ROYAL BELGIAN SOCIETY FOR PLASTIC SURGERY

Scarless Composite Breast Reconstruction Utilizing an Advancement Skin Flap, Loops, and Lipofilling

Aesthetic Surgery Journal
2021, 1–16

DOI: 10.1093/asj/sjab049
www.aestheticsurgeryjournal.com
OXFORD UNIVERSITY PRESS

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Abstract

Background: Autologous fat grafting has gained popularity in breast reconstructive surgery. To further increase the breast volume and provide a reliable breast shape, a skin flap can be advanced from the upper abdomen and lateral thorax to the breast.

Objectives: The aim of this study was to propose a method of breast reconstruction utilizing the principles of power-assisted liposuction and lipofilling (PALL) for breast matrix dissociation applied through infiltration, tunnelization, extensive undermining and lipofilling, in combination with loops (PALLL) to recruit a vascularized flap to reshape the breast.

Methods: A prospective study was performed from January 2014 to January 2019. Demographic data, surgical procedure information (including volumes of the recruited advancement flap and lipofilling, and stages of lipofilling), and complication data were collected. Patient-reported outcomes, including satisfaction and well-being, were measured by a questionnaire.

Results: In total, 37 women (41 breasts) underwent breast reconstruction by PALLL with an average follow-up of 26 months. The mean age of the patients was 54 years, and their mean BMI was 29 kg/m^2. The mean recruited flap volume was 197 mL, and the mean lipofilling volumes were 153 mL for the first session, 190 mL for the second session, and 110 mL for the third session. Nine patients needed 3 sessions, 27 patients 2 sessions, and 1 patient only 1 session. Overall, 94% of patients were satisfied with their breast shape. All patients reported sensitive breasts. There were minimal complications.

Conclusions: Breast reconstruction with PALLL is a minimally invasive alternative to reconstructing and reshaping sensate breasts in which a vascularized skin flap recruited by loops from breast surroundings is combined with fat grafting. This approach provides long-term shape stability with minimal scarring and low complication rates.

Level of Evidence: 4

Editorial Decision date: November 23, 2020; online publish-ahead-of-print January 28, 2021.

Autologous fat grafting has gained popularity in breast reconstructive surgery due to its natural aspect and palpation, its permanent effect, and its trophic action on scar tissue and irradiated zones.[1-3] However, the major challenges for fat grafting in breast reconstruction are the need for repeated sessions to achieve the desired volume, the low maintenance volume when injecting large volumes of fat, and the variable degree of fat resorption.[1-5] Skin tension is the main factor that limits the volume to be injected and results in fat resorption. To reduce skin tension, some authors

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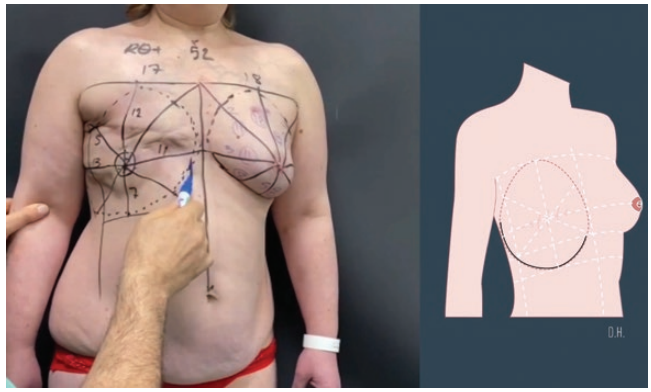
advocate fat grafting with pre-expansion utilizing either implants or expanders[6,7] or Brava to allow increased volumes of fat grafting and achieve higher graft survival rates.[8-11]

Recruitment of adjacent tissue into the breast by loops has been pioneered by Roger Khouri and also extensively utilized by the senior author (M.H.A.).[12-14] Khouri's reverse abdominoplasty and fat transfer (RAFT) technique recruits an epigastric crescent into the breast and utilizes a purse-string suture to define the inframammary fold (IMF) and project the breast. In line with this technique, we present a scarless method of composite breast reconstruction utilizing tissue recruitment by loops combined with lipofilling. The skin flap is advanced from the upper abdomen and lateral thorax and secured with loops to reconstruct the footprint and the IMF and to increase the breast matrix. Our reconstruction method adheres to the principles of power-assisted liposuction and lipofilling (PALL)[15-18] for breast matrix dissociation applied through infiltration, tunnelization, liposuction, extensive undermining and lipofilling, and adds loops (PALLL) to recruit a vascularized flap from the breast surroundings in order to model the matrix and reshape the breast. (A 3-dimensional presentation of the technique is shown in Video 1.) Our aim is to achieve autologous breast reconstruction without pre-expansion and to obtain a similar breast footprint, volume, projection, shape, and IMF position.



Video 1. Watch now at http://academic.oup.com/asj/article-lookup/doi/10.1093/asj/sjab049

METHODS

Patient Selection

Patients with a unilateral or bilateral total mastectomy were included for cases with a small to moderate breast size, a sufficient amount of donor adipose tissue, and sufficient skin laxity at the upper abdomen and lateral thorax. All patients who had previously undergone any type of breast-conserving surgery or breast reconstruction were excluded from the study, as were partial mastectomy patients and those who had been severely irradiated.

This technique is thus not suitable for severely irradiated patients whose affected skin must be replaced with a flap, and for very thin patients who do not have enough fat to harvest or who lack skin laxity in the upper abdomen, preventing flap advancement. Moreover, patients who refused to halt smoking at least 1 month prior to the procedure were not eligible for this intervention.

Patients and Study

A total of 39 patients met the inclusion criteria and were enrolled in a prospective study from January 2014 to January 2019. Two patients lost to follow-up before reaching the final stage of breast reconstruction were excluded. Thus, ultimately, 37 patients (41 breasts) were evaluated in the study, 33 of whom underwent unilateral breast reconstruction and 4 of whom underwent bilateral reconstruction. Detailed information was provided regarding the surgical procedure and the reconstruction process, requiring multiple stages of lipofilling with an interval of at least 4 months to allow fat integration. Written informed consent was obtained. Patients were informed that up to 50% of the injected fat may be resorbed postoperatively. Patients were advised to maintain a stable weight and were told to halt smoking for at least 4 weeks before and after the intervention in order to improve fat survival.

Preoperatively, all patients underwent clinical breast examinations, mammography, and breast ultrasonography. Nine patients also had an MRI scan prior to the reconstruction, as well as an MRI scan posttreatment. Photos were taken pre- and postoperatively in the frontal, oblique, right lateral, and left lateral with the arms elevated and in a resting position. To estimate the volume advanced from the upper abdomen and the lateral thorax, we measured the dimensions of the crescent and copied these on to a plastic film. The mean area was calculated with AutoCAD. Mean skin thickness was estimated from ultrasound. The mean volume was obtained by multiplying the mean area by the mean skin thickness.

Because all patients underwent surgery in a private practice, approval from an IRB or ethics committee was not obtained. The study adhered to the principles set forth in the Declaration of Helsinki, and all of the patients gave informed consent.

Data Collection and Analysis

Demographic data were collected, including age, BMI, and comorbidities. Measurements of the crescent advancement flap volume were noted, as well as the total volume of fat injected per breast. Complications were evaluated. Data were analyzed in an encrypted database.

