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Breast

Technical and Analytical Approach for Breast Reconstruction With IMAP Propeller Flap

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Background: The breast-sharing technique uses the lower quadrants discarded from a contralateral symmetrizing reduction mammoplasty to reconstruct the breast after mastectomy. The aim of our study was to revisit this old technique and to improve its vascular predictability by preoperative computed tomography angiography (angio-CT) and intraoperative indocyanine green (ICG) imaging.

Methods: Twenty-six patients were enrolled and assessed by a preoperative angio-CT to localize and evaluate the internal mammary artery perforator (IMAP). In the selected patients, a Wise skin-pattern reduction was designed to allow elevation of a transversely oriented flap including both inferior poles. The flap was based medially on the IMAP. After elevation, evaluation of its arterial and venous perfusion was assessed with ICG.

Results: Eight patients were excluded after pre- and intraoperative studies. Sixteen breast-sharing flaps were performed. A distal flap venous compromise appeared in 2 cases, requiring debridement and flap repositioning, and an infection occurred in 1 case. Four patients had detectable firm lumps that resolved. There were no issues with donor site healing, and a repositioning of the areola was necessary in 2 patients.

Conclusions: Breast-sharing techniques have not gained popularity for many reasons. By combining current understanding of breast cancer behavior, experience with perforator anatomy, and angio-CT and ICG, we believe this study gives a second life to this flap, identifying its weaknesses and improving them. The IMAP propeller flap, simpler and safer in the presence of comorbidities than a free flap, can be a good choice for well-selected candidates. *(Plast Reconstr Surg Glob Open 2024; 12:e6353; doi: 10.1097/GOX.0000000000006353; Published online 5 December 2024.)*

INTRODUCTION

Many autologous breast reconstruction techniques have been described: transverse rectus abdominis musculocutaneous flap,[1] free transverse rectus abdominis musculocutaneous flap,[2] deep inferior epigastric perforator flap,[3] latissimus dorsi flap,[4] and so forth. Often, during breast reconstruction, the reduction of the contralateral breast is required to achieve symmetry.

Merging these 2 considerations, it is possible to revisit an old method described in 1981 by Marshall et al[5] and recovered with perforator technique in 2001 by Schoeller et al,[6] the breast-sharing technique. In 2005, breast sharing was reported as a free flap transfer.[7]

In this technique, the tissue normally discarded from the reduction mammoplasty is used to reconstruct the breast after mastectomy. This option is more appealing in older women requiring mastectomy on 1 side who have a hypertrophic and ptotic breast on the other and do not have a familial history of breast cancer.

The procedure has a solid anatomical base, well explained by Schmidt et al.[8] The internal mammary artery perforator (IMAP), specifically the fourth IMAP, usually supplies the lower quadrants of the breast, inferior to the nipple-areola complex, until the inframammary fold.

The aim of our study was to give a second life to this old technique based on a more refined understanding of the IMAPs and a pre- and intraoperative vascular evaluation using modern computed tomography angiography (angio-CT) and indocyanine green (ICG).

PATIENTS AND METHODS

From May 2018 to June 2021, we enrolled 26 patients presenting for breast reconstruction for the breast-sharing technique at the department of plastic

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and reconstructive surgery of Policlinico di Modena, Italy. All patients received preoperative local oncological screening with digital mammography, magnetic resonance imaging, and a preoperative study of the IMAPs with angio-CT. All angio-CTs were performed at the same facility (Policlinico di Modena), using the same 128-slice CT scanner (Lightspeed VCT; GE Medical Systems, Milwaukee, WI). Informed consent was obtained from each patient. Examination protocol was the following: 120 kV, 300–400 mA, 0.625-mm slice thickness, 0.625-mm gap, pitch 0.6 s, field of view 32–39 cm. Contrast agent was high-concentration Iomeron 400 (Bracco, Milan, Italy), plus saline flush. The contrast medium was injected at a speed of at least 3.5–4.5 mL/s through an intravenous catheter inserted into an antecubital vein. The infusion of the medium contrast was followed by the injection of 30 mL saline solution at the same rate of flow. The option Smart-Prep scanner, with a region of interest localized at the aortic arch level, was used to synchronize the scanning with the peak of artery opacification, using a densitometric threshold of +100 HU. Angio-CT examination was completed by a precontrastografic acquisition and a venous thoracic–abdominal phase in the case of a specific clinical indication, for example for the purpose of staging.

