

Fat Injection to the Breast: Technique, Results, and Indications Based on 880 Procedures Over 10 Years



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BACKGROUND: Fat injection to the breast is not a new idea, but it has always been controversial. In particular, it has been feared that breast augmentation with autologous fat could lead to the formation of calcifications and cysts that might hinder mammographic examinations for detection of possible breast cancer.

OBJECTIVE: The authors report their experience with fat transplantation in the breast (lipomodeling) covering 880 procedures performed over the past 10 years. They review their technique and results, and describe the various indications for which they have found lipomodeling to be appropriate.

METHODS: Lipomodeling was generally performed under general anesthesia. Fat was harvested from the abdomen or in some cases from the inner thighs, depending on the patient's natural fat deposits. The harvested fat was centrifuged to obtain purified fat, which was transferred to 10-mL syringes for injection directly into the breast. Fat was injected in small quantities under light pressure, utilizing a honeycomb of microtunnels and halting when the recipient tissues were saturated to avoid creation of fatty pools that could lead to fat necrosis. To compensate for fat resorption, 140 mL of fat was injected for a desired final volume of 100 mL.

RESULTS: Clinical follow-up shows that the morphologic results of lipomodeling with regard to the volume obtained are stable three to four months postoperatively if the patient's weight remains constant. The postoperative radiologic appearance is usually that of normal breasts, sometimes showing images of fat necrosis that will not confuse the differential diagnosis of cancer for radiologists experienced in breast imaging. Oncologic follow-up at 10 years postoperatively (for the first patients) showed no increased risk of local recurrence of cancer or development of a new cancer. Results were highly satisfactory for both patients and surgeons. Complications included one case of infection at the harvest site, six cases of infection at the injection site, and one case of intraoperative pneumothorax that was successfully treated in the recovery room with no later consequences. The incidence of fat necrosis was 3%, with most cases occurring early in the surgeon's experience.

CONCLUSIONS: Lipomodeling, because of a low complication rate and positive results, presents a new option for plastic, reconstructive, and aesthetic surgery of the breast. Pre- and postoperative examination by a radiologist specialized in breast imaging is necessary to limit the risk that a cancer may occur coincidentally with lipomodeling. (*Aesthet Surg J*;29:360-378.)

Transferring fat from an area where it is present in excess, such as the abdomen or thighs, to the breast in order to improve breast shape and volume is not a new idea. Following the work of Illouz¹ on liposuction, which led to its widespread use throughout the world, it was tempting to use the fat from adipose deposits to increase breast volume. Illouz himself used this procedure. Similarly, in 1991, Fournier² described his technique of breast augmentation by fat injection, but he limited use of the procedure to patients who refused implants and desired only a moderate increase in volume. The quantities injected ranged from 100 to

250 mL in each breast. Fournier took care to state that he only injected in the retroglandular space and not in the breast parenchyma.

Many surgeons were skeptical about this technique, because the principles enabling fat transfer with little likelihood of focal fat necrosis were not codified. In addition, breast imaging was less advanced than it is today and any swelling in the breast raised a potential diagnostic difficulty. Many clinicians feared that focal fat necrosis would compromise the diagnosis of a possible cancer.

The major blow to the technique was delivered in the wake of the animated controversy erupting after the publication of two papers by Bircoll^{3,4} that provoked virulent opposition.⁵⁻⁷ His detractors emphasized the fact

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that injections of fat in a native breast could generate microcalcifications and cysts, making the detection of cancer difficult. Bircoll stressed in his responses^{8,9} that calcifications after fat transfer differ from neoplastic calcifications in both location and radiologic appearance, and that breast reduction surgery also generates microcalcifications. Nevertheless, in 1987, a committee set up by the American Society of Plastic and Reconstructive Surgeons (ASPRS) to investigate the issue ruled as follows: "The committee is unanimous in deploring the use of autologous fat injection in breast augmentation. Much of the injected fat will not survive and the known physiological response to necrosis of this tissue is scarring and calcification. As a result, detection of early breast carcinoma through xerography and mammography will become difficult and the presence of disease may go undiscovered." These affirmations were made without any references or scientific studies and were based only on the opinions of the committee members. Because of this prohibition by the ASPRS, research and experimental studies in this field came to a halt. Ironically, a retrospective study of mammographic changes after breast reduction,¹⁰ published in the same journal at the same time, reported that calcifications were found in 50% of cases two years postoperatively. The author of that article stressed that, in the majority of cases, it was possible to differentiate them from those observed in cancer. In spite of this very high incidence of radiologic imaging findings and the risk of interference with detection of a breast cancer, no discussion took place on abandoning breast reductions. Since then, in spite of the lack of more extensive research—and although it was recognized at the time that any breast surgery could potentially generate oily cysts and/or mammographic changes—the injection of fat into the breasts has been a subject of controversy that has yet to be settled by any authoritative body.