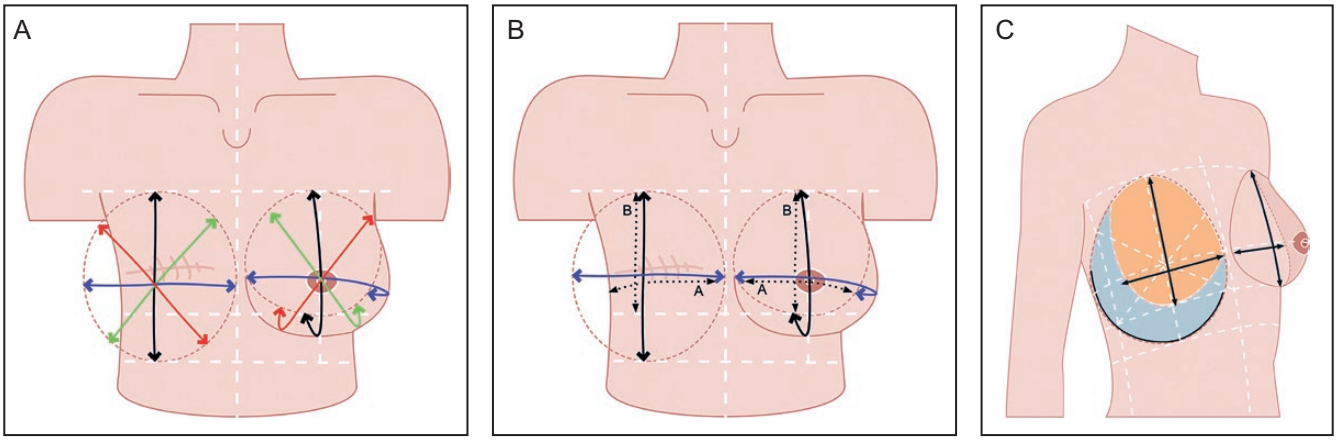


Figure 1. Preoperative markings. (A) The midline, the anterior axillary line, the interaxillary horizontal line, and the inframammary fold are marked. The breast was considered as a pie and was divided into 8 parts. A ninth and tenth zone can also be drawn, representing the areola and nipple, respectively. A mirror image of the unaffected breast was drawn on the breast to be reconstructed. (B) The horizonal and vertical dimensions on both breasts must be equal. (C) The blue crescent shows the skin and fat recruited from the upper abdomen and the lateral thorax to reconstruct the same skin surface as the contralateral breast.

Operative Procedure

Preoperative markings are performed with the patient standing and started on the contralateral breast. More details are provided in Figure 1A-C and Video 2. Under general anesthesia, the patient is placed in a supine position with arms abducted, and 2 g of intravenous cefazolin is administered 30 minutes before the intervention. The breast and the fat donor sites are infiltrated with a solution containing 5 mL of tranexamic acid 0.5 g/5 mL associated with epinephrine 1:100,000 per liter of normal saline utilizing a power-assisted liposuction system (Lipomatic, Eva SP; Euromi SA, Verviers, Belgium) with a 3-mm multihole blunt cannula.[19] Tumescent infiltration is a key step in the procedure to hydrodissect, release adherent scar tissue, and achieve internal expansion of the recipient site. This is followed by multidirectional tunnelization with the cannula detached from the suction system, initially in the plane between the skin and the matrix and then in the plane between the matrix and the fascia. The principle of tunnelization is to free the matrix from the tethering fibers, to dissociate it, and to reduce its tensile force (Figure 2A-C).

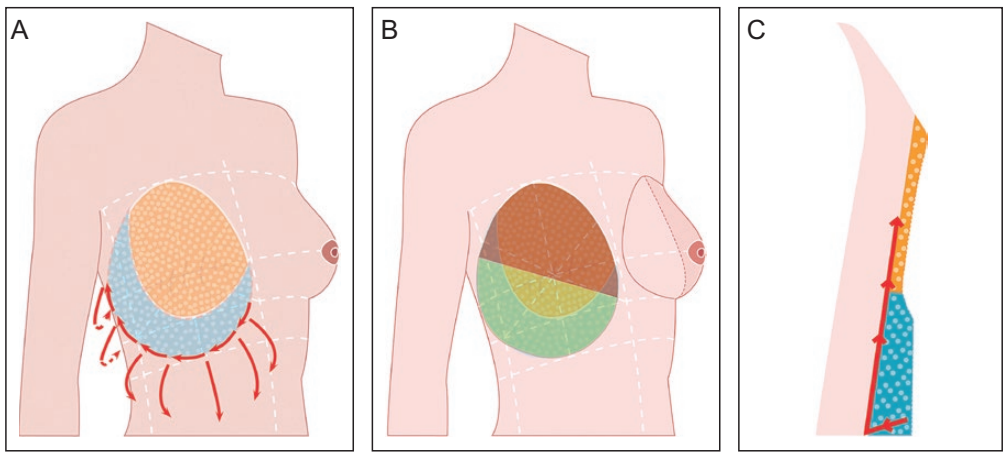


Figure 2. Tunnelization and deep undermining. (A, B) Three-quarter profile. (C) Lateral profile. The effect of tunnelization. (A) Tunnelization is a crucial step to dissociate the matrix from the deep plane and the superficial plane and expand the matrix itself. (B, C) Tunnelization is performed in the upper abdomen, lateral thoracic region, and in the breast to be reconstructed. (B) Superficial tunnelization is performed in the lower quadrants of the new breast (green), and in a deep plane in the upper quadrants (red). (D) Three-quarter profile. The effect of deep undermining: with a Molt elevator, we detach all the tethering fibers and the attachments of the matrix to the pectoralis fascia to facilitate the advancement of the flap into the breast.

