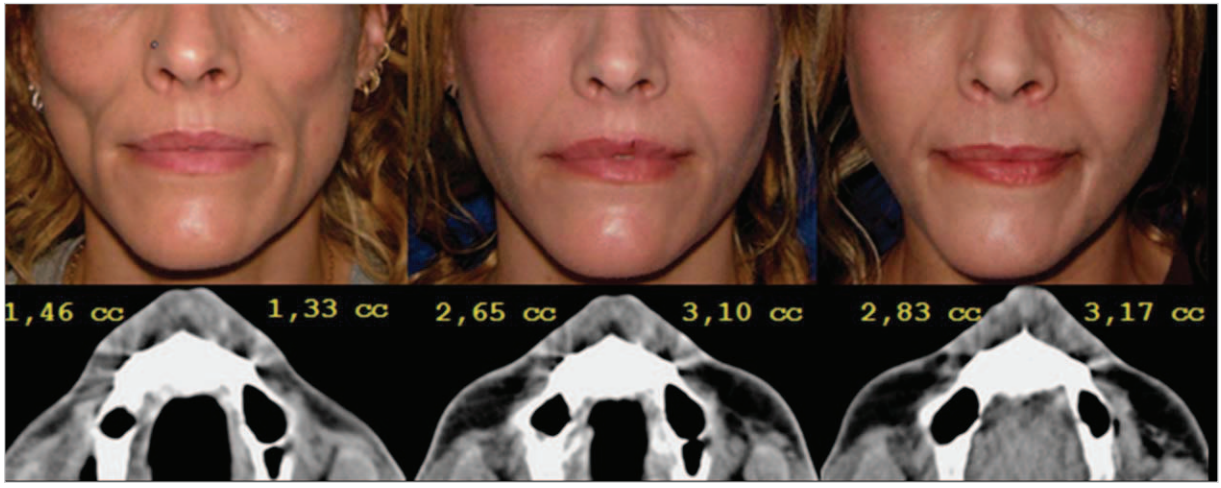

Figure 5. This 40-year-old woman demonstrates grade 3 facial lipoatrophy. In each side of her face, 14 cc of fatty tissue was injected. The numbers indicate the volume of fat detected by CT scan in a fixed cheek area before treatment and 2 and 12 months postinjection.

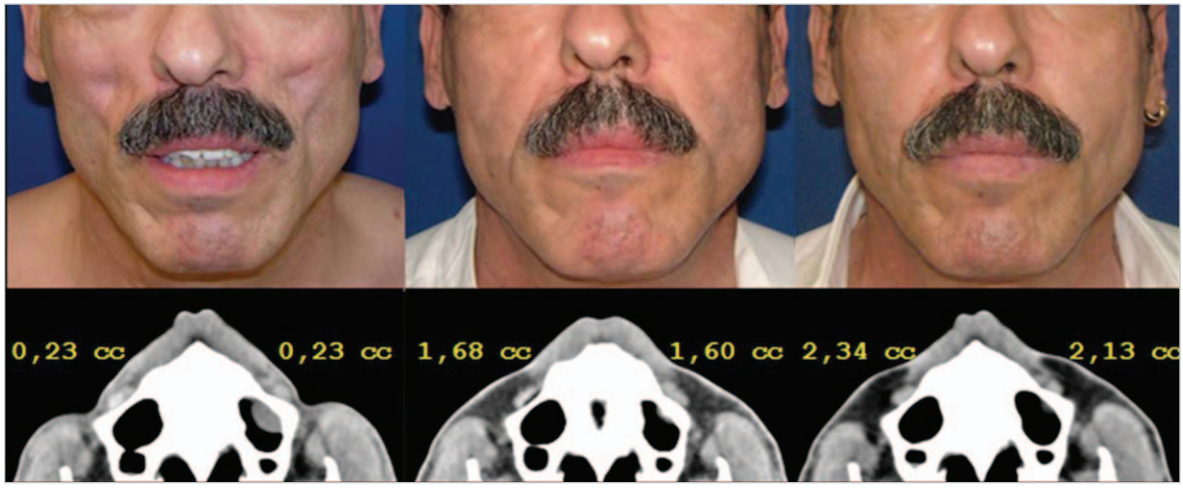

Figure 6. This 52-year-old man demonstrates grade 3 facial lipoatrophy. In each side of his face, 12 cc of fatty tissue was injected. The numbers indicate the volume of fat detected by CT scan in a fixed cheek area before treatment and 2 and 12 months postinjection.