The interest in fat injection was reawakened in the early 1990s following the work of Coleman,^{11,12} who confirmed that fatty tissue could be transferred satisfactorily with the stipulation that a strict protocol for fat preparation and injection was respected. We had also observed that fat transfer was a very effective technique in facial cosmetic surgery and in the revision of posttreatment facial sequelae. Since 1998, the evaluation of fat transfer in the chest wall and breast has been one of our major research interests. As a result, we were able to further develop this technique, which we have called lipomodeling,¹³⁻¹⁵ to evaluate its efficacy and tolerance and to show that it is free of harmful clinical or radiologic effects.

We first applied fat transfer to breast reconstruction with an autologous latissimus dorsi flap, a technique that had been developed in our plastic and reconstructive surgery unit.¹⁶⁻¹⁸ In 70% of cases, the resulting reconstructed breast volume was satisfactory, but in 30%, the volume was not sufficient and the opposite breast had to be reduced or an implant inserted. This meant that the reconstruction was no longer entirely

autologous and it also carried the additional disadvantages associated with implant placement (less natural shape and feel or the need for eventual implant replacement). The protocol was initially proposed to patients who volunteered for the treatment and agreed to undergo strict surveillance. Once we ascertained that this technique was both extremely effective and lacked adverse effects, we extended the indications to the majority of patients who had undergone autologous latissimus dorsi reconstruction and who wished for optimal shape and consistency, with as natural a décolleté as possible.

In parallel, we carried out a mammographic, ultrasound, and magnetic resonance imaging (MRI) study¹⁹ revealing that the effect on breast imaging was far from unacceptable. We then progressively extended the indications of lipomodeling to breast reconstruction in various contexts, then to deformities, then to sequelae of conservative treatment and, more recently, to cosmetic breast surgery. The first presentations of our technique to the Société Française de Chirurgie Plastique et Reconstructrice (SOFCPRE)²⁰ and the International Confederation for Plastic and Reconstructive Surgery²¹ were met with very critical comments, reviving the controversies of 1987. These criticisms were countered point by point. As one congress followed another and additional presentations were made, the opposition of the medical community abated and fat transfers are now accepted as a viable option for breast reconstruction.^{14,22}

This paper seeks to present our lipomodeling technique and its long-term results and to evaluate its success rate, complications, indications, and potential developments.

SURGICAL TECHNIQUE

Preparation

In preparation for lipomodeling, patients were informed of the operative technique, its potential risks and complications, and were given an information leaflet. We have four different information leaflets: lipomodeling in breast reconstruction, lipomodeling for the correction of sequelae of conservative treatment, lipomodeling for the correction of breast deformities, and aesthetic breast lipomodeling.

Note that it is important that the patient's weight be stable at the time of the procedure because the injected fat preserves the characteristics of its origins. If the patient loses weight after lipomodeling, she will lose some of the benefit of the procedure.

The areas of the breast that require correction were identified and marked on the patient. A three-dimensional morphologic study (along with the usual two-dimensional photographs) was then performed in certain patients (ie, those for whom further information would be useful in assessing the amount of fatty tissue to be transferred and in whom fat resorption should be evaluated).

The various adipose areas of the body were examined to identify the natural fat deposits. Generally speaking, abdominal fat was used because the loss of abdominal fat was appreciated by most patients and harvesting in

this area did not require a change in the patient's position during the procedure. The second site was the trochanteric region (saddle bags) and the inside of the thighs and knees. The harvesting areas were outlined with a skin marker.

Anesthesia

Because of the quantities of fat required, lipomodeling was performed under general anesthesia in the vast majority of patients. Generally, in breast reconstruction after mastectomy for cancer, lipomodeling was carried out at the same time as reconstruction of the nipple-areola complex and reduction of the opposite breast (if necessary to obtain symmetry). Conventional prophylactic antibiotics were usually given preoperatively, as we customarily do in the various procedures of plastic surgery. No specific antibiotics were prescribed in the case of lipomodeling. Local anesthesia could only be used for minor revisions to correct any residual defect(s).

Incisions

Incisions were made in the harvesting areas using a no. 15 blade. For abdominal harvesting, four incisions were made around the navel; a lateral incision was also made on each side if lateral abdominal and suprailiac fat were also harvested. For harvesting of fat from the thighs, an incision was made in each subgluteal fold and an additional incision was often made on the inside of the knees.

If previous incisions were already present at the recipient site on the breast, we tried to incise along the same lines. In order to develop a network of transfer tunnels, five or six incisions were needed, two of which were in each submammary fold and one in the décolleté area. The incisions were usually made with the sharp bevel of a trocar so that they were as small as possible.