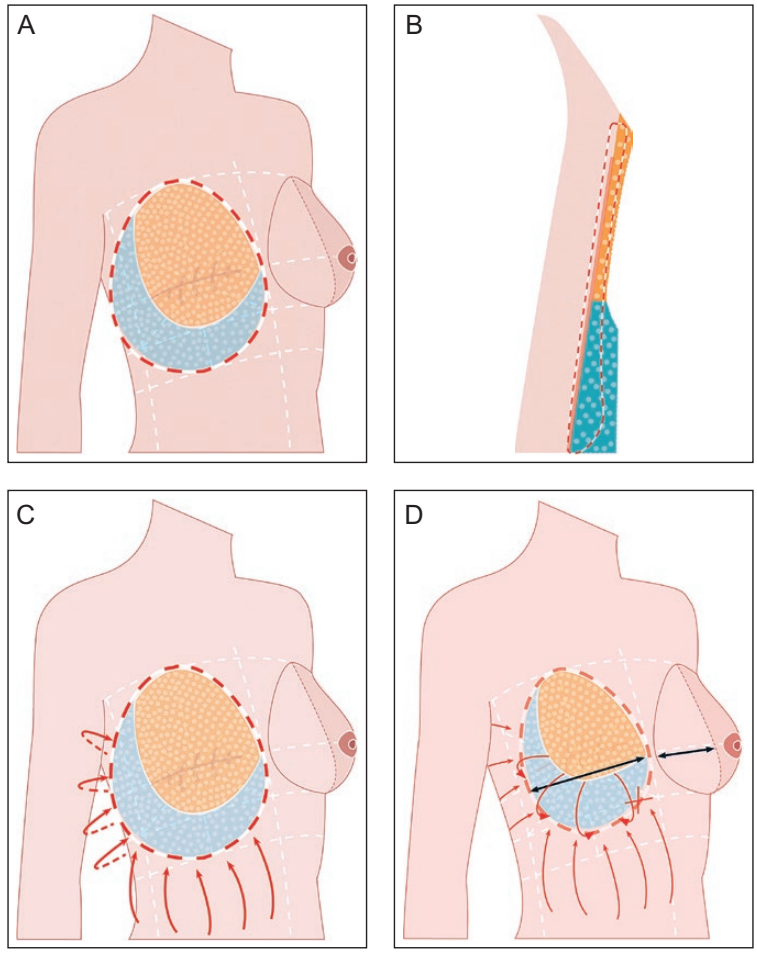


Figure 3. The footprint loop. (A) Three-quarter profile. (B) Lateral profile. The footprint loop, shown in red, is marked in a circular pattern to achieve the same horizontal dimension of the breast footprint as the contralateral breast. (C-E) Three-quarter profile. (E) Lateral profile: the effect of the footprint loop before (C) and after (D-F) tying the knot, shown with a red cross. It defines the horizontal dimension breast footprint, the lateral and the inframammary folds, and recruits skin and fat from the upper abdomen and the lateral thorax toward the breast in a centripetal pattern along the breast axis (red arrows). It increases the matrix for fat injection and increases breast projection.

Liposuction is then performed in the upper abdomen, the lateral thorax, and at the sites of fat harvesting utilizing a 3-mm multihole cannula with the rate set to 3000 rpm and a pressure of 0.78 atmospheres. Multiaxial and multiplanar liposuction are carried out in the upper abdomen until the umbilicus is reached, and in the lateral thorax reaching the upper back beyond the loop markings in a grid pattern, releasing the subcutaneous attachments, and expanding the tissue to be advanced thereby facilitating its mobilization. Liposuction and tunnelization of abdominal and axillary tissue beyond the area to be recruited creates 2 gliding planes, one between the skin and the subcutaneous tissues and one between the latter and the fascia. This is a key step for further tension-free upward and medial migration of the vascularized flap of abdominal and axillary tissue into the breast.

Next, the deep attachments of the matrix to the pectoralis fascia along the newly positioned IMF, the native IMF if intact, and the scar tissue are interrupted utilizing a Molt elevator passed through skin stab incisions (Figure 2D). This deep undermining is crucial to erase the memory of the native IMF, release the scar, and interrupt the continuity of the tissues along the external borders of the recruited crescent to allow the flap to be advanced with minimal tension.

Lipoaspirate is collected into a closed system, then decanted, and the remaining fat solution is transferred into sterile 60-mL syringes. While the fat is being prepared, the surrounding tissue is recruited as a vascularized skin flap with internal loops. Utilizing nonabsorbable sutures (250-cm reel of Filapeau 2; Péters Surgical, Bobigny, France), 2 loops are taken around the breast. Each loop is guided by a 3-mm, 3-hole blunt cannula

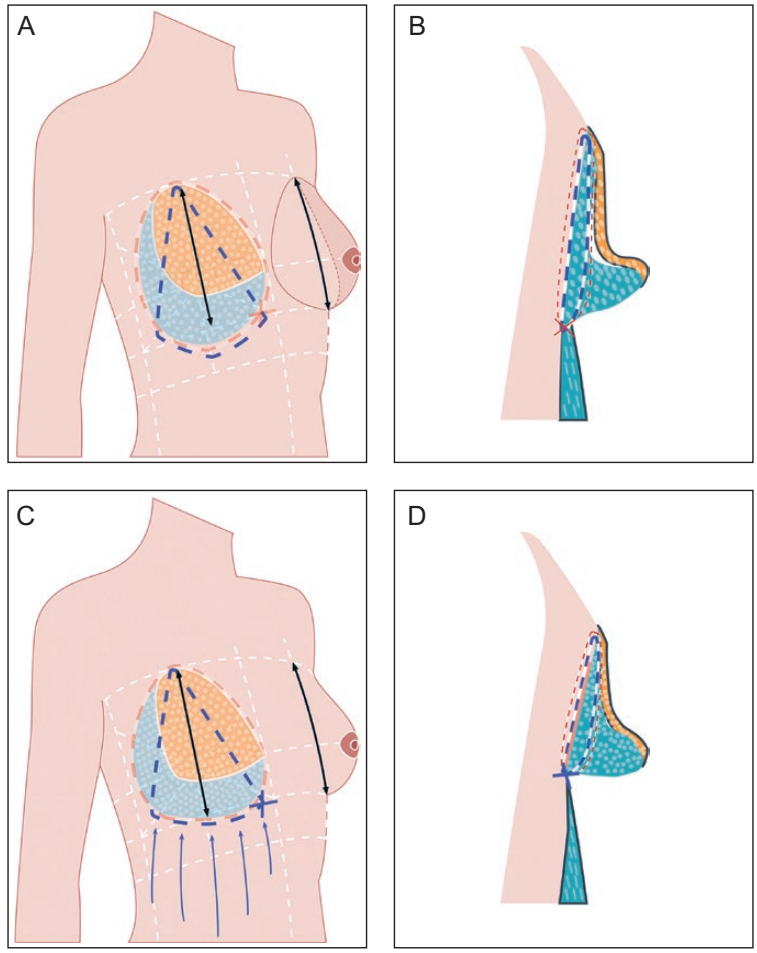


Figure 4. The IMF loop. (A) Three-quarter profile. (B) Lateral profile. The design of the IMF loop, shown in blue, is performed in a triangular pattern, the apex of which is the midpoint of the interaxillary axis on the breast to be reconstructed. (C) Three-quarter profile. (D) Lateral profile. The IMF loop defines the vertical dimension of the breast footprint and suspends the new IMF along the breast axis. IMF, inframammary fold.

passed through skin-stab incisions. The first loop, designed to define the breast footprint and enhance breast projection, spans the superficial subcutaneous tissues at the lower quadrants of the breasts (between 3 o'clock and 9 o'clock) and the deep subcutaneous tissues, in a suprafascial plane in the upper quadrants (between 9 o'clock and 3 o'clock). Particular attention should be made when passing the loops deep between 12 o'clock and 3 o'clock to create a cleavage similar to that of the contralateral breast. The thread is passed twice in the same pattern to minimize the tension on the knot. The loop is pulled with moderate tension to achieve the same width of the contralateral breast footprint, and the knot is tied (Figure 3A-F). The second loop, designed to suspend and fixate the IMF in its new position, is spanned twice, following the superficial subcutaneous tissues along the newly positioned IMF and then towards the head to reach the midpoint of the interaxillary axis. The loop is pulled with moderate tension to achieve the same position and shape as the contralateral IMF (Figure 4A-D). Both loops are anchored to the deep subcutaneous tissues, and no bone or cartilage anchoring is required. The knot is always placed in the same location to facilitate recognition if removal or replacing the thread is required. Skin indentations and contour deformities are thoroughly released utilizing a double-ended Varady extractor with a ball-tip hook and a blunt spatula. Further lipoaspiration beyond the loop markings in the upper abdomen is performed to minimize the tension on the thread and to better mark the transition zone between the breast and the abdomen.

