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Power-Assisted Liposuction and Lipofilling: Techniques and Experience in Large-Volume Fat Grafting

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Abstract

Background: Power-assisted liposuction and lipofilling (PALL) is a simple and reproducible surgical technique for large volume fat grafting.

Objectives: The authors share their 7-year experience with their large-volume fat transfer technique, PALL.

Methods: A total of 417 patients who underwent PALL-related surgeries involving the breast and buttock were evaluated in a retrospective study. Liposculpting and fat harvesting were performed with power-assisted liposuction. Fat was transferred with simultaneous power-assisted vibration and tunnelization to provoke expansion of the recipient site. Following lipofilling, additional external vibration of the recipient site was performed to enhance diffusion of the injected fat.

Results: Liposuction volumes up to 5000 mL were recorded, and injection volumes ranged from 300 to 900 mL per side for each session. Operating times ranged from 45 to 120 minutes. Patients were followed-up for 1 to 4 years. No major complications were recorded.

Conclusions: PALL is an efficient, safe, and reproducible procedure with myriad applications in aesthetic and reconstructive surgery.

Level of Evidence: 4

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In aesthetic and reconstructive surgery, autologous fat grafting is an accepted method for correcting contour and volume abnormalities.[1] Fat transfer techniques are utilized in breast augmentation and reconstruction, face and body contouring, gluteal augmentation, and treatment of posttraumatic deformities, congenital anomalies, and burn injuries.[2–8] Mojallal et al[9] showed that manual and power-assisted liposuction techniques yield aspirates with higher cell yields that, when transferred, have better viability and less resorption compared with syringe-aspirated fat. Keck et al[10] isolated adipose-derived stem cells (ASCs) from fat harvested by power-assisted liposuction or manual aspiration and concluded that power-assisted liposuction collects viable ASCs and is suitable for fat harvesting. ASCs harvested by power-assisted liposuction express significantly higher levels of differentiation markers than do cells harvested by manual aspiration, suggesting that fat transferred from the products of power-assisted liposuction could develop into mature adipocytes more rapidly.[10]

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Traditional procedures for harvesting and injecting large volumes of fat involve long operating times and are associated with surgeon fatigue. Although power-assisted liposuction is a well-known technique,[10–14] the harvesting and transfer of large volumes of fat with power-assisted technology are less common. We developed a technique of large-volume autologous fat grafting that involves power-assisted liposuction and lipofilling (PALL); we have performed this technique successfully in various anatomic areas for >8 years.[13,15] We utilize the Lipomatic Eva SP (Euromi SA, Verviers, Belgium), a powered liposuction instrument in which suction pressure and vibration pressure can be modulated. In our experience, PALL enhances tissue competency for large-volume fat transfer without compromising safety or increasing the operating time. Fat transplantation with PALL is simple, reliable, and efficient.

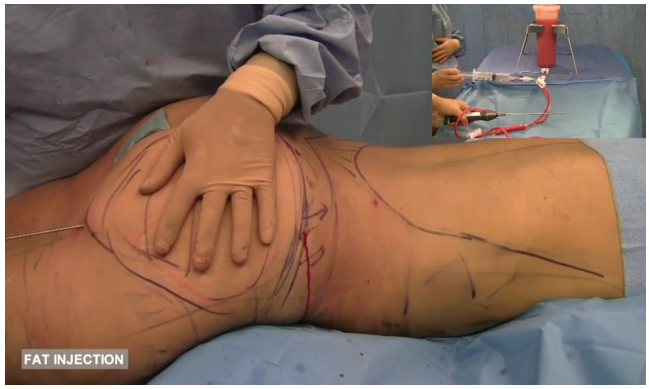
A crucial step in our method of PALL is vibration and tunnelization in the recipient site; this expands the recipient tissues, increasing the volume of fat that can be transferred and facilitating close contact between the graft and recipient matrix. Following transfer of autologous fat, external vibration is carried out. This enhances diffusion of fat throughout the recipient site. Herein, we describe our application of PALL in patients who underwent large-volume fat grafting for breast augmentation, breast reconstruction, or gluteal augmentation. PALL also is indicated for arm contouring.

METHODS

Patients and Study Design

In this retrospective study, the authors reviewed medical records of 417 women who underwent PALL from January 2009 to December 2015. Eighty patients underwent breast augmentation, 227 received breast reconstruction, and 110 underwent gluteal augmentation. Approval from an institutional review board or ethics committee was not obtained because all patients were treated in a private practice. The study was conducted in accordance with guidelines set forth in the Declaration of Helsinki. Patients received detailed information regarding each surgical procedure, and all patients provided written informed consent. Preoperative photographs of all patients were obtained.

All breast augmentations performed in this study constituted revisional surgeries. Patients who underwent power-assisted fat transfer to the breast requested a natural-appearing, ptotic breast with a volume that was the same or slightly smaller than that achieved with the previous breast surgery. Patients wished to undergo explantation because of unsatisfactory outcomes, such as capsular contracture, pain, or excessive upper-pole fullness, or concerns that the augmented breast shape was no longer compatible with the patient's age. Current smoking and a history of heavy smoking (≥20 cigarettes per day for >5 years) were considered contraindications for this procedure and were exclusion criteria for this part of the study. The bra cup size was determined preoperatively and 6 months postoperatively.



Video. Watch now at https://academic.oup.com/asj/article-lookup/doi/10.1093/asj/sjz019.

