A Clinical Trial in Facial Fat Grafting: Filtered and Washed versus Centrifuged Fat

Foot

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Background: Although the increasing trend is to rebuild facial soft-tissue volume with autologous fat transfer, there is no agreement concerning the best way of processing the harvested fat before reinjecting it. Among all the reported fat graft processing techniques, in the present study, the authors compared the clinical results obtained using simple filtered and washed fat with those achieved by means of pure centrifuged fat.
Methods: A prospective double-blind study was conducted on 25 healthy patients undergoing facial fat transplantation from January of 2006 to June of 2006. During the same session, half the face was injected with simple filtered and washed fat, and the other half was instead treated with centrifuged fat. Subjective and objective methods were used to evaluate the results. The subjective methods included a questionnaire, sent to all patients, accompanied by an explanatory letter. The objective method involved the evaluation of preoperative and postoperative photographs by a three-member jury. The average follow-up period was 12 months.
Results: The authors' experimental work demonstrates that there was no significant difference between the two fat-processing techniques. In the long term, the implanted hemifacial regions produced comparable results.
Conclusion: The authors, following their personal experience based on the reported data, went back to using the simple filtered fat after some years of use of centrifuged fat. (*Plast. Reconstr. Surg.* 127: 1, 2011.)

For more than a century, clinicians have attempted to use fat for the treatment of tissue deficiencies and contour abnormalities.[1] Autologous fat transplantation has been used to correct subcutaneous lipoatrophy resulting from acne, trauma, lipodystrophy, hemifacial atrophy, cutaneous lupus erythematosus, and scleroderma[2] and defects resulting from accident, infection, or surgery.[3,4]

However, autologous fat transfer for facial contouring has become popular in plastic surgery only in the past 20 years.[5] In fact, surgeons have understood that aging of the face is not attributable to gravity-induced ptosis alone, but is also a consequence of volume loss caused by tissue atrophy.[1] Thus, volume replacement is the aim of the hereby presented treatment. The use of adipose tissue for this purpose has become the preferred option, as it is readily available, inexpensive, host-compatible, and can be harvested easily and repeatedly when needed,[6] without fear of allergies or foreign body reactions.[7]

Despite clinical optimism associated with autologous fat transfer, uncertainty remains among practitioners regarding the viability of transplanted fat.[8] There is no set way of processing fat to ensure the graft's viability and optimal take,[9] although various preparation techniques have been suggested for improving the long-term survival of fat grafts.[10]

Suggested "cleansing" procedures have included centrifugation,[11–15] simple decantation,[7] vigorous washing,[16,17] no washing at all,[18] and dense-cloth fat concentration.[19] Treatments with such substances as growth factors, β-blockers, insulin, growth media, and even hyperbaric oxygen have been attempted.[20,21] No consistent evidence exists that any of these maneuvers is superior to the others, nor is there universal agreement on what constitutes an ideal method of preventing irregular graft reabsorption.[10]

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The purpose of this study was to evaluate the outcomes of the two most common fat-grafting procedures for soft-tissue augmentation in the facial region. The two chosen procedures were (1) filtration and cleansing and (2) centrifugation. Each patient was treated with fat processed by filtration and cleansing on the left side of the face and centrifugation on the right side.

PATIENTS AND METHODS

An open controlled study was carried out on 25 healthy patients undergoing facial fat transplantation from January of 2006 to June of 2006. The patients' average age was 46.3 years (range, 21 to 72 years). All but four patients were women. The study was approved by the appropriate institutional review boards. Each patient was informed fully regarding the aim of the study, including the possibility that fat grafting might have to be repeated, if necessary. All patients underwent a single fat transplant procedure.

Contraindications included chemotherapy, radiotherapy, chronic use of steroids, connective-tissue diseases, chronic blood abnormalities, and other systemic metabolic disorders, including diabetes, a history of obesity or body dysmorphic disorder, and anticoagulant treatment. The presence of asymmetric facial features was the most important exclusion criterion in this study.