basic clinical observation provides an objective evaluation of fat volume with an average error of only 5%; however, the volumetric measures are less exact than those made using CT scan, so this technique presents a distorting phenomena. Har-Shai et al[51] suggest the use of CT to quantify the volume of fat. This technique can distinguish the density of fat from other tissues. Using a computerized program, the 3-dimensional volume of fat was determined both before and after the autologous fat graft. Thus far, this evaluation method has been

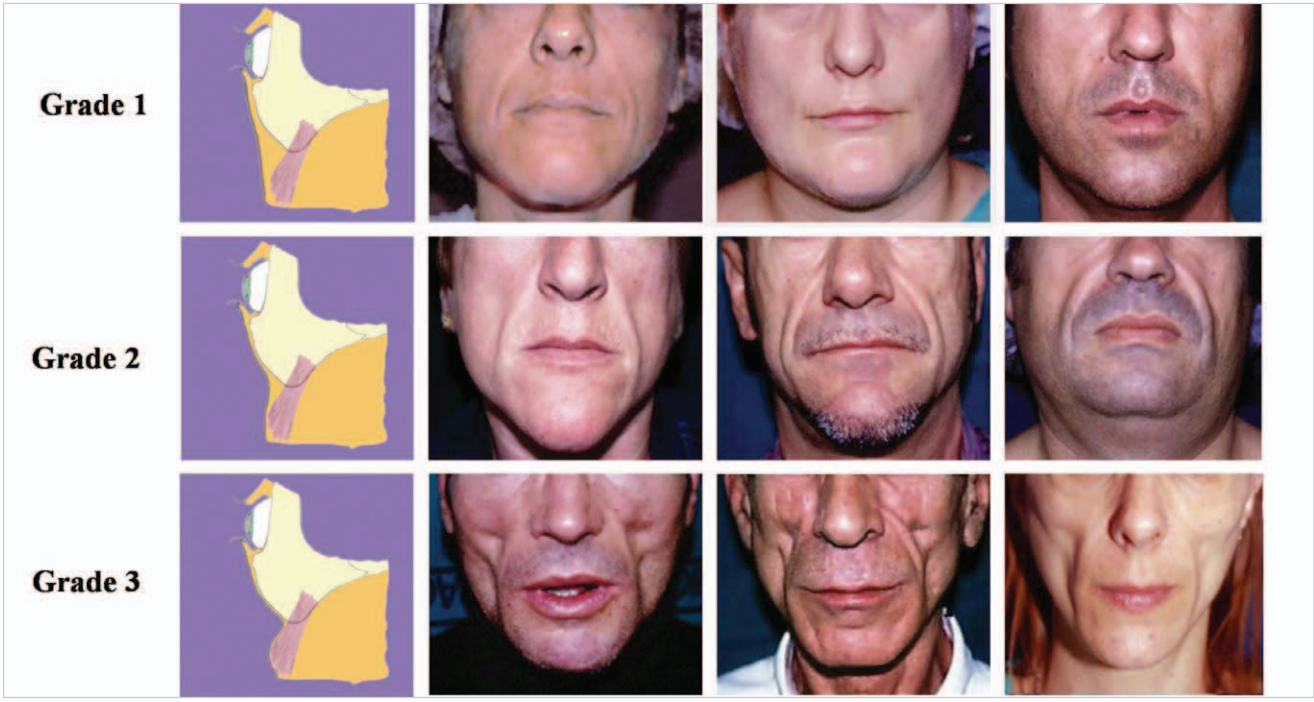

Figure 7. Classification for facial lipoatrophy in HIV-infected adults. Grade 1 indicates a loss of malar relief with flattening of cheek protrusion. Grade 2 indicates the same findings as seen in grade 1 but with skin sinking under the malar bone, resulting in a depression in the cheek. Grade 3 indicates all of the preceding with special evidence of the superficial musculature of the face (especially the zygomatic major muscle), resulting in a skeletal facial appearance.

employed in only 1 case in his work, with a relatively short follow-up (6 months). To our knowledge, prospective comparative quantification of fat graft viability with long-term follow-up using CT scan has not been previously performed.