Fat injection is then achieved by PALL (Figure 5).[15] By simultaneous vibration, tunnelization, and fat injection in a multiplanar multiaxial fashion, grafting is performed in

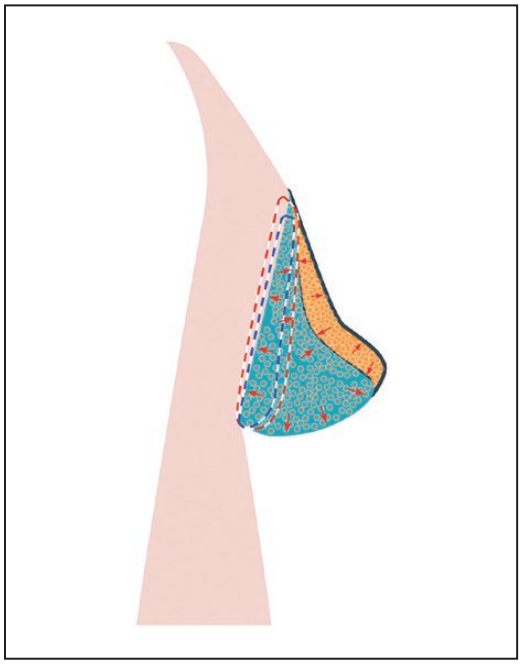


Figure 5. Fat injection. The fat in injected in the residual breast matrix and in the crescent advanced from the upper abdomen and the lateral thorax in a multidirectional multiplanar fashion. No fat is injected into the muscle. The final breast volume is composed of the crescent advanced from breast surroundings, the residual breast volume, and the fat injected.

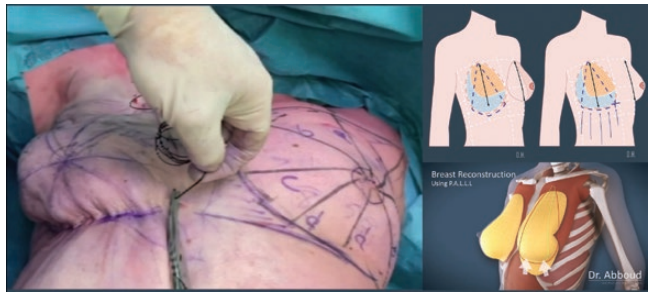
all breast quadrants. Finally, external vibration is applied with the Lipomatic handpiece to enhance diffusion of the injected fat in the breast. (The surgical procedure is shown in Video 1.)

Complementary Session of Breast Reconstruction

During the complementary session of PALLL, the procedure is planned according to the remaining breast deformity. When the footprints or the IMF are not symmetric, the loops are removed and replaced to correct the deformity. If the footprints and the IMF are symmetric, but the volume is lacking, lipofilling is added. Considering that the tension is reduced during the second session and that tissues are more easily moldable, the footprint can be better defined, and the IMF lifted further.

Postoperative Care

Patients are discharged on the day of the operation. Patients are advised to keep wearing a loose sports bra for 2 months and to avoid excessive abduction of the shoulder for 1 month. They are informed about the postoperative pain, and that this will resolve progressively after 3 weeks to 1 month. Patients receive painkillers—paracetamol and nonsteroidal anti-inflammatory drugs—for the first 5 days postoperatively unless there are any contraindications. They are also asked to avoid significant mobilization in the early postoperative period. All patients receive postoperative breast imaging annually. After the last stage of breast reconstruction, light touch sensation is tested with Semmes-Weinstein monofilaments and compared with the results of the preoperative test performed on the patients. The breast is divided into 10 zones, with zone 9 being the areola and zone 10 the nipple (Figure 1A).



Video 2. Watch now at http://academic.oup.com/asj/article-lookup/doi/10.1093/asj/sjab049

Table 1. Patient Demographics and Operative Data (N = 37 Patients)

Number of patients	37
Number of breasts	41
Mean age, years (range)	54 (34-82)
Mean BMI, kg/m^2 (range)	29 (24–35)
Number of smokers (%)	6 (16%)
Number of irradiated patients (%)	3 (8%)
Number of patients who received chemotherapy (%)	7 (19%)
Mean volume of the crescent, mL (range)	197 (145-250)
Mean volume injected, mL (range)	
First session	153 (110-240)
Second session	190 (150-250)
Third session	110 (70-150)

Patient Satisfaction

Six months after the last operation, patients are asked to complete our questionnaire[14,18] (Appendix) to assess their

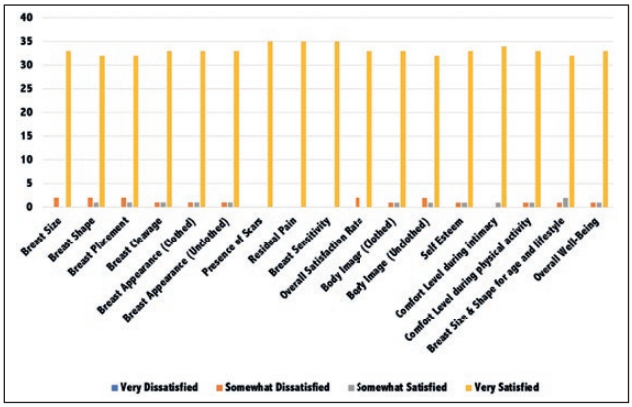


Figure 6. Results of the patient satisfaction questionnaire. Of the 37 patients included in this study, 35 completed the questionnaire prepared by the authors. The blue bars indicate patients giving "very dissatisfied" responses, the orange bars indicate "somewhat dissatisfied," the gray bars indicate "somewhat satisfied," and the yellow bars indicate "very satisfied." A total of 33 of the 35 patients (94%) indicated that they would repeat the surgical procedure or recommend it to a friend.

satisfaction with the surgical outcome and with the preoperative and postoperative care as well as to evaluate their psychological and physical well-being. The paper questionnaire was anonymous, and was distributed by a well-trained nurse working with the senior author.

RESULTS

A total of 37 women (41 breasts) underwent breast reconstruction by PALLL. The mean age of the patients was 54 years (range, 34-82 years), and their mean BMI was 29 kg/m^2 (range, 24-35 kg/m^2). Six of the 37 patients (16%) were former smokers, 3 had been irradiated (8%), and 7 had received chemotherapy (19%). The mean volume of the crescent was 197 mL (range, 145-250 mL). The mean injected volume was 153 mL per breast (range, 110-240 mL) during the first session, 190 mL (range, 150-250 mL) during the second session, and 110 mL (range, 70-150 mL) during the third session (Table 1). Patients were monitored for an average of 26 months (range, 12-48 months).

Regarding the number of sessions needed, 9 patients (24.3%) needed 3 sessions, 27 patients (72.9%) needed 2 sessions, and only 1 patient (2.7%) needed 1 session of lipofilling due to sufficient residual breast volume. All irradiated patients and all cases of bilateral reconstruction needed 3 sessions of PALLL. No seroma or hematoma was detected in any patient. Only 1 patient (2.7%) with a history of diabetes and smoking developed skin redness of the breast without fever 6 days postoperatively. This patient was treated efficiently with oral antibiotics. In the postoperative period, patients complained about pain, as well as mild limitation of shoulder movement, more particularly abduction during the first 3 to 4 weeks. This was well managed by analgesia.