Data were then analyzed on a dedicated workstation (AW7.0; GE Healthcare, Milwaukee, WI). Postprocessing techniques consisted of cross-sectional multiplanar reconstruction and volume rendering images of the chest wall. We recorded location, size, eventual anatomical abnormalities, and the emergence and the path of the inferior mesenteric artery and its perforators (IMAP). The IMAP perforation sites with respect to the chondrosternal articulation and the fascial wall were recorded with a virtual mark on volume rendering reconstruction of the chest wall.

Takeaways

Question: Is the internal mammary artery perforator (IMAP) propeller flap an alternative for breast reconstruction?

Findings: Breast-sharing techniques have not gained popularity for several reasons. With a more refined understanding of the IMAPs and a pre- and intraoperative vascular evaluation using modern computed tomography angiography and indocyanine green, a second life can be given to this old technique.

Meaning: Identifying its weaknesses and improving them with new technologies, the IMAP propeller flap can be a good choice for selected candidates.

SURGICAL PROCEDURE

On the reduction side, the patient was marked in the standing position using the Wise skin-pattern design for reduction with superomedial pedicle (Fig. 1). Preoperative Doppler confirms the site of the IMAPs previously defined on angio-CT (Fig. 2). Once identified, usually the fourth, the Wise pattern may need adjustment so that the medial breast flap includes the territory of the IMAP and the medial limb of the Wise pattern incision is extended to this level (Fig. 3).

The flap size corresponds to the breast's lower poles, which would normally be removed during a reduction mammoplasty with a superomedial pedicle. The size is evaluated, preserved, or modified during the intraoperative phase with the ICG examination.

The patient, now anesthetized, is positioned supine with arms abducted at a 60-degree angle. Flap elevation (Fig. 4A) is performed with 3.5× loupe magnification and starts from lateral to medial following the prefascial plane until the selected perforator is found. With the use of handheld ultrasound Doppler, the perforator is isolated, skeletonizing it sufficiently to obtain a simple rotation of

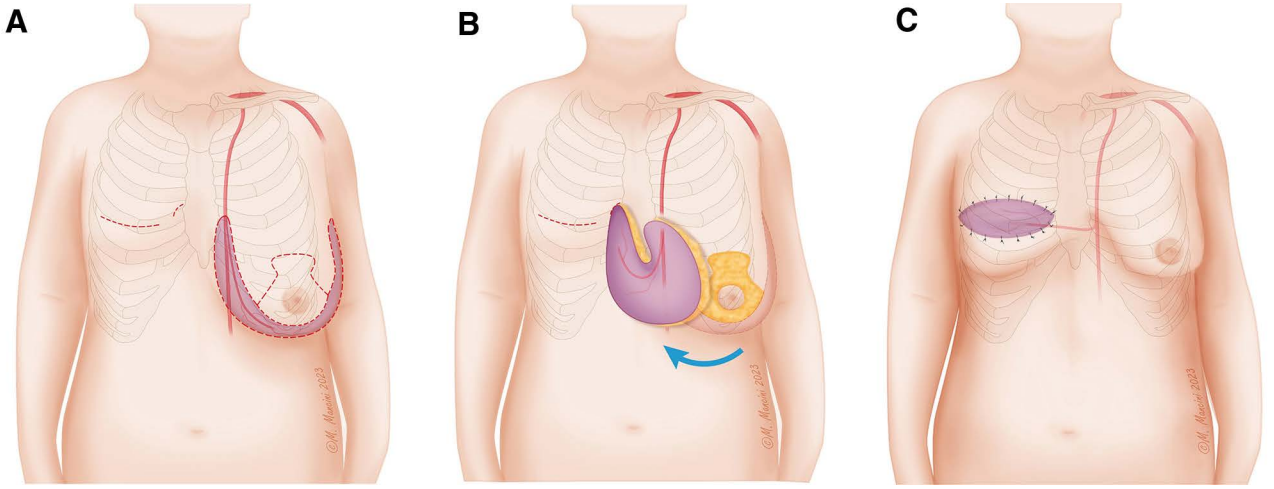

Fig. 1. Illustration of the various phases of surgery, highlighting the vascular axis composed of the internal mammary artery and the perforating artery (IMAP). A, Illustration of preoperative marking of the flap. Note the vascularization of the IMAP from the internal mammary artery inside the flap. B, Illustration of the flap rotation. C, Illustration of the flap insetting.