We chose patients with HIV-associated facial lipodystrophy syndrome because the near complete absence of subcutaneous facial fat in these patients with lipoatrophy minimizes bias in evaluation of fat thickness induced by the preexisting fat in the treated area, and because a significant spontaneous improvement in lipoatrophy in this population has never been observed in spite of attempts to change antiretroviral therapy or include other drugs, such as growth hormone, uridine supplements, and oral hypoglycemiants in the therapeutic approach.[52,53] These patients represent an excellent model for the observation of fat graft behavior in humans.

Recent publications report a resorption rate of 20% to 90%.[2–7] Based on this resorption rate, some authors advocate overcorrection to avoid additional grafting.[16,33] In contrast, the analysis of results in the present study is that with the fat grafting procedure there was a statistically significant increase of fatty tissue volume and this increase was maintained until month 12 with a tendency to increase between the second and twelfth month postprocedure.

We were not able to specify the ratio of retained volume; we only know the total volume of fat grafted in each side of the face, because it is not possible to know, specifically, the volume of fat injected in the area of CT scan measurement. It is possible to calculate the percentage of grafted fat viability if we increase the area of fat volume measurement by the CT to the entire treated area, but this measurement can be incorrect because as a wider surface is explored, the more likely the probability of including fat from ungrafted areas, creating a bias to a lower viability of the grafted fat. For this reason, we decided to evaluate only the area of maximal atrophy in the face.

The additional increase in fat volume observed between months 2 and 12 may support Markman,[54] who suggested that the number of fat cells may increase via the differentiation of existing preadipocytes when fat cells reach a "critical size." The growth observed in the volume of fat between the second and twelfth months can be caused by recovery in fat cell volume, as Peer[8] postulated, or can be an unknown phenomenon in patients with altered lipid physiology. We believe that complementary measures after another 1 or 2 years may be necessary to let us know if this growth will persist or is limited to the time of observation. In accordance with these results, we avoid overcorrection because of the risk of facial lipohypertrophy ("hamster syndrome"),[55,56] which is a very difficult complication to treat. If undercorrection occurs, we prefer to offer another complimentary fat grafting procedure under local anesthesia.

Most authors who have studied the effect of fat grafting in the facial appearance of patients who test positive for HIV, using objective measures or controlled observations, have observed a durable improvement in the correction compared with those who have performed subjective and sporadic observations, which leads us to believe that the perception of reabsorption is a methodological problem.[57–70]

CONCLUSIONS

This study demonstrates with objective measures that a durable result can be achieved with only 1 fat grafting procedure, which persists until at least the twelfth month of follow-up. As no evidence of fat reabsorption was observed, we can confirm that fat grafting in the face is a long-lasting procedure. The increase in volume is in fatty tissue and not secondary to fibrosis or fat necrosis. Most importantly, the grafted fat does not show any tendency for reabsorption. Lipoatrophy in HIV-positive patients provides a more accurate determination of the variations in subcutaneous fat volume, so these patients represent an excellent model for the observation of fat graft behavior in humans.

CT scan was used as an objective and quantitative method for measuring the rate of autologous fat graft. Comparison of the fat volumes pre– and post–fat grafting, when the volume of the injected fat is known, yields a standardized measure of graft take. Because this is a standardized evaluation technique, it can provide an objective method for comparing the efficacy of various procedures used in autologous fat grafts. ◗

ACKNOWLEDGMENT

Support for this study was provided by a grant of the Spanish ministry of Health (Fondo de Investigación Sanitaria) FIS 03/0393.

DISCLOSURES

The authors have no disclosures with respect to the contents of this article.