Patients in the breast augmentation group who had inconclusive or suspicious preoperative ultrasonography and/or mammography results underwent a magnetic resonance imaging (MRI) scan preoperatively and at 12 months postoperatively. These patients' preoperative and 12-months-postoperative breast volumes and fat resorption rates also were measured.

Breast reconstruction procedures included immediate or delayed, unilateral or bilateral reconstruction with or without radiotherapy and/or breast implant placement. Exclusion criteria were: (1) severe skin damage secondary to breast radiotherapy, in which damaged breast skin had to be excised; and (2) loss to follow-up before 1 year postoperatively. Fat resorption analysis and MRI were not performed in the breast reconstruction group.

Gluteal augmentation procedures were performed in patients who were healthy and presented with mild to moderate excess fat in the sacral, posterior, and lateral flank areas. Contraindications for this procedure and exclusion criteria for this part of the study were current smoking or a history of heavy smoking (ie, ≥20 cigarettes per day for >5 years).

Surgical Procedures

Operations were performed under general anesthesia, with the patient in the supine position for breast augmentation/reconstruction or the prone and supine position for gluteal augmentation. A video demonstrating the gluteal augmentation technique is available as Supplementary Material online at www.aestheticsurgeryjournal.com.

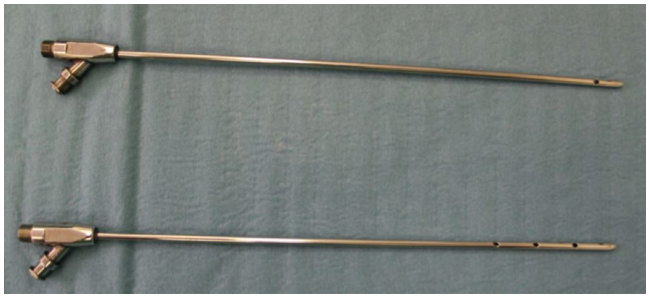


Figure 1. Cannulae utilized for fat harvesting and injection. Each cannula is 3 mm in diameter and 25 cm long. The harvesting cannula contains 9 holes, and the injection cannula contains 3 holes.

Fat Harvesting

The Lipomatic Eva SP system was applied to infiltrate the donor sites with Klein's solution, harvest the lipoaspirate, and transfer the prepared adipose tissue to the recipient site. For fat harvest, a 3-mm, multiple-hole cannula attached to a handpiece and set to 3 bars (vibrating pressure) and 0.7 atm (suction pressure) was guided through several access incisions (Figure 1). A suction pressure of 0.7 atm has been shown to be safe in terms of preserving fat viability.[16] Erdim et al[17] found that liposuction employing a larger cannula produces more viable fat grafts than does liposuction with a smaller cannula.

Fat Preparation

Processing a large volume of fat by centrifugation can increase the operating time dramatically.[18] Instead of centrifugation, we prepared fat by sedimentation in a closed system; this process also has the benefits of preventing compaction of the adipose tissue and preserving its capacity to diffuse into the recipient site. However, dilute fat has a high resorption rate. Therefore, we injected a slight excess of prepared fat to account for some loss to resorption.

In the initial phases of development of the PALL technique, we allowed fat to decant and then transferred it to sterile 60-mL syringes. However, in the past 2 years, we have revised this method. We now utilize a closed system for collection and transfer of fat. The closed system is more practical; lipoaspirate remains in the collection bottle and does not need to be moved into large syringes for transfer. The system consists of a canister with a built-in filter through which adipose tissue is isolated. Excess liquid collects at the bottom of the container, and the resulting fat remains dilute.

Recipient Site Preparation and Fat Transfer

Fat injection was carried out with the Lipomatic Eva SP system disconnected from its suction system but with vibrational power (3 bars) still enabled. Contacts between the transferred adipose tissue and the recipient site were maximized by power-assisted tunnelization at multiple access points[13,15] and by multilayered and multidirectional delivery of fat in the subcutaneous plane by means of a V-shaped, 3-mm, multiple-hole cannula (designed by M.A.) (Figure 1). Vibration of the recipient site during injection of fat increases its capacity, enabling dispersion of fat through the subcutaneous space and preventing the coalescence of fat lobules.[19] These maneuvers have been shown to encourage revascularization and improve the survival of grafted fat.[17,20,21]

Our PALL technique includes safeguards against the high compartmental pressures that can be created in the fat injection process. Tunnelization and tissue vibration were achieved with rapid back-and-forth motions of the cannula. The prepared adipose tissue then was injected under low pressure. This avoids damage to fat cells without compromising speed and precision of fat injection. Because the fat tissue was dilute, fluid resorption in the recipient site protected against high pressures that could otherwise reduce viability of the fat lobules.

During gluteal augmentation, steps were taken to avoid pulmonary fat emboli, which could be fatal.[22] Specifically, we did not inject fat into the deep muscle, we did not perform downward motion of the cannula, and the vibrational movement and rigidity of the cannula connected to the handpiece prevented large-bolus injections of adipose tissue into the vessels.

Fat grafts become vascularized by approximately day 7 posttransplantation.[23] Our procedure allows adequate time for fluid in the dilute fat to be absorbed so that it does not interfere with contact between the graft and the recipient site.

External Vibration

Following completion of fat injection, the Lipomatic Eva SP vibrating handpiece (set to 6 bars) was placed externally on the recipient site over absorbent gauze. This procedure further enhanced diffusion and distribution of fat in the recipient site. External vibration was continued until the recipient site was soft on palpation. Entry wounds then were closed with simple sutures, and a dressing was applied.