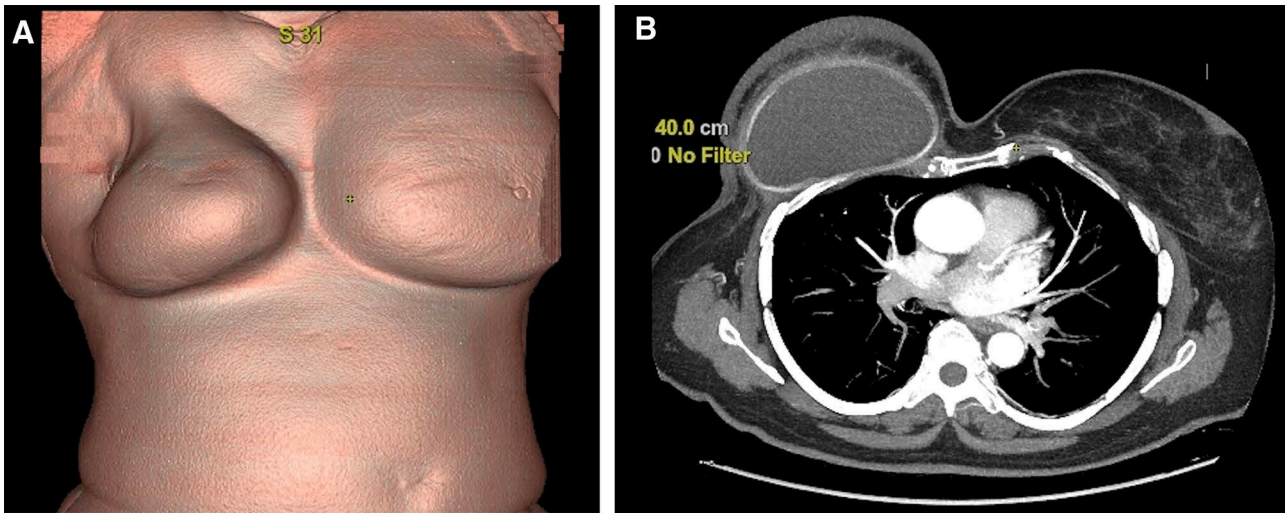

Fig. 2. Case 1: preoperative angio-CT. A, 3D reconstruction with the skin position of the perforator. B, Cross-section of the CT scan on the fourth intercostal space with the perforator's pathway through the medial and lateral inferior poles.

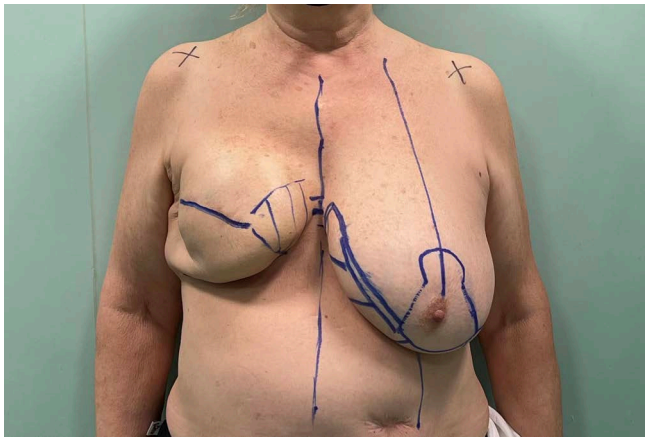

Fig. 3. Case 1: preoperative marking reproducing the Wise pattern mammoplasty reduction, adjusting it medially according to the selected perforator.

the flap. The prepectoral fascia is incised circumferentially around the perforator to reduce the risk of kinking.

The dissection continues through the pectoralis major muscle until the origin of the perforator is reached. To avoid the subsequent medial bulging of the flap, a subcutaneous tunnel is created above the sternum and an accurate skeletonization of the perforator is necessary before the rotation.

The flap is rotated at a 180-degree angle and laid into the contralateral mastectomy defect in an anticlockwise direction if the donor breast is the right one and in a clockwise direction if the donor breast is the left (Fig. 4B, C).