Table 2. Breast Sensation Assessment Pre- and Post-PALLL Comparing the Breasts in Patients Who Had Mastectomy and Those Who Did Not

	Preoperative average mastectomy (n = 17)	Postoperative average mastectomy (n = 17)	Preoperative average nonmastectomy (n = 11)	Postoperative average nonmastectomy (n = 11)
Zone 1	3.2	2.4 (25% better)	1.7	1.8 (6% worse)
Zone 2	3.2	2.1 (28% better)	1.7	1.8 (6% worse)
Zone 3	3.3	1.8 (45% better)	1.7	1.8 (6% worse)
Zone 4	3.9	2.0 (49% better)	1.7	2.3 (35% worse)
Zone 5	3.9	2.1 (46% better)	2.1	2.3 (10% worse)
Zone 6	4.0	2.2 (45% better)	2.3	2.3 (no change)
Zone 7	3.9	2.9 (26% better)	2.2	1.9 (14% better)
Zone 8	3.5	2.7 (20% better)	1.8	1.9 (6% worse)
Zone 9	3.5	4.2 (20% worse)	2.3	3.1 (35% worse)
Zone 10	3.8	4.2 (11% worse)	2.8	3.2 (14% worse)
P value	*P* = 0.006 (statistical difference)		*P* = 0.8 (normal variability)	

In breasts of patient who received power-assisted liposuction and lipofilling combined with loops (PALLL) following mastectomy, there is a significant increase in breast sensation as measured by Semmes-Weinstein monofilaments (*P* = 0.0006). The lower quadrant (zones 3-6), in particular, demonstrate the greatest improvement, likely in part related to the recruitment of abdominal and axillary tissue. As a control, Semmes-Weinstein testing is also performed on breasts of patients who did not have mastectomy and who did not have loops-based tissue recruitment. In this group, we note normal variability in the results (*P* = 0.8).

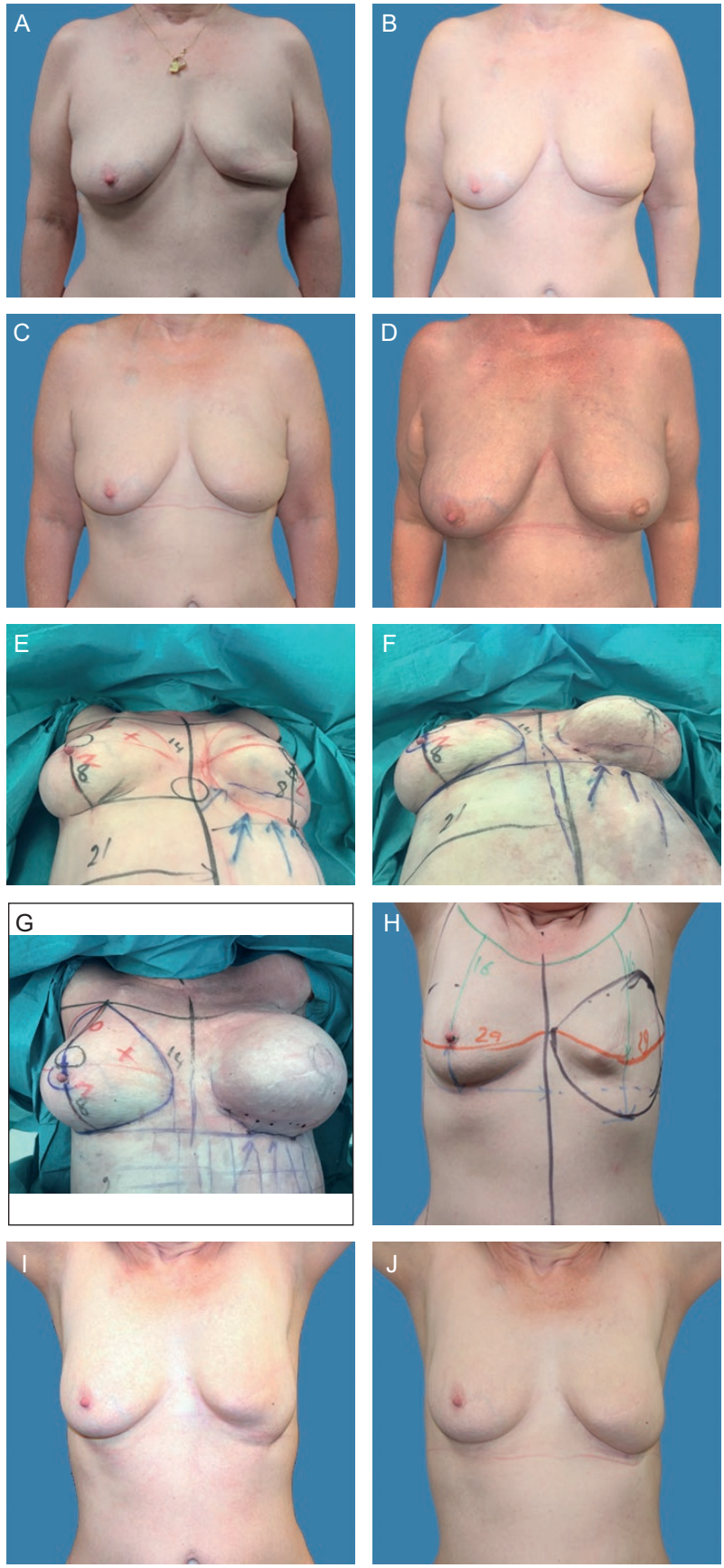


Figure 7. A 54-year-old female patient with left mastectomy. She underwent 2 sessions of PALLL for left breast reconstruction. The volume of fat injected was 100 mL during the first session and 150 mL during the second session. Scarless mastopexy was performed on the right breast with injection of 90 mL of fat.

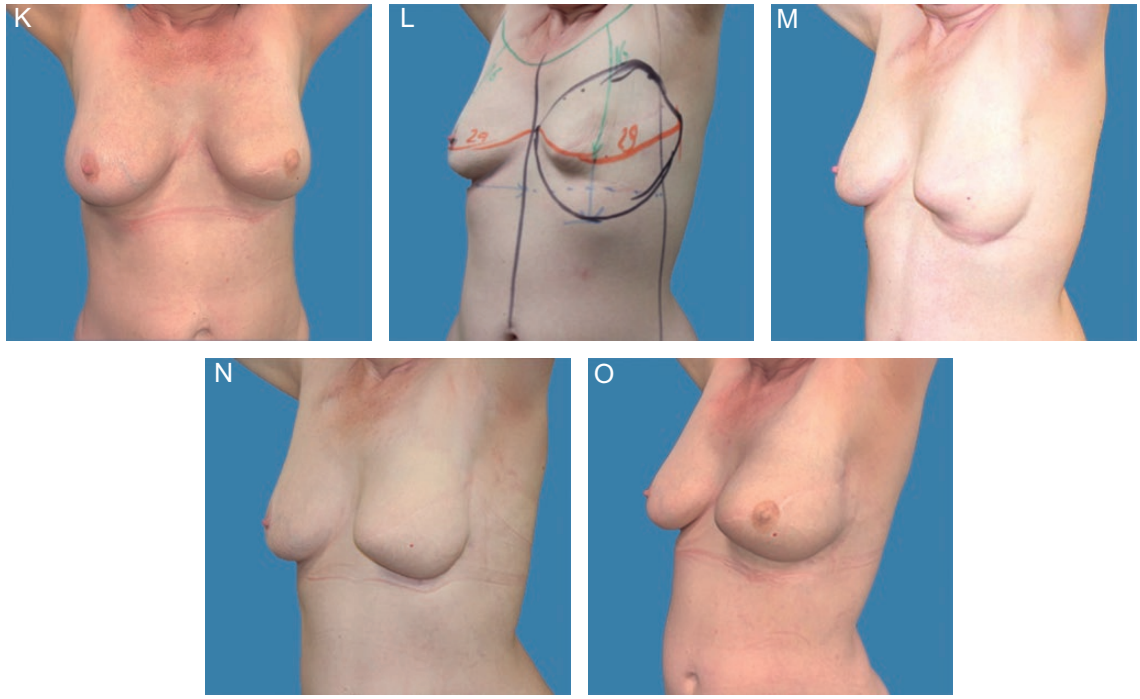


Figure 7. Continued. Frontal view with arms in resting position (A, B, C, D), perioperative basal view before and after placing the loops (E, F) and after fat injection (G), frontal view with arms elevated (H, I, J, K), three-quarter profile with arms elevated (L, M, N, O). Photographs were taken preoperatively (A, H, L), and 6 months (B, I, M), 1 year (C, J, N), and 2 years postoperatively (D, K, O).