REFERENCES

1. Chajchir A. Fat injection: long-term follow-up. *Aesthetic Plast Surg* 1996;20:291–296.
2. Boschert MT, Beckert BW, Puckett CL, Concannon MJ. Analysis of lipocyte viability after liposuction. *Plast Reconstr Surg* 2002;109:761–765.
3. Boyce RG, Nuss DW, Kluka EA. The use of autogenous fat, fascia, and nonvascularized muscle grafts in the head and neck. *Otolaryngol Clin North Am* 1994;27:39–68.
4. Jackson IT, Simman R, Tholen R, DiNick VD. A successful long-term method of fat grafting: recontouring of a large subcutaneous postradiation thigh defect with autologous fat transplantation. *Aesthetic Plast Surg* 2001;25:165–169.
5. Matsudo PK, Toledo LS. Experience of injected fat grafting. *Aesthetic Plast Surg* 1988;12:35–38.
6. Nguyen A, Pasyk KA, Bouvier TN, Hassett CA, Argenta LC. Comparative study of survival of autologous adipose tissue taken and transplanted by different techniques. *Plast Reconstr Surg* 1990;85:378–386.
7. 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.
8. Peer LA. Cell survival theory versus replacement theory. *Plast Reconstr Surg* 1955;16:161–168.
9. Smahel J. Experimental implantation of adipose tissue fragments. *Br J Plast Surg* 1989;42:207–211.
10. Bartynski J, Marion MS, Wang TD. Histopathologic evaluation of adipose autografts in a rabbit ear model. *Otolaryngol Head Neck Surg* 1990;102:314–321.
11. Moscona R, Shoshani O, Lichtig H, Karnieli E. Viability of adipose tissue injected and treated by different methods: an experimental study in the rat. *Ann Plast Surg* 1994;33:500–506.
12. Piasecki JH, Gutowski KA, Lahvis GP, Moreno KI. An experimental model for improving fat graft viability and purity. *Plast Reconstr Surg* 2007;119:1571–1583.
13. Shoshani O, Shupak A, Ullmann Y, Ramon Y, Gilhar A, Kehat I, et al. The effect of hyperbaric oxygenation on the viability of human fat injected into nude mice. *Plast Reconstr Surg* 2000;106:1390–1396.
14. Shoshani O, Berger J, Fodor L, Ramon Y, Shupak A, Kehat I, 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.
15. Shoshani O, Livne E, Armoni M, Shupak A, Berger J, Ramon Y, et al. The effect of interleukin-8 on the viability of injected adipose tissue in nude mice. *Plast Reconstr Surg* 2005;115:853–859.
16. Smith P, Adams Jr WP, Lipschitz AH, Chau B, Sorokin E, Rohrich RJ, et al. Autologous human fat grafting: effect of harvesting and preparation techniques on adipocyte graft survival. *Plast Reconstr Surg* 2006;117:1836–1844.
17. Ullmann Y, Hyams M, Ramon Y, Beach D, Peled IJ, Lindenbaum ES. Enhancing the survival of aspirated human fat injected into nude mice. *Plast Reconstr Surg* 1998;101:1940–1944.
18. Ullmann Y, Shoshani O, Fodor A, Ramon Y, Carmi N, Eldor L, 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.
19. Baran CN, Celebioglu S, Sensoz O, Ulusoy G, Civelek B, Ortak T. The behavior of fat grafts in recipient areas with enhanced vascularity. *Plast Reconstr Surg* 2002;109:1646–1651.
20. Fagrell D, Enestrom S, Berggren A, Kniola B. Fat cylinder transplantation: an experimental comparative study of three different kinds of fat transplants. *Plast Reconstr Surg* 1996;98:90–96.
21. Guerrerosantos J, Gonzalez-Mendoza A, Masmela Y, Gonzalez MA, Deos M, Diaz P. Long-term survival of free fat grafts in muscle: an experimental study in rats. *Aesthetic Plast Surg* 1996;20:403–408.
22. Kononas TC, Bucky LP, Hurley C, May Jr JW. 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.
23. Nishimura T, Hashimoto H, Nakanishi I, Furukawa M. Microvascular angiogenesis and apoptosis in the survival of free fat grafts. *Laryngoscope* 2000;110:1333–1338.
24. Rieck B, Schlaak S. Measurement in vivo of the survival rate in autologous adipocyte transplantation. *Plast Reconstr Surg* 2003;111:2315–2323.
25. Gormley DE, Eremia S. Quantitative assessment of augmentation therapy. *J Dermatol Surg Oncol* 1990;16:1147–1151.
26. Jauffret JL, Champsaur P, Robaglia-Schlupp A, Andrac-Meyer L, Magalon G. Arguments in favor of adipocyte grafts with the S.R. Coleman technique [in French]. *Ann Chir Plast Esthet* 2001;46:31–38.
27. Kaminer MS, Omura NE. Autologous fat transplantation. *Arch Dermatol* 2001;137:812–814.
28. Niechajev I, Sevcuk O. Long-term results of fat transplantation: clinical and histologic studies. *Plast Reconstr Surg* 1994;94:496–506.
29. Novaes F, dos Reis N, Baroudi R. Counting method of live fat cells used in lipoinjection procedures. *Aesthetic Plast Surg* 1998;22:12–15.
30. Pu LL, Cui X, Fink BF, Cibull ML, Gao D. The viability of fatty tissues within adipose aspirates after conventional liposuction: a comprehensive study. *Ann Plast Surg* 2005;54:288–292.
31. Rohrich RJ, Morales DE, Krueger JE, Ansari M, Ochoa O, Robinson Jr J, et al. Comparative lipoplasty analysis of in vivo–treated adipose tissue. *Plast Reconstr Surg* 2000;105:2152–2158.
32. Sadick NS, Hudgins LC. Fatty acid analysis of transplanted adipose tissue. *Arch Dermatol* 2001;137:723–727.
33. Shiffman MA, Mirrafati S. Fat transfer techniques: the effect of harvest and transfer methods on adipocyte viability and review of the literature. *Dermatol Surg* 2001;27:819–826.
34. Sommer B, Sattler G. Current concepts of fat graft survival: histology of aspirated adipose tissue and review of the literature. *Dermatol Surg* 2000;26:1159–1166.
35. von Heimburg D, Pallua N. Two-year histological outcome of facial lipofilling. *Ann Plast Surg* 2001;46:644–646.
36. Pessa JE, Desvigne LD, Lambros VS, Nimerick J, Sugunan B, Zadoo VP. Changes in ocular globe-to-orbital rim position with age: implications