An evaluation of the flap perfusion is made before and after the flap rotation with fluorescence angiography ICG, allowing 20 minutes to pass between the first and the second injection. We use the Fluobeam device (Fluoptics, Grenoble, France),[9] which includes a 780-nm laser light source and a camera collecting only ICG-induced fluorescence. The ICG dye is administered intravenously. The maximum dose is 0.5 mg/kg per patient. In agreement with the anesthetist, we injected half of the maximum dose to be able to repeat it twice. It has a short plasma half-life of .75 minutes and is excreted via the liver. According to the fluorescence intensity and the rapidity of wash out, it is possible to evaluate the distal arterial and venous perfusion of the flap.

If the distal part is not well perfused being black during the ICG evaluation or with a slow washout remaining highlighted even when the other areas go back to black, it may be possible to perform an additional venous anastomosis between a superficial vein of the distal part of the flap chosen during dissection and the thoracoepigastric vein or another vein of the subscapularis system on the contralateral side (Fig. 5).[10] An alternative is to discard the poorly vascularized portion of the flap if the residual volume is sufficient to reconstruct the breast or to abandon the flap, choosing another reconstructive method.

At the end of the vitality evaluation, the flap is inset to create the new breast mound anchoring the distal part to the axillary pillar. The donor breast is closed as a superior or superomedial pedicle reduction mammoplasty (Fig. 6).

After 1 year of follow-up, a good symmetry of shape and volume is achieved (Fig. 7).

RESULTS

We enrolled 26 patients whom we thought were appropriate for a breast-sharing technique. After preoperative studies, 8 patients were excluded: 7 due to an incompatible anatomy because the main perforator was in the second intercostal space; the other was unsuitable because although the perforator was in the fourth intercostal space, its distribution was to the contralateral breast. In 2 further patients, intraoperative fluorescence angiography ICG revealed poor vascularization following rotation of the flap, so the flap was discarded and

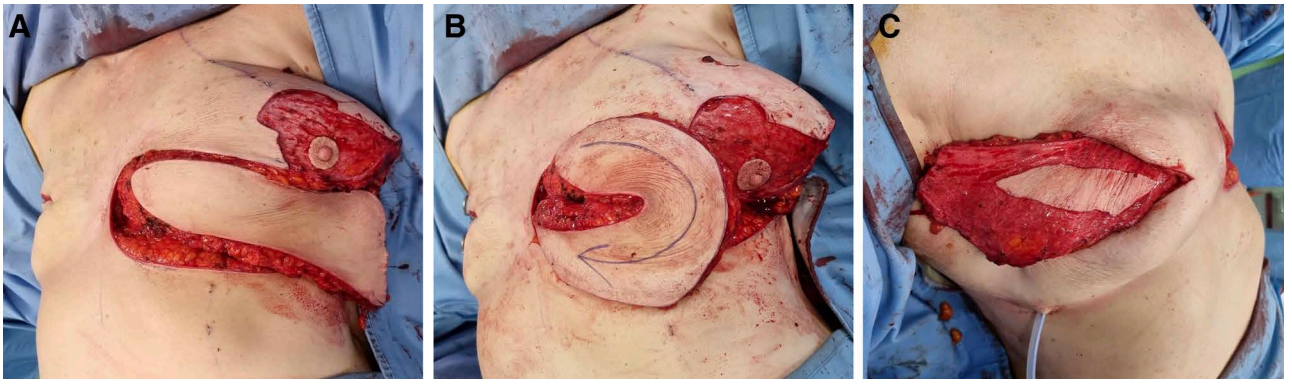

Fig. 4. Case 1: intraoperative view of a breast-sharing technique for the reconstruction of the right breast. A, Harvesting of IMAP propeller flap. B, Rotation of the flap in a clockwise direction. C, IMAP flap after rotation.