Postoperative Care

For patients in the breast augmentation group, fat resorption was estimated 6 months postoperatively by measuring the patient's bra cup size and comparing it with the preoperative cup size.

Assessment of Satisfaction

A questionnaire was prepared by the authors as a means to ascertain patient satisfaction. The questionnaire

Table 1. Patient Demographics

	Breast augmentation group	Breast reconstruction group	Buttock augmentation group	Overall
No. of patients	80	227	110	417
No. of breasts	160	262	NA	422
No. of buttocks	NA	NA	110	110
Mean age, y (range)	42 (25–68)	51 (38–70)	34 (24–55)	45.8 (24–70)
Mean BMI, kg/m^2 (range)	26 (23–35)	26 (20–35)	30 (26–36)	27 (20–36)
Mean injection volume, mL/breast (range)	420 (300–600)	300 (200–700)	450 (300–900)	362.6 (200–900)
Mean implant volume, mL (range)	275 (200–400)	NA	NA	275 (200–400)
Mean operating time, min (range)	65 (45–90)	85 (45–180)	70 (60–120)	77.2 (45–180)
No. of sessions, (range)	1	1.1 (1–2)	1.2 (1–2)	1.1 (1–2)
Mean follow-up, y (range)	2 (1–4)	2 (1–4)	3 (1–5)	2.2 (1–5)

BMI, body mass index; NA, not applicable.

Table 2. Incidence of Complications

Complication	Breast augmentation group No. (%)	Breast reconstruction group No. (%)	Buttock augmentation group No. (%)	Overall no. (%)
Infection in recipient site	2 (1.25)	2 (0.76)	1 (0.9)	5 (0.94)
Cystic masses	9 (5.6)	12 (4.6)	0 (0)	21 (3.94)
Burning sensation in donor site	2 (2.5)	3 (1.3)	5 (4.5)	10 (2.32)
Persistent swelling and/or seroma	0 (0)	0 (0)	3 (2.7)	3 (0.5)
Major complications	0 (0)	0 (0)	0 (0)	0 (0)

N = 160 breasts in the breast augmentation group, N = 262 breasts in the breast reconstruction group, N = 110 patients in the buttock augmentation group.

addressed surgical outcomes, care received pre- and postoperatively, and the psychologic and physical well-being of the patients. Six months postoperatively, patients were asked to complete this questionnaire, in which they were identified by name. Blank copies of the questionnaires are available as Supplementary Material online at www.aestheticsurgeryjournal.com (Appendices A-C).

RESULTS

Patient demographics are summarized for all groups in Table 1. Complications of each surgical procedure are noted in Table 2. No patient developed seroma or hematoma postoperatively, and there were no major complications (eg, fat embolism) at the donor or recipient sites.

Breast Augmentation

Eighty patients (160 breasts) were included in the breast augmentation group. The patients' mean age was 42 years (range, 25–68 years), mean body mass index (BMI) was 26 kg/m^2 (range, 23–35 kg/m^2), mean total fat injected per breast was 420 mL (range, 300–600 mL), and mean operating time was 65 minutes (range, 45–90 minutes). All patients underwent explantation and fat transfer in 1 surgical session. Patients were monitored for 1 to 4 years, with an average follow-up of 2 years. Six months postoperatively, all patients had maintenance of bra cup size following exchange of breast implants with autologous fat.

At 3 months postoperatively, cystic masses developed in 9 of the 160 breasts (5.6%). Of these, 8 breasts (5%) were treated conservatively with careful observation, and the cystic masses gradually resolved without surgical intervention. A cystic mass that developed in 1 breast (0.6%) yielded a yellowish substance on aspiration. This material was submitted for microbiologic analysis and was found to be consistent with sterile abscesses of necrotic fatty tissue. Of 80 patients, 2 (2.5%) experienced unilateral infection, which comprised erythema and mild cellulitis and resolved with oral antibiotics. Physical examination and imaging findings revealed no other evidence of discharge or fluid collection. There were no other complications at