Fat Harvesting

Recent works on fat transfer have contributed to standardization of the technique for harvesting and injection, so as to reduce any pitfalls at each stage. Procedures should be followed rigorously in the various stages to ensure fat survival in the short, medium, and long term. For harvesting, a disposable or Coleman cannula was used. These cannulas have a blunt tip that can be inserted in 4-mm incisions made with a no. 15 blade. Harvesting was performed with a syringe. A 10-mL Luer-Lok syringe (Becton Dickinson, Franklin Lakes, NJ) was fitted directly on to the harvesting cannula. Suction was moderate (Figure 1, A) in order to minimize the damage to adipocytes. Excessive mechanical suction could have a harmful effect on adipocyte survival. Sufficient fat was harvested to compensate for loss during centrifugation and for the overcorrection necessary during fat injection. In order to perfect the morphologic result, the harvesting areas were smoothed by conventional liposuction with a 4-mm cannula. The cutaneous incisions were closed with fine, rapidly absorbed sutures.

Fat Preparation

As harvesting continued, the assistant prepared the syringes for centrifugation. They were sealed with a screw top (Figure 1, B) and then centrifuged in batches of six (Figure 1, C) for three minutes at 3200 rpm.

Centrifugation separated the harvested fat into three layers (Figure 1, D): (1) a top layer of oily fluid which contains chylomicrons and triglycerides resulting from cell lysis; (2) a lower layer of blood residues and serum, along with the infiltration fluid if harvesting was performed under local anesthesia; and (3) a middle layer of purified fat. For our purposes, the middle layer was the useful one, and this was the layer that was injected. The other layers were disposed of: the lower layer simply by removing the cap (Figure 1, E) and the upper layer by pouring off the oil that covers the middle layer (Figure 1, F).

The team was well-organized so that the fat could be prepared efficiently and rapidly. Using a three-way tap, the purified fat was grouped into 10-mL units by transfer from one syringe to another (Figure 1, G).

Fat Transfer

After the fat was prepared, a number of 10-mL syringes of purified fat were ready. The fat was transferred directly to the breast region from these syringes, which were fitted with special disposable transfer cannulas that are 2 mm in diameter—slightly longer and stronger (Figure 2, A) than the cannulas used in the region of the face—because mechanical stresses are greater here and because the recipient tissue is firmer and more fibrous.

The incisions in the breast were made using a 17-gauge trocar (Figure 2, B). This made an adequate incision while limiting scar sequelae, which were punctuate and practically invisible. Several incisions were made in order to create a honeycomb of multiple microtunnels for fat transfer.

The fat was injected in small quantities, in the form of fine cylinders resembling spaghetti (Figure 2, C and D). It was necessary to create microtunnels in many directions.^{14,15,22,23} Transfer was made from a deep to a superficial plane. Good spatial visualization was necessary to form a sort of three-dimensional honeycomb, so as to avoid creating areas of fatty pools that would lead to fat necrosis. Instead, each microtunnel was designed to be surrounded by well-vascularized tissue. The fat was injected under light pressure, while simultaneously gently withdrawing the cannula.

It is necessary to know how to overcorrect the quantity of fat injected if the recipient tissues allow it, because resorption of about 30% of the volume transferred can be expected. The 140% rule must be applied, meaning that 140 mL of fat must be injected for a desired final volume of 100 mL.

Fat injection was halted when the recipient was saturated and could not absorb additional fat, because of the risk of inducing areas of fat necrosis. This principle of oversaturation avoidance in the recipient tissue must be