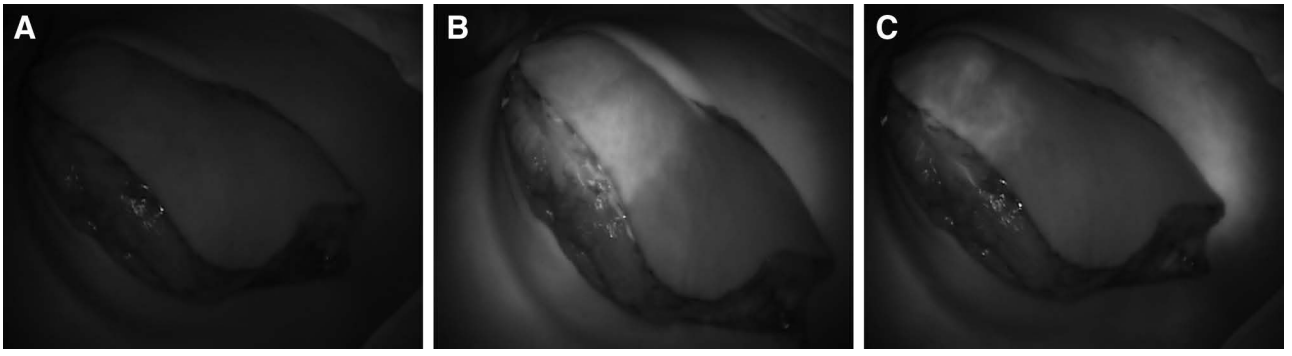

Fig. 5. Intraoperative fluorescence angiography with ICG. The ICG dye is administered intravenously. In this case, it can be seen that approximately half of the flap is not perfused. For this reason, half of the flap was discarded. A, Fluorescence angiography 0 seconds after injection of ICG. B, Fluorescence angiography 2 minutes after injection of ICG. C, Fluorescence angiography 5 minutes after injection of ICG.

Fig. 6. Flap inset and wound closure.

an expander was placed under the pectoralis major muscle for the reconstruction. In 1 case, after having detected a partial distal congestion of the rotated flap, a venous anastomosis was performed, improving the venous discharge. At the end, 16 breast-sharing flaps were performed.

The median age of the patients was 56 (range, 38–68) years, all with class I obesity (body mass index [BMI], >30 kg/m^2). All had comorbidities as shown in Table 1. Thirteen patients had preoperative radiotherapy (Table 2). As for the breast cancer histology, 7 patients had the diagnosis of invasive ductal carcinoma, 8 of invasive lobular carcinoma, and 1 of pleomorphic lobular carcinoma. Three patients had a tumor stage I, 6 patients had a tumor stage II, 6 patients had a tumor stage III, and 1 patient had a tumor stage IV. For chemotherapy treatments and hormonal therapy, see Table 2. Four patients required axillary dissections. In 7 patients, breast-sharing reconstruction was performed at the same time as the mastectomy, and in 9 it was a delayed procedure.

In 10 cases, the indocyanine evaluation showed complete perfusion of the flap, and in these, there were no complications related to necrosis. In the remaining 6 cases, ICG perfusion of the distal tip region was not uniform with a darker area even with ICG present, so it was judged adequate to proceed. Of these, 2 cases developed distal flap compromise requiring surgical debridement and a small reduction of the opposite breast for symmetry. In 1 case there was an infection, which resolved with antibiotic therapy. Late complications occurred in 4 patients who had detectable firm lumps consistent with small areas of fat necrosis (Table 3). Of the 16 cases, 9 (56%)

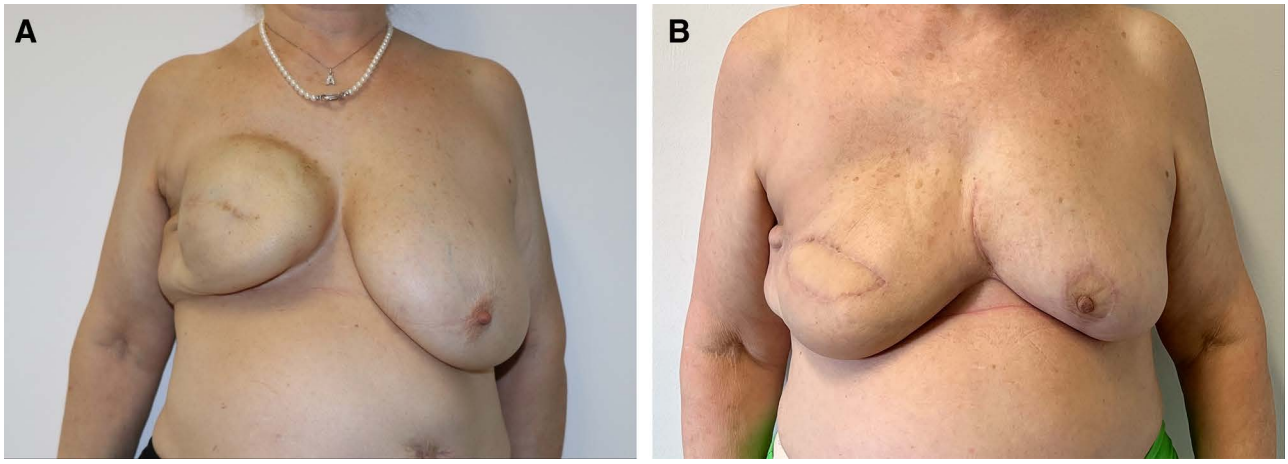

Fig. 7. Case 1. A, Preoperative view of the right breast after reconstruction with a tissue expander and radiotherapy. B, Right breast reconstructed with a left IMAP propeller flap after 1 year and a half of follow-up.