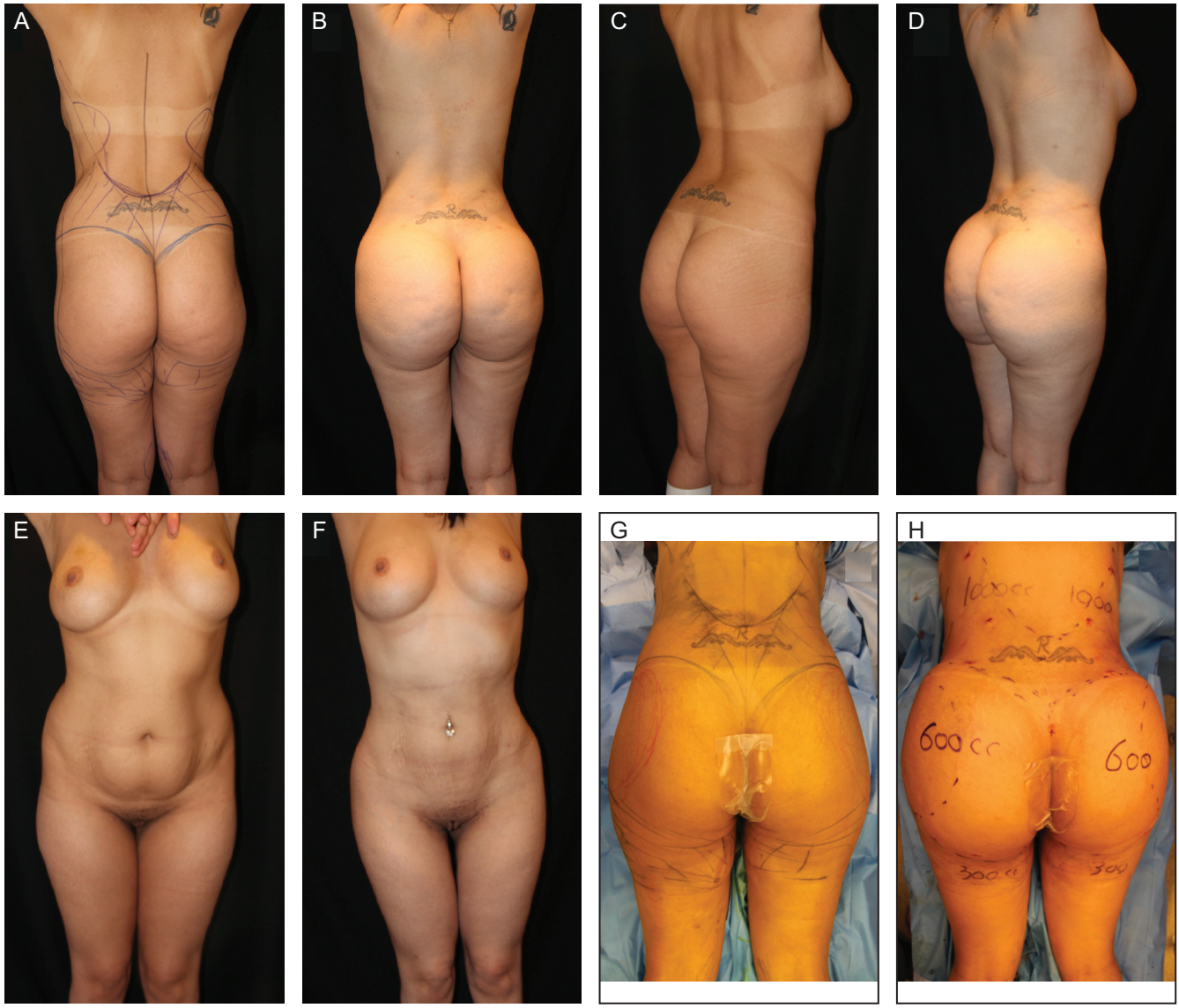


Figure 2. (A, C, E) This 36-year-old woman received power-assisted gluteal augmentation. She underwent liposuction of the back, flanks, and thighs (lipoaspirate volume, 2600 mL) as well as the abdomen (lipoaspirate volume, 1100 mL). Subsequently, 600 mL of autologous fat was transferred to each buttock. (B, D, F) One year postoperatively. (G, H) Intraoperative views of the back, flanks, and thighs before and after liposculpting and lipofilling.

the recipient site (eg, pneumothorax, fat embolism) or the donor site.

Patients in this group who had inconclusive or suspicious preoperative ultrasonography and/or mammography results and underwent an MRI scan also received fat resorption rate analysis. The average fat resorption rate in this subgroup was 40.6% (range, 36.8%-43.4%).

Breast Reconstruction

A total of 227 patients (262 breasts) underwent postmastectomy breast reconstruction with a thoracodorsal flap.[24] Thirty-five women received bilateral breast reconstruction, and 192 underwent unilateral reconstruction. The patients' mean age was 51 years (range, 38–70 years), mean BMI was 26 kg/m^2 (range, 20–35 kg/m^2), and mean total fat injected per breast was 300 mL (range, 200–700 mL). An average of 1.1 lipofilling sessions (range, 1–2 sessions) was needed to achieve the desired outcomes of breast reconstruction. Patients were monitored for 1 to 4 years, with an average follow-up of 2 years. Cystic masses were noted in 12 of the 262 breasts (4.6%). All were treated conservatively with careful observation and resolved without surgical intervention. Two patients (0.9%) had transient cellulitis that resolved with oral antibiotics. No other complications related to fat injection were recorded.