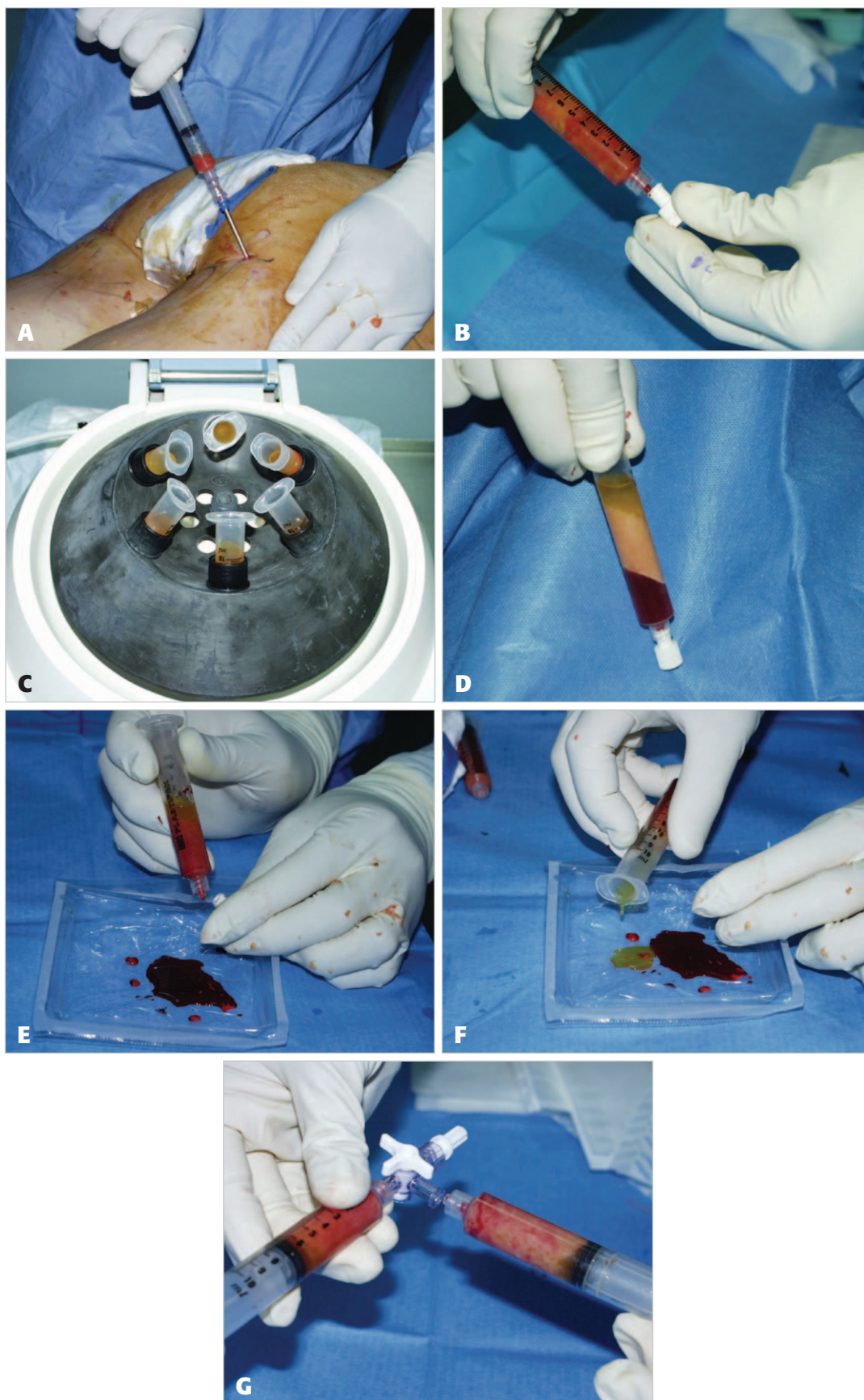


Figure 1. Fat harvesting and preparation. **A**, Harvesting with the harvesting cannula fitted directly on to the 10-mL Luer-Lok syringe (Becton Dickinson, Franklin Lakes, NJ). **B**, The syringe is sealed with a screw top. **C**, Centrifugation of the syringes in batches of six. **D**, Centrifugation separates the fat into three layers. Only the middle layer of purified fat is retained. **E**, The bottom layer (serous fluid) is discarded by removing the cap. **F**, The oily top layer is removed. **G**, Transfer from one syringe to another, using a three-way tap to obtain 10-mL syringes containing pure fat.