Table 1. Demographic and Comorbidity Characteristics of the Population

Population Characteristics	Patients	%
Age, y		
Mean (range)	56 (38–68)	
Comorbidity, n		
Arterial hypertension	14	87.5
Type II diabetes mellitus	4	25
Hypothyroidism	3	18.75
Transient ischemic attack	1	6.25
Metastasis	1	6.25
Ever smoked	9	56.25

Table 2. Population Cancer Therapies

Oncological and Reconstructive Treatments	Patients, n
Surgery and RT	
Immediate reconstruction	
No previous RT	3
Previous quadrantectomy and RT	4
Delayed reconstruction	
Previous mastectomy and RT	3
Previous mastectomy and expander placement + subsequent RT	6
Other therapy	
Neoadjuvant chemotherapy	6
Adjuvant chemotherapy	3
Hormonal therapy	16

RT, radiation therapy.

had autologous fat grafting for symmetrizing or contour restoration.

Regarding the donor site, no issues of healing occurred. A repositioning of the areola of the donor breast in 2 (12.5%) patients was necessary, but 1 of them refused the proposed procedure (Figs. 8, 9; Table 4).

After an average follow-up of 3 years, patients' satisfaction regarding volume and symmetry was high, no recurrences were detected, and 1 patient died due to metastatic spread.

Table 3. Population Early and Late Complication Rates

Complication Rates	Patients	%
Early		
Distal ischemia	2	12.5
Infection	1	6.25
Late		
Hard lumps	4	25

DISCUSSION

Nowadays autologous breast reconstruction is accepted as the gold standard, and patients who undergo this procedure report the highest satisfaction.[11] It is particularly indicated when there has been prior radiation therapy. Here, implant-based reconstructions are associated with high morbidity.[12] Moreover, when patients have received premastectomy whole breast radiation therapy, as in 5 of our 16 patients, it is strongly recommended to consider autologous reconstruction.[13,14]

In the last 3 decades, profound advancements have been seen in the field of breast reconstruction, trying to perfect the best breast mound both in shape and in consistency. With respect to consistency, there is no greater replica than breast tissue itself.

Despite this, breast-sharing techniques have not gained popularity for several reasons. At the time of the publication by Marshall et al,[5] there was a different understanding of breast cancer and its behavior. Would reconstruction mask recurrence, should it be only done after a prescribed time delay, does the opposite breast in a patient with cancer have a higher incidence of cancer, and would implantation of tissue from the opposite breast risk recurrent cancer? We now know that many of these concerns have proven baseless, but still, proper evaluation of bilateral cancer risk is essential. Another reason the sharing technique was poorly adopted was because of its need for a 2 or more staged procedure and the bulk of the twisted medial pedicle causing symmastia. With the advent of perforator concepts, a 1-stage propeller design is now possible, including the capacity to primarily debulk the