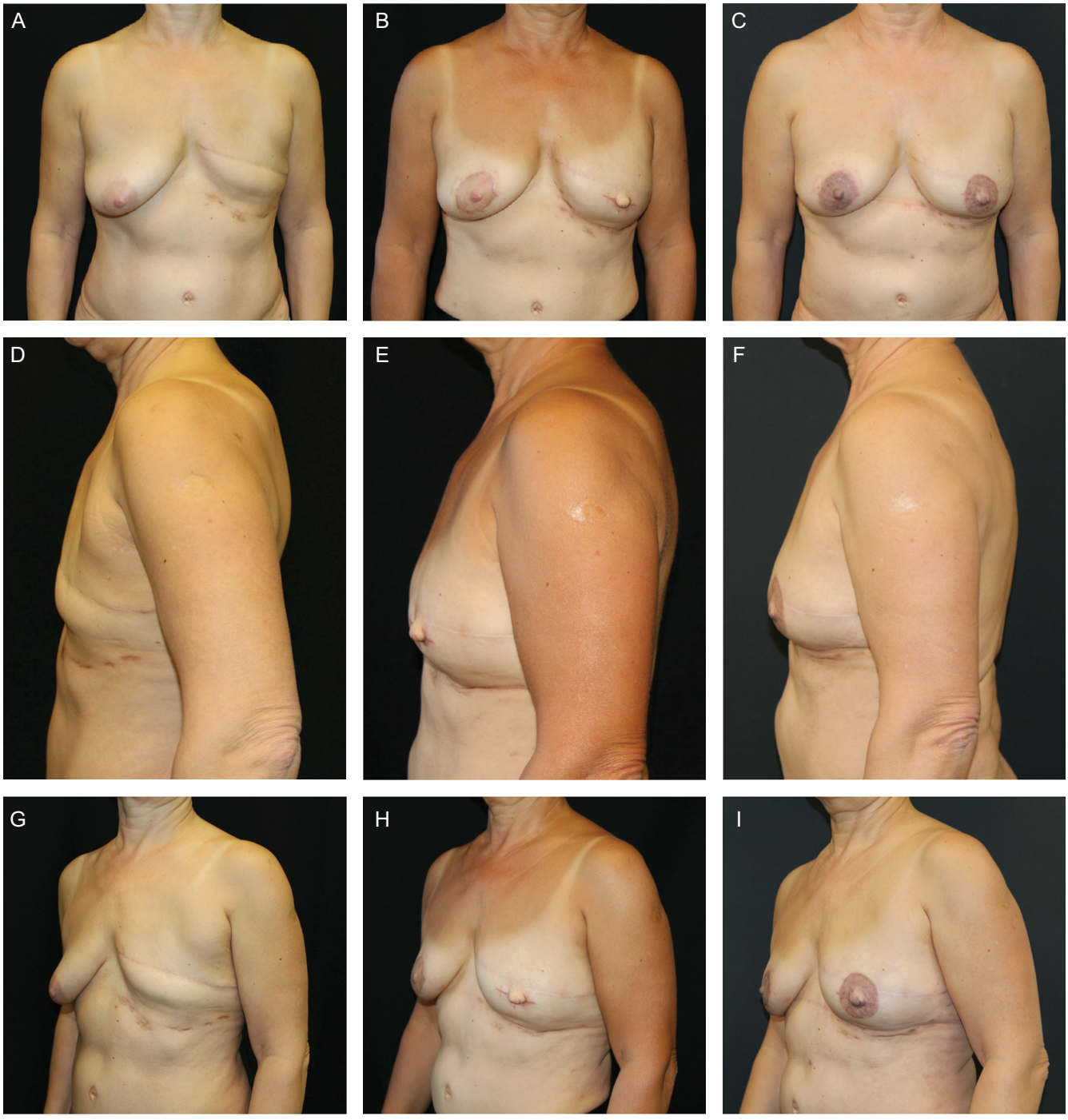


Figure 3. (A, D, G) This 60-year-old woman underwent unilateral mastectomy and presented for reconstruction of the left breast. In a single surgical session, she received 600 mL of autologous fat in the reconstructed breast, definition of the inframammary fold by means of transdermal and deep V-Loc sutures, reconstruction of the nipple-areola complex, and contralateral circumareolar mastopexy to yield bilateral breast symmetry. (B, E, H) Six months postoperatively. (C, F, I) At 9 months postoperatively, bilateral tattooing of the nipple-areola complex was performed to complete the breast reconstruction.

Gluteal Enhancement

A total of 110 women in this study received gluteal reshaping or augmentation. The patients' mean age was 34 years (range, 24–55 years), mean BMI was 30 kg/m^2 (range, 26–36 kg/m^2), mean liposuction volume was 2000 mL (range, 1400–5000 mL), mean injected fat volume was 450 mL (range, 300–900 mL), and mean operating time was 70 minutes (range, 60–120 minutes). An average of 1.2 surgical sessions (range, 1–2 sessions) was required to achieve