Each patient was examined preoperatively to precisely evaluate and mark any area to be treated (Fig. 1). At this time, the total amount of fat to be transplanted into each area of the face was estimated. A mirror was found useful to help fully understand what the patients actually saw and what they expected.[22] Fat was collected by liposuction performed on the abdomen, knees, or thigh regions using the superwet technique. In thinner patients, several areas often had to be harvested to obtain an adequate amount.

Under light sedation, the area to be suctioned was first infiltrated by means of a 3-mm Klein cannula with anesthetic solution consisting of saline with 0.25% mepivacaine and 1:500,000 epinephrine in a ratio of 1 ml of solution for 1 ml of tissue to be aspirated. Fat harvesting was performed using a 2-mm, two-hole, blunt microcannula attached to a 10-ml Luer-Lok syringe under manual regulation of negative pressure, not exceeding 2 cc.

The cannula had two large openings near the tip that helped remove fat less traumatically. Hand-syringe liposuction was preferred for a more delicate suction (Fig. 2). The mean quantity of harvested fat was 55 ml (range, 35 to 68 ml).

Fat Processing

Half the aspirated fat was filtered under sterile conditions using a common strainer and then washed with 0.9% saline solution (Fig. 3). A 1:4 aspirated fat–to–saline solution ratio was used (i.e., for every 10 ml of fat, 40 ml of saline solution was used).

A strainer was used to concentrate the fat particles and separate them from fluids, oil, and debris. The following washing was to eliminate any residual foreign substances. The last step consisted of gently tapping on the bottom part of the strainer with a large sterile gauze to accurately dry

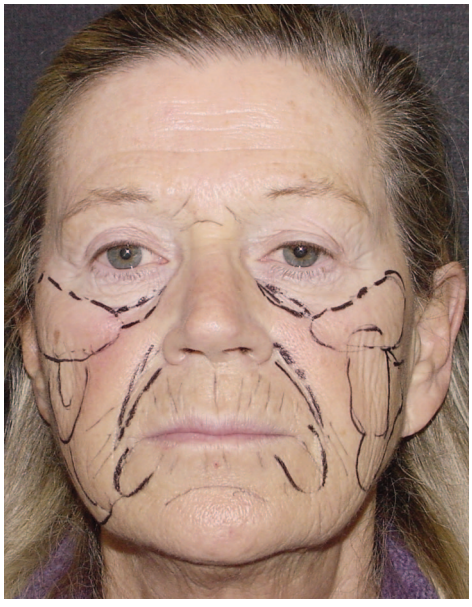

Fig. 1. Precise preoperative marking of the facial area to be treated.

Fig. 2. Hand-syringe liposuction is preferred because it is thought to provide a more delicate suction.

Fig. 3. Half the aspirated fat was filtered under sterile conditions using a common strainer and then washed with 0.9% saline solution.

F4 the fat (Fig. 4). The degree of fat drying can be varied; in fact, the more this absorbing maneuver is repeated, the dryer the fat becomes, until it reaches a semisolid state with truly minimal water
F5 content (Fig. 5).

The purified fat was then collected using a sterile surgical spoon and placed in a 10-cc Luer-Lok syringe. The remaining half of the aspirated fat (to be inserted into the other half of the face) was processed by centrifugation; the aspirated fat, collected in syringes, was spun at 3000 rpm for 3 minutes to separate the fat into a top layer of oil from ruptured adipocytes, a middle layer of usable fat tissue, and a bottom layer of blood and tumescent solution. The purified fat tissue, obtained

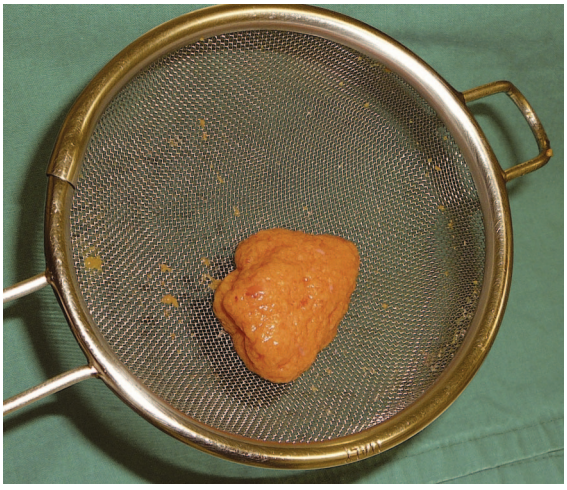

Fig. 4. The last step consists of gently tapping on the bottom part of the strainer with by a large sterile gauze to accurately dry the fat.