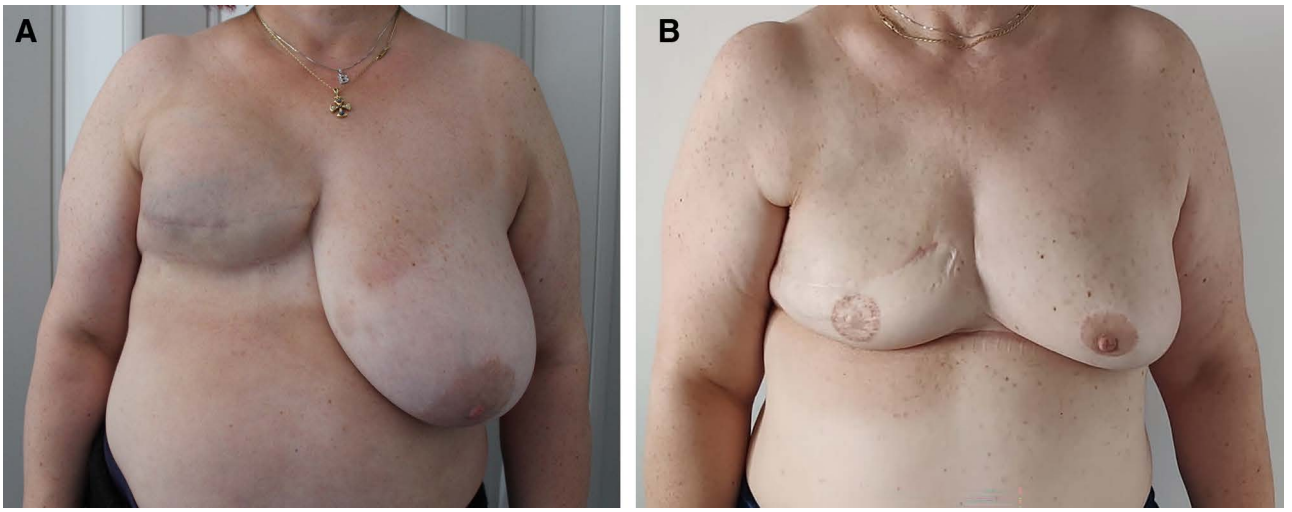

Fig. 8. Case 2. A, Preoperative view of the right breast after reconstruction with a tissue expander and radiotherapy. B, Postoperative view after 1 year and a half of follow-up and after repositioning of the left areola.

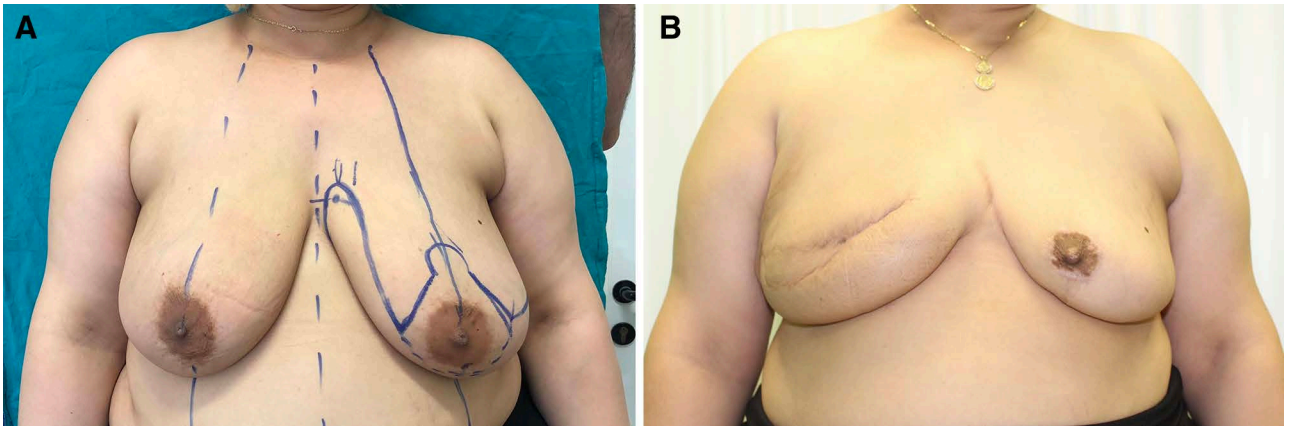

Fig. 9. Case 3. A, Preoperative view with marker reproducing the Wise pattern mammoplasty reduction. Here, the localization of the IMAP on the fourth intercostal space can be seen. B, Postoperative view of the right breast reconstructed with an immediate left IMAP propeller flap after 1 year follow-up. This patient refused the proposed procedure of repositioning the areola of the donor breast.

Table 4. Touch-up Procedures

Procedure	Patients	%
Autologous fat graft	9	56
Areola repositioning	1	6.25

pedicle base. The ultimate deterrent to the procedure's popularity was its vascular unpredictability; in particular, venous congestion, distal flap loss, and early and late fat necrosis.[15,16] Perforator anatomy, angio-CT, and intraoperative ICG have developed since the procedure was first proposed, and with experience, vascular risks can now be quantified and minimized. To contrast all these concerns, we have developed some modifications and implementations to this technique.