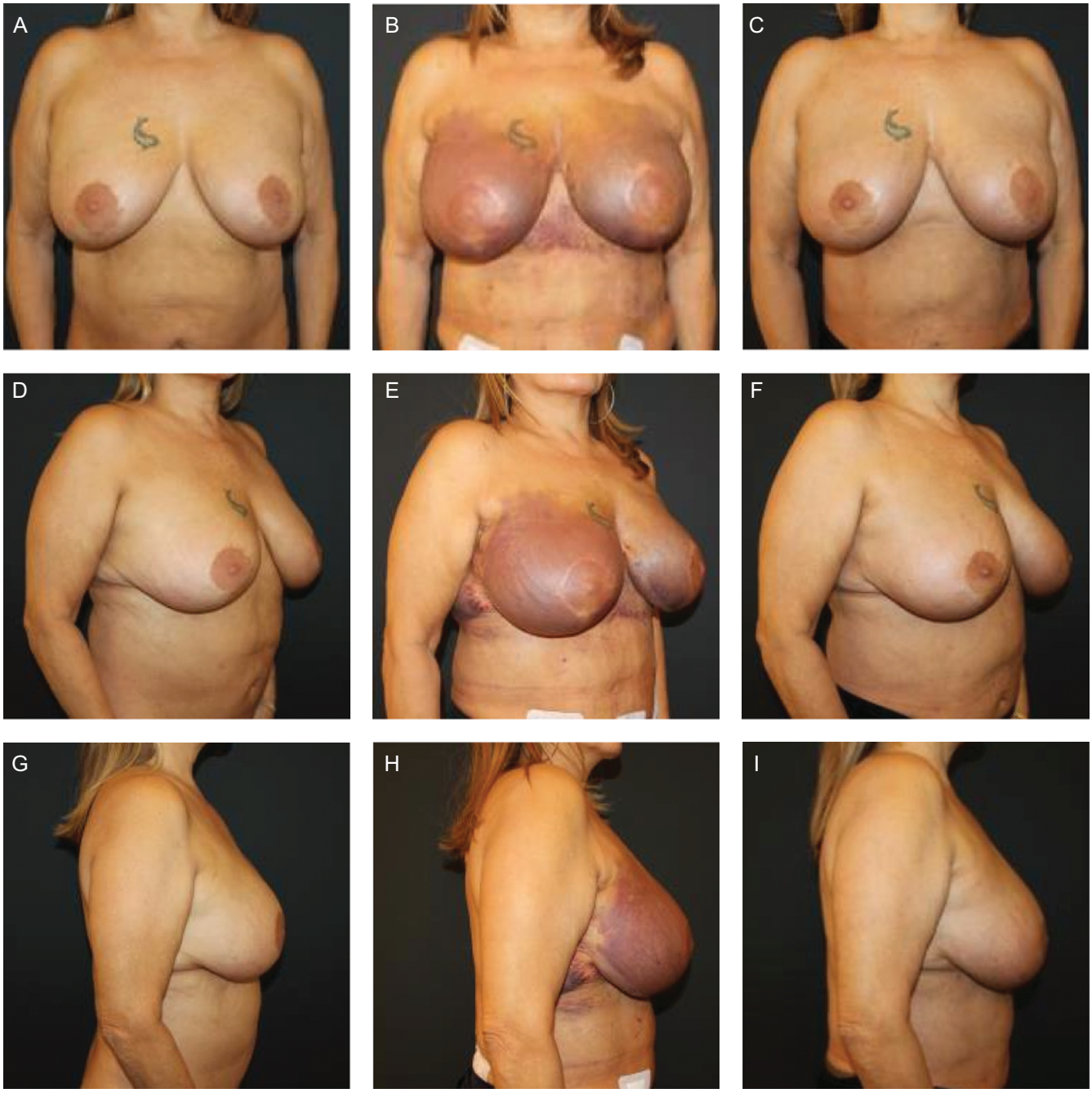


Figure 4. (A, D, G) This 42-year-old woman previously underwent bilateral breast augmentation with silicone implants (300 cc per breast). She presented with bilateral grade 1 capsular contracture and received explantation and injection of 400 mL of autologous fat per breast. (B, E, H) One week postoperatively. (C, F, I) One year postoperatively.

the desired outcomes in this group. Patients were monitored for 1 to 5 years with an average follow-up of 3 years. Figures 2–4 depict patients in this study who underwent gluteal reshaping and augmentation, breast reconstruction, and revisional breast augmentation, respectively.

Five of the 110 patients (4.5%) experienced an intermittent burning sensation in the flank. This sensation was attributed to aggressive liposuction in the area; it resolved spontaneously in all patients by 6 months postoperatively. Three patients (2.7%) experienced swelling of the sacral area and lower back and were advised to undergo kinesiotherapy. By 6 months postoperatively, swelling had resolved in these patients. One woman (0.9%) had mild erythema of the buttocks on day 10 postoperatively; this patient had received 600 mL of fat on each side. There was no evidence of other systemic signs of infection or