Fig. 5. By subjecting the fat to other drying processes, we can modify the fat to a semisolid state with truly minimal water content.

from the two above-described treatments, was transferred from the 10-cc syringes into the 1-cc syringes through a two-way connector (Fig. 6). The F6 centrifuged fat was carefully kept separated from the washed and filtered fat.

Fat Injection

Each patient was treated with filtered and washed fat on the left side of the face, whereas only centrifuged fat was used on the right side. The fat was injected through a 1-, 1.5-, or 2-mm blunt-tip cannula, with a lateral opening. The graft was performed following the principles of structural fat grafting.[23] The fat grafting should be performed very gently while withdrawing the cannula

Fig. 6. The purified fat tissue was transferred from the 10-cc syringes into the 1-cc syringes through a two-way connector.

by applying a slight pressure; a very regular layer of tiny particles of viable fat tissue can thus be deposited precisely and multiple strips injected on different levels in each area, fanning out from the entrance site (Fig. 7). Data on the amount of fat transplanted per facial aesthetic subunit are shown in Figure 8. These quantities were equal on both sides of the face.

Postoperative care consisted of applying small Steri-Strips (3M, St. Paul, Minn.) to seal the cannula entrance sites and administering systemic antibiotic therapy. The transplanted areas were kept cool by means of ice packs for 20 to 30 minutes after the procedure and were iced for 15 to 20 minutes per hour for the following 5 to 7 hours; paper tapes and a light compression garment were used in the aspirated districts.

Photographs were obtained preoperatively and systematically at 2, 6, 12, and 24 months postoperatively. Position, facial expression, focal distance, and camera settings were standardized.

Subjective and objective methods were used to assess the results of the operation. The subjective method was a self-assessment obtained from patients through a questionnaire sent to them together with an explanatory letter after a 6-month follow-up period, once the surgical results were considered stabilized (Table 1). The questionnaire concerned the following:

1. The general level of satisfaction for each side (possible answers: good, sufficient, bad).
2. The presence of notable asymmetries in terms of volume of the treated areas (possible answers: yes in one region, yes in several regions, no).
3. The presence of deformities, nodules, thickened areas, ecchymosis, pain on either side (possible answers: yes, no).
4. The level of improvement of skin texture (possible answers: high, medium, absent).
5. Their level of satisfaction scoring from 0 (very bad) to 10 (very good), both globally and for 10 specific areas (i.e., temporal area, eyelids, malar zone, tear trough, cheek, nasolabial fold, lips, mandible, marionette fold, and chin) on the left and the right sides (Table 2).

Fig. 7. The fat was injected with a 1-, 1.5-, or 2-mm cannula following the principles of structural fat grafting.

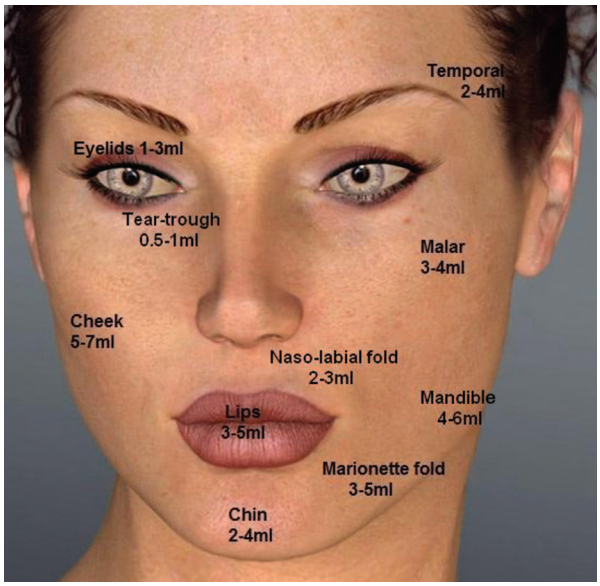

Fig. 8. Data on the amount of fat transplanted per facial aesthetic subunit.