Six months after the last session of PALLL, 35 patients completed a questionnaire to assess their satisfaction (Figure 6). Among these 35 patients, 33 (94%) would repeat the surgical procedure or recommend it to a friend and were satisfied with their breast shape. Two patients desired more volume and more upper pole. All 35 patients reported sensitive breasts.

In 14 patients (11 unilateral, 3 bilateral), the sensation was tested pre- and postoperatively (Table 2), showing improved sensation in the reconstructed breast especially in the lower quadrants of the breast (zones 3-6). Zonal sensibility was affected by the location of the scar. Clinical cases of patients who underwent this procedure are shown in Figures 7-9 and Supplemental Figure 1.

Imaging Findings

A total of 9 patients had comparative MRI scans. Assessment of the MRI scans posttreatment showed that it was difficult to distinguish between the volume recruited through the creation of an adipocutaneous flap by loops and the fat that was grafted. This made it challenging to accurately calculate the amount of fat that was resorbed radiologically; however, important loss of volume was not assessed clinically. On ultrasound, 2 patients had cystic masses that did not require any intervention. No suspicious masses were detected, and the threads were not visible on radiologic exams.

DISCUSSION

Fat grafting has proven its efficacy and safety and has become a cornerstone in breast surgery. It provides minimally invasive autologous breast reconstruction and may be considered an alternative to implant- and flap-based reconstruction.[2-5,20] However, major challenges remain for fat grafting, including the need for multiple sessions due to the limited volume of lipofilling per session, the lack of breast reshaping, and the poorly defined IMF. Colleagues around the world have described the use of loops in breasts (Table 3).[1,21-24] The senior author developed a new, minimally invasive technique for breast reconstruction and reshaping, without a resulting scar, that is based on matrix modeling, tissue advancement, and lipofilling. The main objective is to achieve symmetric breasts and to reduce the intensity and the number of procedures.

To obtain this symmetry, 4 elements should be taken into consideration: the skin surface, the breast footprint, the IMF position, and the breast volume. Hence,

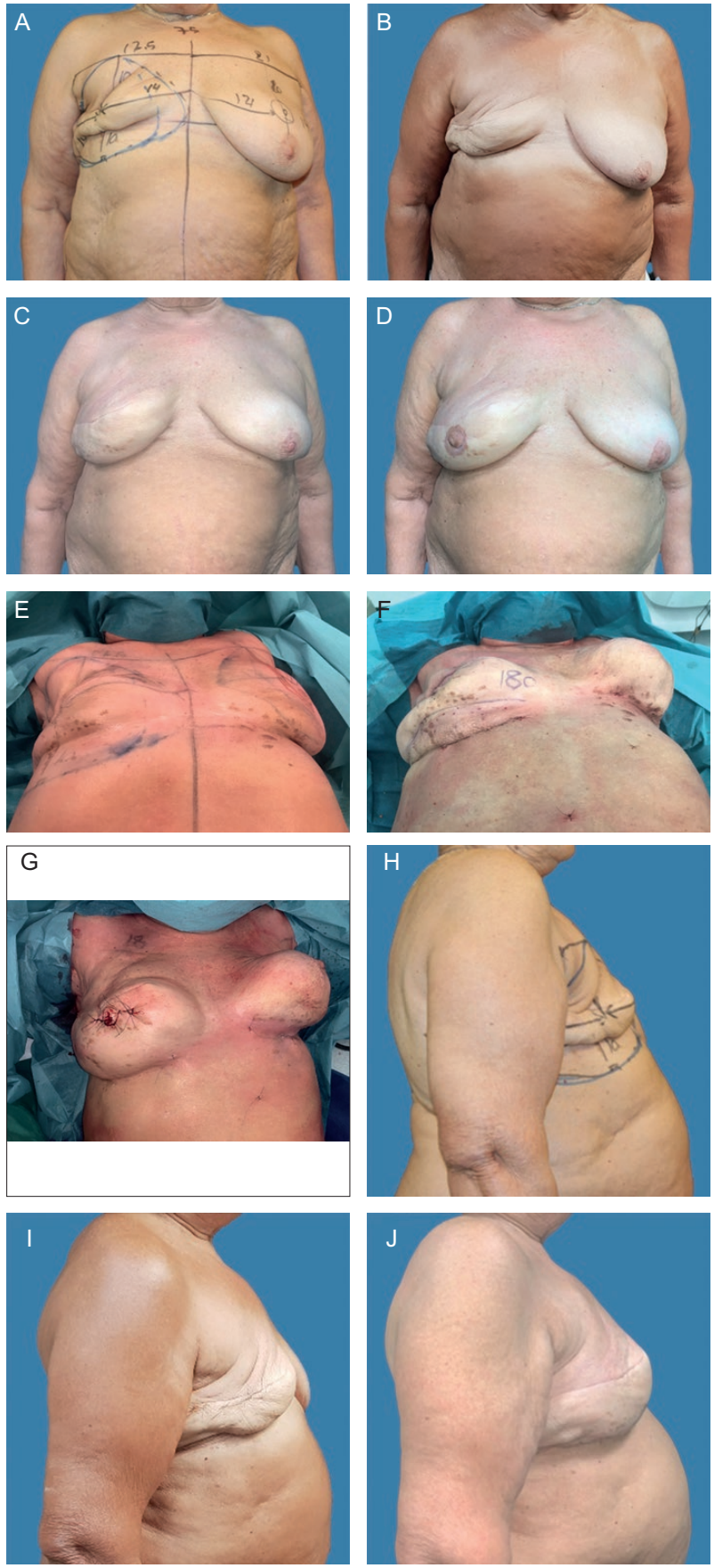


Figure 8. A 74-year-old female patient with right mastectomy. She underwent 2 sessions of PALLL for right breast reconstruction. The volume of fat injected was 180 mL during the first session and 200 mL during the second session. Scarless mastopexy was performed on the left breast. Frontal view with arms in resting position (A, B, C, D),