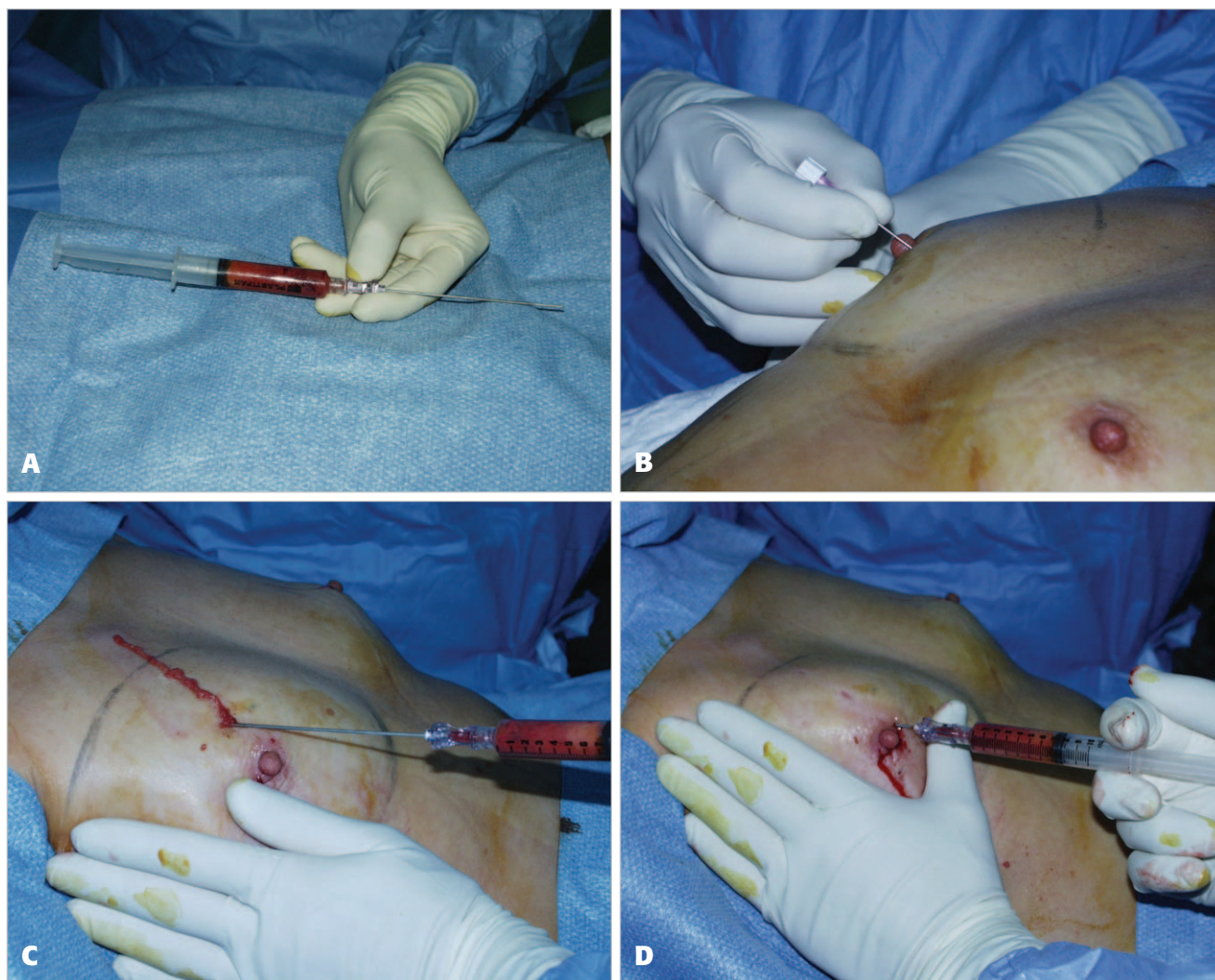


Figure 2. Fat transfer. **A**, Disposable cannula designed for fat injection in lipomodeling. **B**, Incision in the breast with a 17-gauge trocar. **C**, Demonstration of the principle of fat transfer. Fat is injected while the cannula is gently withdrawn, leaving a fine cylinder of fat that resembles a spaghetti noodle. **D**, Fat injection into the breast.

respected. (It is better to plan a complementary session in a few months, when the tissues will be able to accommodate additional fat.) Sutures were placed using very fine, rapidly-absorbed suture material and the breast was covered with an ordinary dry dressing for a few days. At the end of the procedure, a compressive Elastoplast dressing (Smith & Nephew, Victoria, Australia) was left in place for five days. Class I analgesics were prescribed for about two weeks.

POSTOPERATIVE CARE

Care of Harvesting Sites

Pain in the harvesting sites was similar to the pain experienced after liposuction. Patients normally complained of fairly acute pain for 48 hours, which was treated with ordinary analgesics. We used infiltration of diluted ropivacaine at the end of harvesting to control pain in these sites during the first 24 hours postprocedure. The pain gave way to uncomfortable hypersensitivity that lasted for two to three months. Bruising was very pronounced and persisted for about three weeks. Postoperative edema resolved complete-

ly or almost completely in three months. To hasten resorption, we asked patients to massage their harvesting areas with a circular motion. An abdominal support belt may be advisable for six weeks, but was not prescribed systematically. In rare cases when edema persists for a longer period, we recommended about 10 endermology sessions.

Care of the Breast

Bruising resolved in about two weeks. Edema resulting from the procedure resolved in about one month. During the first three postoperative months, 30% to 40% of the added volume was gradually lost. As a result of the edema, patients may have the impression that they have

Table. Distribution of lipomodeling procedures (N = 880)

Type of procedure	No. of procedures
Breast reconstruction	734
Correction of congenital deformities	106
Aesthetic breast surgery	30
Correction of previous surgical defects	10

lost about 50% of the volume because the patient sees the results the day after the procedure, when the breast is most swollen.