The objective method was basically a questionnaire identical to item 5 of the one given to patients (Table 3). This form was submitted to three independent observers, a three-member jury, uninformed both on the aim of this study and on the surgical techniques. The independent observers were a surgeon, a nurse, and a makeup artist. Two photographs of each patient were presented side by side on a computer screen: on the left was a preoperative photograph and on the right was a postoperative photograph (6 months later). The two photographs had the same dimensions and similar brightness and contrast. The images were presented on PowerPoint slides (Microsoft Corp., Redmond, Wash). The duration of each case presentation was 30 seconds. The observers were asked to give a score from 0 to 10 for the overall aspect and to the 10 specific areas listed above.

Statistical analyses were performed by means of the Wilcoxon signed ranks test (paired for the

Table 1. Subjective Assessment: Questions and Possible Answers Included in the Questionnaire

Question	Possible Answers	Left Side (Filtered and Washed) (%)	Right Side (Centrifuged) (%)	*p*
1. General level of satisfaction	Good	17 (68)	18 (72)	0.317
	Sufficient	5 (20)	4 (16)	
	Bad	3 (12)	3 (12)	
2. Notable side differences of volume	Yes, in 1 region	1 (4)	1 (0)	1.000
	Yes, in >1 region	0 (0)	0 (0)	
	No	24 (96)	24 (100)	
3. Notable irregularities	Deformities	1 (4)	1 (4)	1.000
	Nodules	3 (12)	0 (0)	0.235
	Thickened areas	4 (16)	4 (16)	1.000
	Ecchymosis	7 (30)	5 (20)	0.742
	Pain	2 (8)	2 (8)	1.000
4. Level of improvement for skin texture	High	17 (68)	18 (72)	0.317

Table 2. Subjective Assessment: Patient Satisfaction per Area

Question 5	Left Side (Filtered and Washed) (mean ± SD)*	Right Side (Centrifuged) (mean ± SD)*	*p*†
Temporal	6.2 ± 1.4	6.7 ± 1.5	0.065
Eyelids	8.8 ± 1.2	9.1 ± 1.3	0.378
Malar	8.9 ± 1.2	8.7 ± 1.3	0.485
Tear trough	8.5 ± 1.5	8.5 ± 1.5	0.792
Cheek	7.2 ± 2.0	7.0 ± 2.2	0.611
Nasolabial fold	7.6 ± 2.1	7.9 ± 2.0	0.426
Lips	6.1 ± 2.0	6.7 ± 2.0	0.010
Mandible	7.4 ± 1.7	7.6 ± 1.8	0.357
Marionette fold	7.9 ± 2.0	7.6 ± 2.1	0.253
Chin	7.4 ± 1.8	7.2 ± 1.7	0.334
Global	7.5 ± 1.9	7.6 ± 1.9	0.867

*Score, 0 to 10.
†Wilcoxon signed ranks test.

Table 3. Objective Assessment: Independent Observers' Satisfaction per Area

Evaluation of Independent Observers	Left Side (Filtered and Washed) (mean ± SD)*	Right Side (Centrifuged) (mean ± SD)*
Temporal	6.0 ± 2.0	6.3 ± 2.1
Eyelids	8.7 ± 1.2	9.0 ± 1.0
Malar	9.3 ± 1.2	9.0 ± 1.0
Tear trough	8.7 ± 1.2	8.7 ± 1.2
Cheek	7.0 ± 1.0	6.7 ± 0.6
Nasolabial fold	6.7 ± 0.6	6.7 ± 0.6
Lips	6.3 ± 1.5	6.3 ± 1.5
Mandible	7.7 ± 1.5	8.7 ± 1.2
Marionette fold	7.7 ± 2.0	7.7 ± 2.1
Chin	7.0 ± 1.0	7.0 ± 1.0
Global	7.7 ± 0.6	8.0 ± 1.0

*Score, 0 to 10.

two face sides of the same subject) for questions 1, 2, 4, and 5 of the patients' questionnaire; a Fisher's exact test was used for question 3. Finally, only descriptive statistics were used for the objective assessment because of the reduced sample size of the observers. A value of $p < 0.05$ was considered significant.