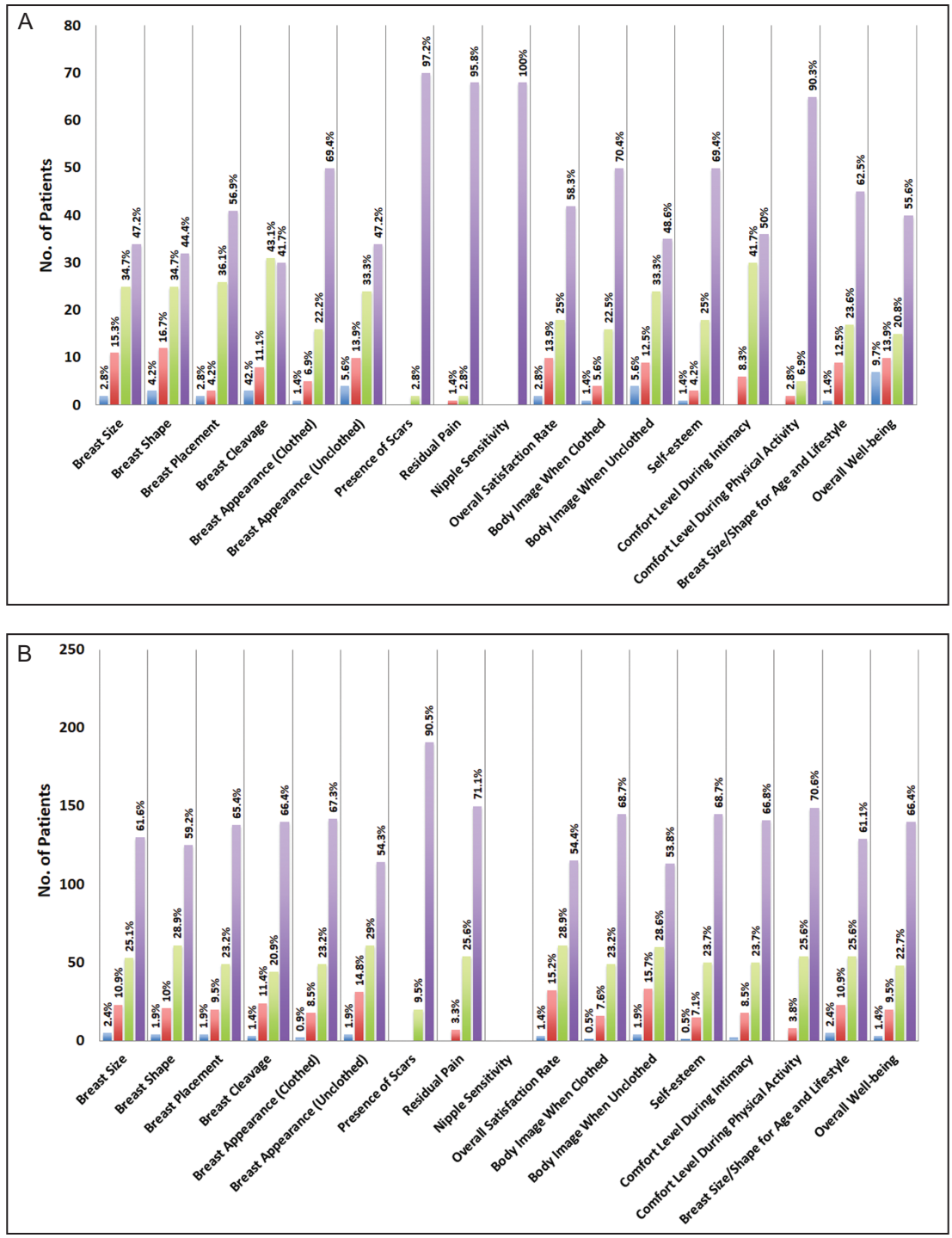


Figure 5. Findings of the patient satisfaction questionnaire, which was administered 6 months postoperatively. Results correspond to (A) the breast augmentation group, (B) the breast reconstruction group, and (C) the gluteal augmentation group. Response categories are color-coded: blue bars correspond to "very dissatisfied/not good;" red bars, "somewhat dissatisfied/not good;" green bars, "somewhat dissatisfied/good;" and purple bars, "very satisfied/good." A dissatisfied rating comprised responses of "very/somewhat dissatisfied" and "not good/somewhat good." Satisfied ratings entailed responses of "very satisfied/somewhat satisfied" and "somewhat good/very good." In the breast augmentation group (A), 90.2% of patients indicated they would choose to undergo the procedure again. In the breast reconstruction group (B), 86.7% of patients noted they would choose to undergo the operation again. In (A) and (B), 4 patients without nipple sensitivity preoperatively did not respond to the question about nipple sensitivity.

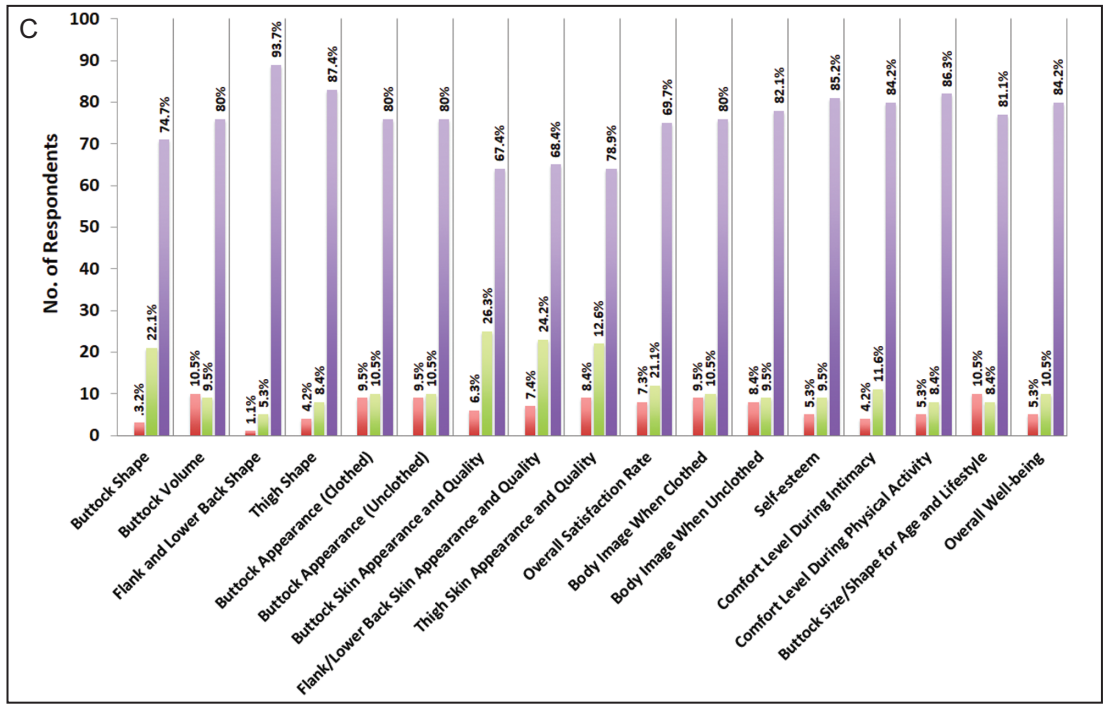


Figure 5. Continued

purulence at the recipient site. The patient was given oral antibiotic therapy, and the erythema resolved spontaneously at 16 days postoperatively.