Concerning breast cancer recurrence, first, it is of overwhelming importance to evaluate if the patient is a candidate for risk-reducing contralateral mastectomy. Nowadays, it is indicated in patients considered to be at high risk of developing contralateral breast cancer (CBC), that is, patients with hereditary breast cancer. The annual CBC risk is around 0.5% in the general population and up to 3% in BRCA1/2 mutation carriers.[17,18] According to a recent meta-analysis[19] some risk factors have been described as predictors of a moderately increased risk of CBC (ie, radiotherapy for primary breast cancer [PBC] at a young age). Others have decreased CBC risk, such as older age at PBC diagnosis and administration of adjuvant chemotherapy or endocrine therapy. An increased association with CBC risk for lobular PBC was described in older studies,[20] but it was less observed after 2000, an era in which adjuvant systemic therapy was more widely given.

Thus, in our experience, an accurate selection of patients is really important. Obviously, the donor breast must be hypertrophic and or ptotic. The ideal candidate is likely an older woman with a relatively high BMI. Comorbidities and a history of radiotherapy are the most feared for autologous

breast reconstruction; in particular, BMI greater than 30 kg/m^2 is associated with increased overall complications, donor- and recipient-site complications, and partial flap failure.[21–25] Conversely, and somewhat counterintuitively, it could be argued that these comorbidities favor the selection of contralateral pedicled breast reconstruction.

To avoid symmastia, apart from pruning the accurately located pedicle as described earlier, we create a presternal subcutaneous tunnel including fat removal, which guarantees the formation of 2 well-distinct breast mounds.

Regarding the importance of incidence of vascular complications, according to the recent study by Vegas et al,[26] an accurate preoperative imaging study is mandatory to enroll patients for breast-sharing reconstruction: In our study, 10 of 26 patients were excluded preoperatively because of inadequate perfusion.

If venous congestion occurs intraoperatively, a venous anastomosis can be performed, in accordance with Schoeller et al. We have performed it in only 1 case, improving venous drainage and saving the flap.[10]

ICG angiography is now widely used in plastic surgery.[27,28] In assessing flap perfusion since 2002[29] for different flaps including the versatile anterolateral thigh flap, free tissue transfers in head and neck reconstruction and in particular for breast reconstruction. ICG has been shown to reduce the incidence of postoperative complications, such as flap necrosis and congestion.[30,31] Our experience concurs with these reports, allowing us to abandon the procedure intraoperatively when needed and to have confidence that if the ICG demonstrates full perfusion, then the procedure could proceed complication-free. The nuance of ICG evaluation of full or partial perfusion is an issue. The speed of wash out and density of dye perfusion and semiquantitative measures can change with twisting of the pedicle, compression, positioning, and so forth. The complications experienced in this series occurred in the group of 6 who had suboptimal perfusion but were considered adequate to proceed.

The advantages of the breast-sharing technique are many. The potential for a simultaneous, 1-stage procedure for reconstruction and symmetrizing contralateral reduction is attractive. Simultaneous reduction at the time of free autologous reconstruction is a reasonable option due to no difference in the revision rate, although there is a higher complication rate in the immediate procedure.[32] However, simultaneous reduction at the time of free flaps greatly extends the length of complex surgery and the authors prefer, most of the time, to postpone it to a later date, to achieve a better symmetry with a stable flap.

The donor tissue in the breast-sharing procedure is the ultimate "like with like." Compared with free flap reconstructions, the perforator flap is a simpler and generally safer procedure, especially in the presence of comorbidities. It does not invade the abdomen with its attendant complications such as scarring, necrotic flaps, late herniation, and muscle weakness. Disadvantages include eligibility. The candidate must have excess tissue for donation, and the vascularity must be assessed as accurately as possible before embarkation. As this series demonstrates, the presence of the fourth perforator and its distribution is variable, estimated to be suitable in only 16 of 26 cases (61.5%). Two more cases showed inadequate perfusion on the table. The applicability of this procedure is therefore limited to favorable candidates. The flap shape is elliptical rather than round and may need folding to fill the upper pole region. As with all breast flap reconstructions, nuance of flap inset, aesthetic appreciation, and repetition are needed to maximize outcomes. Just as for free flap reconstructions, the need for secondary touch-ups such as nipple reconstruction, liposuction, fat injection, and other adjustments is likely in some cases of breast sharing to compensate for the minor contour defects and asymmetries.

CONCLUSIONS

Combining our current understanding of breast cancer behavior, sophisticated knowledge of and experience with perforator anatomy, and preoperative angio-CT and intraoperative ICG, we believe this study gives a second life to an old breast reconstruction technique, breast sharing, identifying its weaknesses and improving them with new technologies, making it a good choice for selected candidates.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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