LONG-TERM CLINICAL FOLLOW-UP

All patients were clinically followed-up and seen in consultation after 15 days, three months, and one year. Photographs were taken at each consultation. A detailed follow-up protocol was aimed at assessing the quality of the result from both the patient's and the surgeon's viewpoints, patient satisfaction, and any adverse effects or complications. Patients who had had breast cancer and underwent lipomodeling after conservative treatment or breast reconstruction were then followed by their oncologist, who referred them to us if there was any change. For the other patients, quality long-term follow-up was made possible by shared computerized medical records.

RESULTS

Among the 880 procedures performed during the course of our study, 734 were performed for breast reconstruction, 106 for the correction of congenital deformities, 30 for aesthetic breast surgery, and 10 for the correction of previous surgery defects (Table). Based on the first author's (ED) personal experience with these interventions and considering the 10-year follow-up for the first patients, reliable indications on long-term follow-up can be given.

The results were considered very good or good in the majority of cases. Very few results were considered moderately good and no results were considered poor. The percentage of good or very good results depended on the subpopulation studied in relation to the indication. For example, for correction by lipomodeling of sequelae of conservative treatment, there were 50% very good, 40% good, and 10% moderately good results.²⁴

Long-Term Radiologic Follow-Up

Given the fears concerning the possible effect of fat transfer in the breast on imaging that were prevalent when we began our investigation in 1998, we sought to analyze the effect of fat transfer on breast imaging. We carried out three studies: imaging of breasts reconstructed by autologous latissimus dorsi flap and lipomodeling (mammography, ultrasound, and MRI),¹⁹ imaging of conserved breasts after lipomodeling (mammography, ultrasound, and MRI),²⁵ and imaging of breasts with defects corrected by lipomodeling (asymmetry, tuberous breasts, or Poland syndrome); this study is still in progress.

Our findings showed that if lipomodeling was carried out in accordance with modern principles of fat transfer, it in no way hindered breast imaging. These results are of fundamental importance in justifying the use of fat transfer in aesthetic surgery. It is crucial to note, however, that these findings are based on the work of a surgical team that had completed its learn-

ing curve and of specialized radiologists familiar with the images potentially produced by fat transfer.

Imaging in the majority of reconstructed breasts was normal, with some images of oily cysts and fat necrosis. All of the images observed were in favor of benign lesions easily distinguished from suspicious lesions. Abnormal images were essentially oily cysts, occurring in 15% of cases. The most complex situation concerned lipomodeling for the sequelae of conservative treatment, because fat necrosis developed in about 20% of patients from this population following conservative treatment; lipomodeling doubles this rate by generating mainly oily cysts, but occasionally more complex lesions of fat necrosis. Because of the spontaneous local cancer recurrence rate of 1.5% per year, surveillance must be rigorous. We believe that this indication should be restricted to performance by multidisciplinary teams working with radiologists with demonstrated mastery of the subject.

Long-Term Oncologic Follow-Up

Ten years of oncologic follow-up have not revealed any increased risk of local recurrence after mastectomy or after conservative treatment. The clinical impression even seems to suggest the contrary, but in order to confirm this clinical impression, more complex oncologic studies must be performed that match treated populations with reference populations having the same oncologic status.

Evaluation of the Success Rate

Clinical Evaluation. The success rate was fairly easy to evaluate by clinical examination, the patient's opinion, and comparison of the photographs taken at each post-operative consultation with earlier photographs. Thirty percent to 40% of the volume gained by fat transfer was gradually lost. Volume was stable after three to four months and remains so if the patient maintains a constant weight. If the fat harvested was very oily (ie, if it had a very high percentage of oil after centrifugation), resorption had the potential to be higher (at 40% to 50%) and may continue over a longer period of up to five to six months.

If the patient lost weight, the volume of the transferred fat decreased and the resulting smaller breast size may lead to asymmetry. Consequently, it is important for the patient to understand that she must maintain a stable weight. Inversely, if she gains weight, breast volume increases in relation to the fat from the adipose deposit. When a second session was required to obtain sufficient fullness, resorption seemed to be less (between 20% and 30%). This reduction in the fat resorption rate has been clinically assessed. In a few cases in which patients required a second fat transfer session, an interferometric evaluation objectively confirmed this clinical impression.

Very long-term evaluation (five to six years) confirmed that volume remained stable. If breast asymmetry returned after weight loss (eg, after the discontinuation of antihormonal treatments in the adjuvant therapy of

breast cancer), a complementary lipomodeling session could easily be performed. This technique offered a flexibility and precision for long-term revision that is much appreciated by the patients.