RESULTS

In our study, only plain photographs for the evaluation of the aesthetic results were used, without the aid of any imaging diagnosis (e.g., ultrasound, magnetic resonance imaging, or three-dimensional scans). Results are shown in Figures 9 through 12. A good level of patient satisfaction was recorded for both face sides. F9-12

Three patients reported a low level of satisfaction bilaterally. Furthermore, only two patients reported to have noted a volume difference on the two sides. The rest of the irregularities were bilateral, with the exception of nodules, which were recorded on only the left (filtered and washed) side. These nodules were in the lower eyelid region in two patients and in the tear trough region in one patient. Furthermore, medium or high skin texture improvement was achieved bilaterally (Table 1). Dividing patient satisfaction level by area, the results were not significantly different between the left and right sides, with the exception of a single significant difference recorded at the lip level (Table 2). The results of the objective assessment were similar to those of the patients (Table 2). In fact, both patients and observers assigned very high scores to the periorbital (eyelids, malar, and tear trough areas) and the mandibular regions and marionette fold, whereas the temporal regions and lips received the lowest scores. No donor- or recipient-site complications such as necrosis, infections, hematoma, seroma, cyst formation, or vascular/nervous injury were noted.

DISCUSSION

Adipose tissue may be an ideal substance for facial soft-tissue augmentation. Lipofilling is a quick, safe, and inexpensive way of restoring vol-

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Fig. 9. (*Left*) A 58-year-old woman after lipostructure of the lower eyelid and the cheek and temporal regions. (*Right*) Postoperative result 12 months after the grafting procedure.

Fig. 10. (*Left*) A 67-year-old woman after lipostructure of the malar and tear trough areas, cheek region, marionette and nasolabial folds, and lips. (*Right*) Postoperative result 12 months after the grafting procedure.

ume in the aged face.[1] Despite the clinical optimism associated with autologous fat transfer, uncertainty remains among practitioners regarding the viability of grafted fat.[8]

Over the past 20 years, several different lipoinjection techniques have been developed, but a standard procedure has not yet been adopted by all practitioners. There is no agreement as to the best way of processing the fat to ensure maximal take and viability.[9]

Centrifugation and filtration/washing are ways of fat graft processing to be evaluated and compared.[5] To separate fat cells from debris to decrease inflammatory response,[24,25] a number of authors advocate washing the fat with saline solution,[16,17,26–29] whereas others recommend

AQ: 3

Fig. 11. (*Left*) A 48-year-old woman demonstrating cervicofacial lift and lipostructure of the cheek region. (*Right*) Postoperative result 12 months after the grafting and surgical procedures.

Fig. 12. (*Left*) A 52-year-old man with significant postacne sequelae; lipostructure of cheek region is shown. (*Right*) Postoperative result 12 months after the grafting procedure.

centrifugation.[11–15] Although some claimed that the presence of blood in the injected fat would stimulate macrophage activity to remove fat cells,[30] the actual effect of blood in the graft has not yet been clearly elucidated.[31]

Coleman stressed the importance of removing nonviable fat aspirate components such as oil, blood, and lidocaine by centrifugation.[11] He reports high physician and patient satisfaction from his "structural fat grafting" technique.[5] This method has gained widespread clinical application and has become fundamental to many techniques described by numerous other authors.[22,32–34]

Centrifugation has been challenged by Rohrich et al.,[35] who found the centrifugation technique laborious and cumbersome and with a

fat survival rate no better than that for filtration. Ramon et al.[36] used a naked mouse model to examine the survival of fat grafts, comparing centrifugation with the use of a sterile cloth as an absorbent platform to concentrate the fat cells, separating them from fluids, oil, and debris. After 16 weeks, they found no significant differences in fat graft weight and volume. By the end of this study, the authors reported a clear tendency to better survival of the newly implanted fat cells treated with the cotton towel technique.