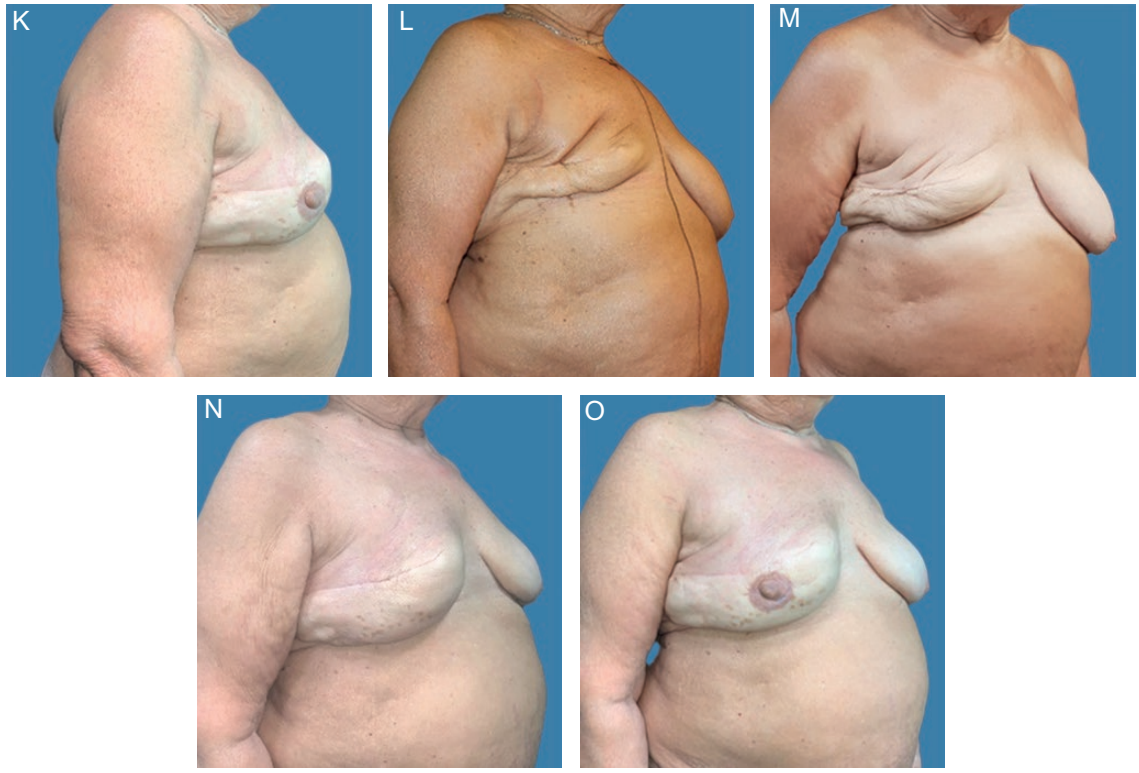


Figure 8. Continued. immediate postoperative basal view after each session (E, F, G), lateral profile (H, I, J, K), three-quarter profile (L, M, N, O). Photographs were taken preoperatively (A, H, L), and 6 months (B, I, M), 1 year (C,J , N), and 2 years postoperatively (D, K, O).

preoperative markings are crucial to design the loops in order to achieve this symmetry, to define the amount of tissue to be advanced from the upper abdomen and the lateral thorax, and to determine the new IMF position. This is, to our knowledge, the first report that describes how to design the loops in order to achieve the same cutaneous surface as the contralateral breast and to perform a simple and tailored breast reconstruction (Figures 3 and 4). Although the main objective of the loops in our technique of breast reduction[12] is to redrape the skin excess in the axillary and thoracic region, the aim of the loops in breast reconstruction is to recruit skin and fat from the upper abdomen and the lateral thorax to increase the skin surface and to replace the skin defect.

Our concept for breast reconstruction is based on matrix dissociation that consists of separating the skin from the matrix and the matrix from the underlying fascia to create gliding planes, reduce the tensile force, and allow an easier modeling of tissues. Matrix dissociation is achieved through infiltration, tunnelization, and lipoaspiration. Thereafter, matrix modeling is obtained with loops that advance the skin flap from the upper abdomen and the lateral thorax and immobilize the breast in its new position like an internal splint. Loops are passed through a blunt cannula and are only anchored to the subcutaneous tissues. The use of a blunt cannula and the absence of bone or muscular anchoring may explain our low rate of complications, especially pneumothorax and nerve entrapment, which have been reported with other techniques of breast suspension with threads. Both loops are made with a 250-cm reel of nonabsorbable, high-tensile Filapeau 2.

Early in our experience, we used absorbable sutures, namely polydioxanone, but the thread was not strong enough and the suture broke. For the newly designed IMF, we have tried absorbable barbed sutures (V-Loc 0-180) passed back and forth, but we encountered suture rupture and a lack of long-term shape stability. We believe that the early resorption of the thread as well as the significant effects of abdominal and axillary skin tension resulted in unsatisfactory results. We then shifted to polypropylene suture (Prolene* 1, 150 cm); however, this thread was not strong and long enough to maintain the breast shape. We finally tried the reel of Filapeau. This thread fitted our needs best because it was long enough, and more importantly strong enough, to support the high skin tension in the particular case of breast reconstruction.

After attaining the required skin surface, the next step is volume replacement. The senior author's technique[15-18] of power-assisted breast reconstruction expands the