Evaluation by Interferometry. Three-dimensional technology was used to assess changes over time in breasts after lipomodeling. This was performed using interferometry,²⁶⁻²⁸ which is a technique that consists of projecting recognizable structures (light fringes) onto the object of study. These are then captured and processed using modeling algorithms. The InSpeck system (InSpeck; Montreal, Quebec, Canada) consists of two capturers and two software programs. The capturers each incorporate a digital camera and a collimated light source. Two InSpeck digitizers are connected to a Compaq personal computer (Houston, TX) to process the data using FAP 4.6 software (InSpeck, Montreal, Canada). The acquisitions of the two digitizers generate two three-dimensional models of the left and right sides of the bust. These two acquisitions are fused by a semi-automated process, giving a single three-dimensional model of the complete bust. This last model is used as a reference for later measurements. By comparing the models of the bust, breast volume can be accurately studied and the quantity of fat remaining after resorption can be assessed. This study confirmed our clinical impression; the rate of fat resorption at three months postoperatively was estimated to be between 30% and 40%. It also confirmed that the volume remained stable after this period, on the condition that the patient maintained a constant weight.

Complications

Scars at the harvesting site must be concealed as much as possible, generally in a fold or in the periumbilical region. No patients have complained of unaesthetic scars in a harvesting site. We had one case of unevenness in the suprailiac region that required secondary correction of a hollow area by lipomodeling. The majority of patients were satisfied by the loss of excess fat and this secondary advantage probably contributes to the very high rate of satisfaction with this technique.²⁴ Irregularities at the donor site may be related to uneven harvesting of the fat deposit, so harvesting was sometimes completed by liposuction to further improve the result for greater patient satisfaction. It is essential that this procedure is carried out by experienced plastic surgeons, because previous experience in cosmetic liposuction is valuable in that it helps limit the risk of complications and gives the patient the best possible cosmetic result. Local infection occurred in only one of the 880 lipomodeling procedures. This was seen as redness around the navel and was treated without difficulty by antibiotics and local application of ice, with no long-term consequences.

In the breast, the scars must be well-placed, either in the submammary fold or its axillary prolongation, or in the areolar region, where scars are always of good quality. The presternal area should be avoided because there

is an increased risk of hypertrophic scarring that presents as small red punctate scars. The incisions are usually practically invisible, because they are made with a trocar and only measure 1.5 mm.

Six infections occurred among the 880 lipomodeling procedures of the breast and chest wall. They presented as redness of the breast. The suture in the transfer area was removed. An effusion of cloudy fat developed. Topical treatment, antibiotics, and the application of ice resolved the problem with no impact on the final result.

It should be noted that we had one case of intraoperative pneumothorax, probably caused by the transfer cannula piercing the pleura. The pneumothorax was revealed by oxygen desaturation during the procedure. In the recovery room, a pleural drain was inserted and oxygen saturation returned to normal, with total recovery and no later consequences. To avoid this complication, projection of the areolar region should be improved via two incisions in the submammary fold, not via the areolar region itself.

There was no incidence of fat embolism. The risk might occur if fat was injected in a large vessel. Extreme caution is recommended in the subclavian area. In particular, in the breast and chest wall deformities of patients with Poland syndrome, the subclavian vessels may lie lower than is typical.

We observed focal clinical fat necrosis in 3% of cases. The risk was higher during the first author's (ED) early experience (15% in the first 50 cases). This was assessed by comparing the first 50 cases of our series to the last 100 procedures performed during the last two years. In these cases, excessive fat had been "forced" into recipient sites that could not absorb a large amount of fat. When the recipient tissue is saturated with fat, the surgeon should desist from further injection; otherwise, areas of fat necrosis may develop. Such areas are characteristic: slightly sensitive and stable over time, but gradually decreasing. Any increase in size or a hard swelling, even in a reconstructed breast, should undergo micro-biopsy by a radiologist in order to rule out a cancerous change. Nodules of fat necrosis are mainly seen in the early stages of the surgeons' learning curve and decrease as their experience increases, if they respect the principle of the three-dimensional network and avoid fat saturation of the recipient site.

INDICATIONS

Lipomodeling of the breast and chest wall is a technique that now has numerous indications. It can be used after breast reconstruction whenever a localized defect requires correction or additional volume. The décolleté area is ideal for fat injection. Lipomodeling improves the volume, shape, projection, feel, and silhouette of the breast.

After flap reconstructions, fat transfer can add considerable volume to preserve the autologous nature of the reconstruction. In breast and chest wall deformities, fat injection makes it possible to achieve very natural reconstructions without an implant or a flap, which is

unobtainable with conventional techniques. In aesthetic surgery of the breast, in some cases fat transfer eliminates the need for an implant (ie, augmentation or mastopexy with a slight lack of fullness of the upper pole of the breast) or can correct certain defects of implant augmentations.