Karacalar et al.[37] promoted fat harvesting in a bloodless field using a pneumatic tourniquet, thus eliminating the need for further processing or centrifugation. Marques et al.[38] reported increased graft survival rates after washing performed by lactated Ringer's solution.

An interesting study by Smith et al.[39] evaluated the effects of different harvesting and preparation techniques on human fat viability. The authors concentrated on six different fat preparation techniques and reported no significant differences in fat cell viability, as assessed by graft weight stability or histologic evaluations.

Khater et al.,[40] in a clinical and experimental study, presented their experience with two different techniques of fat processing: centrifugation and serum washing. The authors concluded that in noncentrifuged adipose tissue, more active preadipocytes are found, which could possibly lead to enhanced chances of survival and even development of de novo fat.

A recent study by Condé-Green et al.[7] compared the influence of the three most used fat-processing techniques (i.e., decantation, washing, and centrifugation) on the viability and number of adipocytes and mesenchymal stem cells in the aspirated fat. They conclude that washing is the best processing method for adipose tissue grafting, as it maintains adipocyte integrity and number, clears the fat of most blood contaminants, and has a greater number of endothelial cells and mesenchymal stem cells.

Some authors[41–45] advocate using newly emerging approaches where fat tissue engineering principles are applied. These approaches are sophisticated, complex, and expensive.[9]

Among all the reported techniques for fat graft processing, we decided to evaluate the two most common fat grafting procedures for soft-tissue augmentation by comparing clinical results obtained by means of simple filtered and washed fat with those achieved by fat centrifugation.

This experimental study, where half the face was treated with the first technique (filtered and washed fat) and the other half was instead grafted with centrifuged fat, demonstrates no significant difference between the two fat-processing methods. In fact, the long-term results in the two implanted hemifacial regions produced virtually identical results in the subjective evaluations of both patients and surgeons in a double-blind study. Because of the results obtained, the authors went back to using the simple fat filtration technique after some years of using centrifuged fat. Besides filtered fat being simpler and easier to obtain, it allowed the authors to achieve very good results for more than 25 years.

In any case, centrifuged fat proved itself more effective and safer than any otherwise-treated fat in the augmentation of the periorbital region because of its smoother consistency. The periorbital region is often suitable for lipofilling[1] but shows a very high risk of developing nodules of adipose tissue and other irregularities visible in tangential perspectives.[22] Centrifugation leads to fat homogenization, thus granting smoother filling of the eyelid and tear trough regions and allowing a precise injection of very small doses of fat.

These clinical results are confirmed by a microscopic examination of unfixed fat. There is an evident difference between filtered and centrifuged fat, with the filtered one presenting more granularity.

Furthermore, it appears that a larger quantity of adipocytes per cubic centimeter is injected when using filtered fat compared with the centrifuged one. The amount of injected fat must necessarily be moderate. If excessive quantities are introduced, even if distributed on different planes and areas, the fat will not be adequately vascularized and will therefore be subject to a high degree of necrosis and reabsorption.

CONCLUSIONS

Regarding lipofilling outcomes using filtered versus centrifuged fat, both the subjective self-evaluation by patients and the objective assessment by a three-member jury lead to the conclusion that the two fat-processing methods considered in this study yield results with similar quality. Although in the majority of cases excellent results with nearly complete revascularization were achieved in the transplanted fat, in a limited number of patients, there was severe reabsorption of the injected fat. This phenomenon took place uniformly and symmetrically on both sides of the face, regardless of the fat-processing methods used. One may therefore conclude that reabsorption or survival rate of aspirated fat cell grafts depends not on the process-

ing method but on other factors, probably related to each subject's fat anatomical/physiologic features and to the quality of the recipient site.

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PATIENT CONSENT

Patients provided written consent for the use of their images.

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AUTHOR QUERIES

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