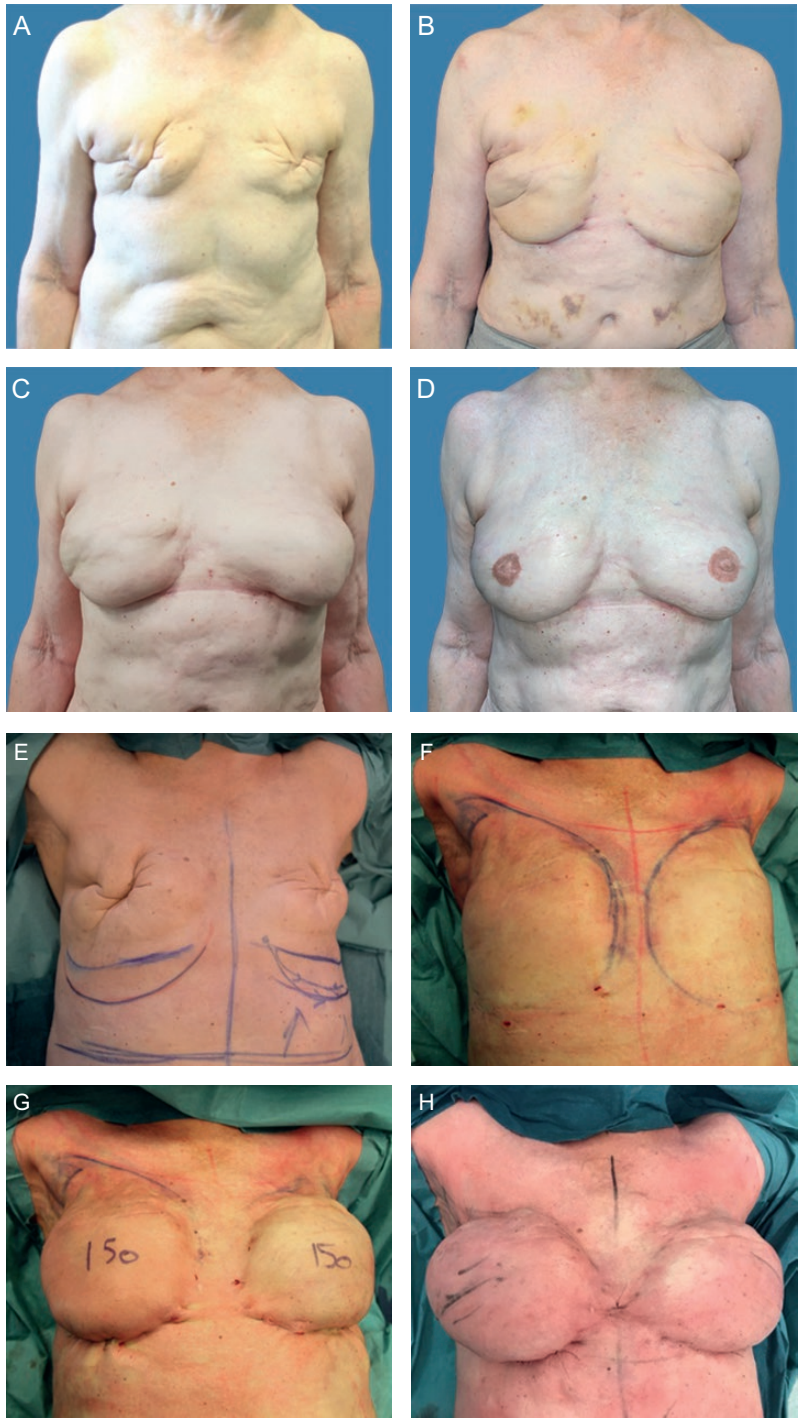


Figure 9. A 69-year-old female patient with bilateral mastectomy and radiotherapy. She underwent 3 sessions of PALLL. The volume of fat injected was 150 mL during the first session, 180 mL during the second session, and 160 mL during the third session. Frontal view with arms in resting position (A, B, C, D), perioperative view during the first session (E, F, G, H), three-quarter profile (I, J, K, L), lateral view (M, N, O, P). Photographs were taken preoperatively (A, I, M), and 6 months (B, J, N), 1 year (C, K, O), and 2 years postoperatively (D, L, P).

recipient site by means of vibration and tunnelization during fat injection, which we suggest maximizes dispersal of fat in the breast space by expanding it as the fat is injected. The combination of vibration and tunnelization applied to the reconstructed breast with the added flap advanced from breast surroundings creates an optimal

Figure 9. Continued.

Table 3. Comparison Between Different Loop Techniques in Breast Surgery

Reference	Suture design	Suture passes	Suture passer	Type of suture	Suture effect	Indication	Consideration prior to thread placement
Khouri and Khouri[1]	Percutaneous purse string suture	In the subdermal tissue at the caudal end of the epigastric crescent. The suture was suspended to the clavicle at first, and then to the pectoralis muscle after the technique had been refined	Sharp needle	Absorbable (2.0 polydioxanone suture)	Recruitment of an epigastric crescent into the breast as in a reverse abdominoplasty	Adjunct to flaps	Liposuction beyond the area to be recruited
						Primary breast reconstruction with and without Brava	
					Definition of the IMF	Breast augmentation for tuberous breasts	
					Increase in breast projection		
Hamdi et al[21]	Percutaneous purse string suture	First superficial pass under the deep dermis. Second deep pass along the deep subcutaneous tissues along the lateral side of the breast and the IMF, deep to the pectoralis muscle along the superior pole of the breast	Lipofilling cannula	Absorbable (2.0 polydioxanone suture)	Tightening of the existing layer through breast footprint reduction	Adjunct to flaps	None
						Adjunct to lipofilling with and without Brava	
					Better IMF definition		
					Increased breast projection		
Abboud et al[14]	Double loop: a circular footprint loop designed to define the breast footprint and enhance breast projection, and a triangular IMF loop designed to suspend and fixate the IMF in its new position	The first loop spans the superficial subcutaneous tissues at the lower quadrants of the breasts (between 3 o'clock and 9 o'clock) and the deep subcutaneous tissues, in a suprafascial plane in the upper quadrants (between 9 o'clock and 3 o'clock). The second loop spans the superficial subcutaneous tissues along the newly positioned IMF and then towards the head to reach the midpoint of the interaxillary axis. Each loop is passed twice. The suture is anchored in the subcutaneous tissue of the upper inner quadrant.	Abboud 3-mm 3-hole blunt cannula	Nonabsorbable Filapeau 2, 250 cm	Recruit skin and fat from the upper abdomen and lateral thorax	Main component in total breast reconstruction with lipofilling considered as an adjunct	Extensive liposuction and tunnelization in the upper abdomen and lateral thorax beyond the loop markings. Deep undermining using a Varady retractor along the scar tissue and the remnant of the native IMF. This is performed in order to release the subcutaneous attachments, to expand the tissue to be advanced, thereby facilitating its mobilization
					Reconstruct the same skin surface, breast footprint and IMF as the contralateral breast		
					Increase breast volume and projection		

IMF, inframammary fold.

scaffold for large-volume fat grafting. Moreover, the diluted injected fat adds a margin of safety against overgrafting. Considering the volume ensured by tissue recruitment, the volume of fat that needs to be injected is reduced. As stated by Khouri and Khouri,[1] the crescent provides between 150 and 250 mL of tissue and 5 to 10 cm of skin into the breast. In our study, the advanced flap provided 197 mL, which is more than double the injected fat volume (153 mL), taking into consideration the resorption rate. Additional external vibration at the end of injection further disperses fat in the recipient site and yields a softer feel. The final breast volume is therefore composed first and foremost of the volume recruited from the upper abdomen and the lateral thorax, and secondarily from the injected fat and the residual breast volume after mastectomy. In fact, our incisionless advancement flap provides the main

volume of the reconstructed breast. This explains why the majority of our patients only need 2 sessions of lipofilling to achieve the desired volume. Nevertheless, for severely irradiated patients, fat intake was reduced per session; this is why those patients usually required a third session. At the final stage of breast reconstruction, when performing the tattoo for the areolar reconstruction, the threads are removed. The senior author believes that internal loops provide short-term stability whereas long-term results are ensured by the fibrosis that follows. Considering the fact that the fibrosis can only be confirmed by biopsy, further studies are required in this field.

An interesting point of this technique is the potential ability to provide more sensate breasts, compared to insensate implants[25] and poorly sensing flaps.[26,27] Most of the patients reported near-normal light touch sensation of the breast skin surface tested with Semmes-Weinstein monofilaments. Regaining sensibility may be due to the innervated skin flap advanced from the abdomen and the lateral thorax, especially in the lower breast quadrants and related to the potential regenerative effect of the injected fat.[28,29]

Limitations

Although the study was detailed and care was taken with its design, we recognize its limitations. The authors' application of internal threads, tunnelization, and vibration is based on the results of clinical observation. Basic research is nevertheless warranted to address the potential benefits and drawbacks of these procedures. In addition, our technique of breast reconstruction utilizing liposuction, loops, and lipofilling is still evolving. Finally, the reduction in skin tension is a clinical hypothesis, and more studies should be performed to quantify skin tension before and after adding loops.

Moreover, our satisfaction questionnaire has not been validated, limiting its interpretation. Nonetheless, this survey was the standard in our department. This questionnaire has been used in previous studies since 2015 for a total of 664 patients reported in the literature.[12,14-16,18]

CONCLUSIONS

Breast reconstruction by PALLL is a minimally invasive alternative for reconstructing and reshaping sensate breasts utilizing a vascularized skin flap recruited by loops from breast surroundings in combination with fat grafting. The restoration of sensation is a major breakthrough when compared to conventional methods of breast reconstruction. The technique is a simple and safe option to reconstruct small and moderate breasts, even when irradiated. The technique is reproducible once the learning curve has been completed. It provides long-term shape stability with minimal scarring and a low complication rate.

Supplemental Material

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

Acknowledgments

We thank Dana Hawi and Sofie Abboud for the creation of the artwork and videos.

Disclosures

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

Funding

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

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