Patient Satisfaction

Results of the patient satisfaction questionnaires are presented in Figure 5. A total of 378 women completed the patient satisfaction questionnaire, including 211 patients in the breast reconstruction group, 95 in the buttock augmentation group, and 72 in the breast augmentation group. Twenty-nine patients declined to complete the questionnaire (13 in the breast reconstruction group, 11 in the buttock augmentation group, and 5 in the breast augmentation group). Eleven patients withdrew from the study in the postoperative period (3 in the breast reconstruction group, 4 in the buttock augmentation group, and 3 in the breast augmentation group).

In the breast reconstruction, gluteal enhancement, and breast augmentation groups, respectively, a total of 183, 84, and 65 women (86.7%, 88.4%, and 90.2%) indicated that they would choose to undergo the procedure again; 186, 82, and 59 patients (88.1%, 86.3%, and 81.9%) expressed satisfaction with final shape of the breast/buttock; and 188, 80, and 55 women (89.1%, 84.2%, and 76.3%) noted improvement in their psychologic well-being as a result of the surgery. The overall satisfaction rate was 91.6%, 83.4%, and 83.3% for the breast reconstruction, gluteal enhancement, and breast augmentation groups, respectively.

DISCUSSION

Transplantation of large volumes of autologous fat is challenging. Traditional manual methods of fat transfer involve liposuction, tedious centrifugation cycles, and injection of 1 to 2 mL of prepared fat per pass into a tunnelized recipient site by means of 5- or 10-mL syringes.[25,26] In large-volume transfer of fat (eg, ≥500 mL), this traditional approach requires hours in the operating room, resulting in prolonged anesthesia, higher costs, surgeon fatigue, diminished concentration, and possibly patient morbidity. For these reasons, we and other investigators have sought to improve the efficiency of large-volume fat grafting without compromising safety.[27] Herein, we describe our technique of PALL, which can be applied in cases of gluteal augmentation, arm or body contouring, and breast surgery.

PALL involves a handpiece that delivers reciprocating motion through the cannula tip; this allows the surgeon to harvest and transfer large amounts of adipose tissue without extensive manual labor. In our experience, PALL enables efficient and safe fat grafting and produces pleasing aesthetic results. Our technique of multilayered perforation and tunnelization of the recipient site yields an expanded matrix in one-third the time required for standard techniques. Vibration of the recipient site and additional external vibration improve the diffusion of fat, producing a maximally filled space and promoting graft take. This dispersion of fat can be detected intraoperatively by palpating; the recipient site softens gradually, indicating decreased compartmental pressures.

We utilize the same instrument and same vibration settings in fat harvesting and delivery. The level of vibration pressure we apply is known to be safe for fat lobules during lipoaspiration;[9,10] it is reasonable to expect that this pressure also is harmless during and after injection. This procedure facilitates homogeneous occupation of fat into the recipient matrix—which we demonstrated radiologically in a previous study—and is associated with graft survival and satisfactory outcomes.[15]

The Lipomatic Eva SP exerts nutational (ie, reciprocating and circular) motion, which creates tunnels of relatively large diameter in each pass. The uncompacted, dilute fat tissue injected into these spaces diffuses easily. In large-volume fat grafting, small variations in fat resorption do not affect the aesthetic results.

Other researchers have performed rigotomy (ie, the release of scar-tissue adhesions with small needles inserted percutaneously) in conjunction with fat transfer to the breast.[28] These authors noted that rigotomy releases constrictions owing to parenchymal tethering and ligamentous bands to help expand the breast.[28] We presume that the nutational motion and vibration involved in the PALL technique duplicates the percutaneous release achieved with rigotomy. However, we did not determine this directly.

Power-assisted liposuction yields healthy, viable fat cells for transfer. ASCs play an important role in tissue engineering and are crucial in the survival of grafted fat.[10,29] Keck et al[10] showed that fat cells obtained from power-assisted liposuction are metabolically functional and have a higher capacity for differentiation compared with fat cells harvested by manual aspiration. A major aim in autologous fat transplantation is avoiding extensive reabsorption;[2,30-32] healthy fat cells are more likely to survive and persist in the recipient site. In a study of large-volume fat grafting to the breast with a powered device immediately after explantation,[15] the mean resorption rate was found to be 40.6% (range, 36.8%-43.4%). Additional clinical research is needed to assess the resorption characteristics of fat obtained with powered devices.

Study Limitations

This study has several limitations. The authors' application of tunnelization and vibration is based on the results of clinical observation; basic research still is warranted to address the potential benefits and drawbacks of these procedures in large-volume fat transfer. In addition, our methods of large-volume fat grafting are still evolving. Work is ongoing to systematically compare techniques of large-volume transplantation of fat. We did not evaluate patient medical records to ascertain whether different outcomes were obtained for patients with BMI <30 kg/m^2 vs >30 kg/m^2; we speculate that these groups would have similar outcomes, assuming sufficient adipose tissue was available for harvesting and transfer in each case.

CONCLUSIONS

We developed a technique that applies PALL to enable large-volume fat transfer in aesthetic and reconstructive surgery. The technique is adaptable to various anatomic areas, involves a relatively short operating time, and often can be carried out in 1 surgical session. Moreover, patients generally are satisfied with the aesthetic results of PALL and indicate they would choose to undergo the procedure again.

Supplementary Material

This article contains supplementary material located online at www.aestheticsurgeryjournal.com.

Disclosures

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

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