for aesthetic blepharoplasty of the lower eyelids. *Aesthetic Plast Surg* 1999;23:337–342.
37. Pessa JE, Desvigne LD, Zadoo VP. The effect of skeletal remodeling on the nasal profile: considerations for rhinoplasty in the older patient. *Aesthetic Plast Surg* 1999;23:239–242.
38. Pessa JE. An algorithm of facial aging: verification of Lambros's theory by three-dimensional stereolithography, with reference to the pathogenesis of midfacial aging, scleral show, and the lateral suborbital trough deformity. *Plast Reconstr Surg* 2000;106:479–488.
39. Pessa JE, Chen Y. Curve analysis of the aging orbital aperture. *Plast Reconstr Surg* 2002;109:751–755.
40. Rose Jr JG, Lucarelli MJ, Lemke BN, Dortzbach RK, Boxrud CA, Obagi S, et al. Histologic comparison of autologous fat processing methods. *Ophthal Plast Reconstr Surg* 2006;22:195–200.
41. Serra-Renom JM, Fontdevila J. Treatment of facial fat atrophy related to treatment with protease inhibitors by autologous fat injection in patients with human immunodeficiency virus infection. *Plast Reconstr Surg* 2004;114:551–555.
42. Coleman SR. Long-term survival of fat transplants: controlled demonstrations. *Aesthetic Plast Surg* 1995;19:421–425.
43. Coleman SR. Facial recontouring with lipostructure. *Clin Plast Surg* 1997;24:347–367.
44. Coleman SR. Structural fat grafts: the ideal filler? *Clin Plast Surg* 2001;28:111–119.
45. Fontdevila J, Milinkovic A, Martinez E. Clinical classification of facial lipoatrophy in HIV-infected patients. *Antivir Ther* 2003;8:L81 [abstr].
46. Fontdevila J, Martinez E, Rubio-Murillo JM, Milinkovic A, Serra-Renom JM, Gatell J. A practical classification for the surgical filling of facial lipoatrophy. *Antivir Ther* 2005;10:L28 [abstr].
47. Carraway JH, Mellow CG. Syringe aspiration and fat concentration: a simple technique for autologous fat injection. *Ann Plast Surg* 1990;24:293–296.
48. Ellenbogen R. Free autogenous pearl fat grafts in the face—a preliminary report of a rediscovered technique. *Ann Plast Surg* 1986;16:179–194.
49. 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.
50. 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.
51. Har-Shai Y, Lindenbaum ES, Gamliel-Lazarovich A, Beach D, Hirshowitz B. An integrated approach for increasing the survival of autologous fat grafts in the treatment of contour defects. *Plast Reconstr Surg* 1999;104:945–954.
52. Milinkovic A. HIV-associated lipodystrophy syndrome. *Coll Antropol* 2006;30(suppl 2):59–62.
53. Waters L, Nelson M. Long-term complications of antiretroviral therapy: lipoatrophy. *Int J Clin Pract* 2007;61:999-1014.
54. Markman B. Anatomy and physiology of adipose tissue. *Clin Plast Surg* 1989;16:235–244.
55. Guaraldi G, De Fazio D, Orlando G, Murri R, Wu A, Guaraldi P, et al. Facial lipohypertrophy in HIV-infected subjects who underwent autologous fat tissue transplantation. *Clin Infect Dis* 2005;40:e13–e15.
56. Fontdevila J, Martinez E, Rubio-Murillo JM, Serra-Renom JM, Gatell J. Factors involved in the lipohypertrophy in facial fat grafting for the treatment of the lipoatrophy. *Antivir Ther* 2006;11:L59 [abstr].
57. Levan P, Nguyen TH, Lallemand F, Mazetier L, Mimoun M, Rozembaum W, Girard PM. Correction of facial lipoatrophy in HIV-infected patients on highly active antiretroviral therapy by injection of autologous fatty tissue. *AIDS* 2002; 16(14):1985–1987.
58. Caye N, LeFourn B, Pannier M. Traitement chirurgical des lipoatrophies facials. *Ann Chir Plast Esthét* 2003; 48:2–12.
59. Fontdevila J, Milinkovic A, Martinez E, Yoon TS, Gatell JM, Serra JM. Treatment of facial lipoatrophy by injection of autologous adipose tissue. *Antivir Ther* 2003; 8:L76 [abstr].
60. Guaraldi G, Orlando G, De Fazio D, Vigo M, De Lorenzi I, Rottino A et al. Autologous fat transfer for the treatment of HIV-related face lipoatrophy: a long follow up experience. *Antivir Ther* 2004; 9(6):L50 [abstr].
61. Burnouf M, Buffet M, Schwarzinger M, Roman P, Bui P, Prévot M, Deleuze J, Morini JP, Franck N, Gorin I, Dupin N. Evaluation of Coleman lipoestructure for treatment of facial lipoatrophy in patients with human immunodeficiency virus and parameters associated with the efficiency of this technique. *Arch Dermatol* 2005;141:1220–1224.
62. Valantin MA, Aubron-Olivier C, Ghosn J, Laglenne E, Pauchard M, Schoen H, Bousquet®, Katz P, Costagliola D, Katlama C. Polytactic acid implants (New-Fill)® to corrrect facial lipoatrophy in HIV-infected patients: results of the open-label study VEGA. *AIDS* 2003;17:2471–2477.
63. Moyle GJ. Bridging a gp: surgical management of HIV-associated lipoatrophy. *AIDS Read* 2004;14(9):472–475.
64. Talmor M, Hoffman LA, LaTrenta GS. Facial atrophy in HIV-related fat redistribution syndrome: anatomic evaluation and surgical reconstruction. *Ann Plast Surg* 2002;49:11–18.
65. James J, Carruthers A, Carruthers J. HIV-associated facial lipoatrophy. *Dermatol Surg* 2002;28:979–986.
66. Jones D. HIV facial lipoatrophy: causes and treatment options. *Dermatol Surg* 2005; 31(11 Pt 2):1519–1529.
67. Gooderham M, Solish N. Use of hyaluronic acid for soft tissue augmentation of HIV-associated facial lipodystrophy. *Dermatol Surg* 2005;31(1):104–108.
68. Burgess CM, Quiroga RM. Assessment of the safety and efficacy of poly-L-lactic acid for the treatment of HIV-associated facial lipoatrophy. *J Am Acad Dermatol* 2005;52:233–9.
69. Mole B. [Lasting treatment of facial HIV and non HIV lipoatrophies through the use of SAM GoreTex malar implants and polyacrylamide hydrogel filler Eutrophill. About 90 consecutive cases]. *Ann Chir Plast Esthet* 2006;51(2):129–141.
70. Treacy P, Goldberg DJ. Use of a biopolymer polyalkylimide filler for facial lipodystrophy in HIV-positive patients undergoing treatment with antiretroviral drugs. *Dermatol Surg* 2006;32:804–808.

Accepted for publication May 8, 2008.

Reprint requests: Mauricio Raigosa, MD, Servicio de Cirugía Plástica y Reparadora, Hospital Clinic, C/ Villarroel 170, 08036, Barcelona, Spain. E-mail: mauroraigosa@gmail.com.

1090-820X/$34.00

doi:10.1016/j.asj.2008.05.002