Lipomodeling After Autologous Latissimus Dorsi Breast Reconstruction

In breast reconstruction, the plastic surgeon seeks to achieve a new breast with a natural shape and feel that is similar to the opposite breast. Autologous reconstruction avoids the complications of implants; the flap can also be modeled to form a breast resembling the opposite breast that will be stable over time and will be better integrated into the patient's body image. The autologous latissimus dorsi flap¹⁶⁻¹⁸ has gradually replaced the transverse rectus abdominis myocutaneous (TRAM) flap over the last 10 years because the postoperative course is simpler and the procedure makes better use of local thoracic tissue, avoiding a patch effect on the breast. In some cases, however (ie, if the patient is very slim or if there is marked atrophy of the flap), the reconstructed breast may be too small. In these circumstances, the classic solution was secondary insertion of an implant beneath the flap. The reconstruction was no longer entirely autologous and the shape was less natural, with the added drawbacks of implants. In other cases, even if the overall result was good, a lack of projection or a localized defect (mainly in the superior medial area of the breast, the décolleté area) might be present, which lowers the quality of the reconstruction.^{14,15,22,23}

Lipomodeling a breast reconstructed by autologous latissimus dorsi flap offers numerous advantages: the reconstruction is still entirely autologous, the cost is relatively low, the technique is reproducible, the procedure can be repeated if the result is not adequate, the breast has a natural appearance and feel and is symmetric to the opposite breast, and the suction of the patient's displeasing fat provides a secondary benefit.

The autologous latissimus dorsi flap is the most suitable tissue to receive fat transfer because it is very well vascularized and very large quantities of fat can be injected. In the early stages of our experience, we injected moderate quantities (100 to 120 mL). Because of the resorption rate, this was not sufficient. Lipomodeling then made it possible to correct localized abnormalities or defects of the décolleté area. Experience taught us that very large amounts of fat could be transferred after autologous latissimus dorsi reconstruction; in single sessions, mean volumes of 200 mL and up to 470 mL (the largest amount as yet) per breast and per session have been injected with very good results.

Fat is injected from the deep plane toward the surface. It is initially injected in the costal plane, moving up into the pectoralis major muscle, and then in the reconstructed breast, up to the subcutaneous plane. A large number of different tunnels must be created to form a

truly three-dimensional network. In areas of limited tissue thickness, it is better to plan several sessions, possibly under local anesthesia. It is easy to see the value of availability of the latissimus dorsi flap over the entire base of the breast, because the autologous latissimus dorsi flap can now be conceived as an auxiliary that prepares the breast recipient site for future lipomodeling. This is particularly true in very slim patients, in whom the final volume that can be expected (after five months, corresponding to the duration of muscle atrophy) is small. In these cases, the site is well-prepared for transfer, because the flap has been placed and managed with the idea of using it as a future recipient site for lipomodeling. In patients in whom the flap is very muscular, we carry out lipomodeling quite early (after three months, before atrophy is maximized) in order to take advantage of the volume effect that allows the area to accept sufficient fat.

This technique is well accepted by patients, who can see its efficacy and clearly understand its concept. The morphologic results are objectively considered as very good (Figure 3), and the patients are very satisfied with a procedure that both improves the reconstructed breast and reduces unaesthetic fat deposits. In cases where the results are considered adequate, patients understand that repeat sessions are necessary and that each stage will contribute to gradual improvement of the result. In my experience, the autologous latissimus dorsi flap in combination with lipomodeling now makes implant-free reconstruction possible in the vast majority of cases.^{15,22,23}

Lipomodeling of the Implant-Reconstructed Breast

The defects of implant reconstructions²⁹ fall into three categories (Figure 4): (1) defect of the décolleté with rippling of the upper part of the breast and lack of symmetry in relation to the opposite breast; (2) a medial defect with rippling and overly wide cleavage; and (3) a lateral defect with a hollow at the lateral part of the breast, just below the anterior axillary line.

We transposed the experience gained with breasts reconstructed using an autologous latissimus dorsi flap to implant reconstructions. The technique consists of transferring fat to the décolleté area (that is, the upper medial part of the breast), where lipomodeling is mainly intrapectoral. When lipomodeling is performed during replacement of an implant, fat is injected between the skin and the capsule. Laterally, fat is injected between the skin and the capsule; this can only be done when the implant is changed.

We have learned from experience that the best results are obtained when lipomodeling is combined with implant replacement, because lipomodeling can be effective in correcting the three defects observed in implant reconstructions. In this setting, smaller quantities are injected—from 50 to 150 mL, depending on the recipient tissue and the trophicity (in particular, the trophicity of

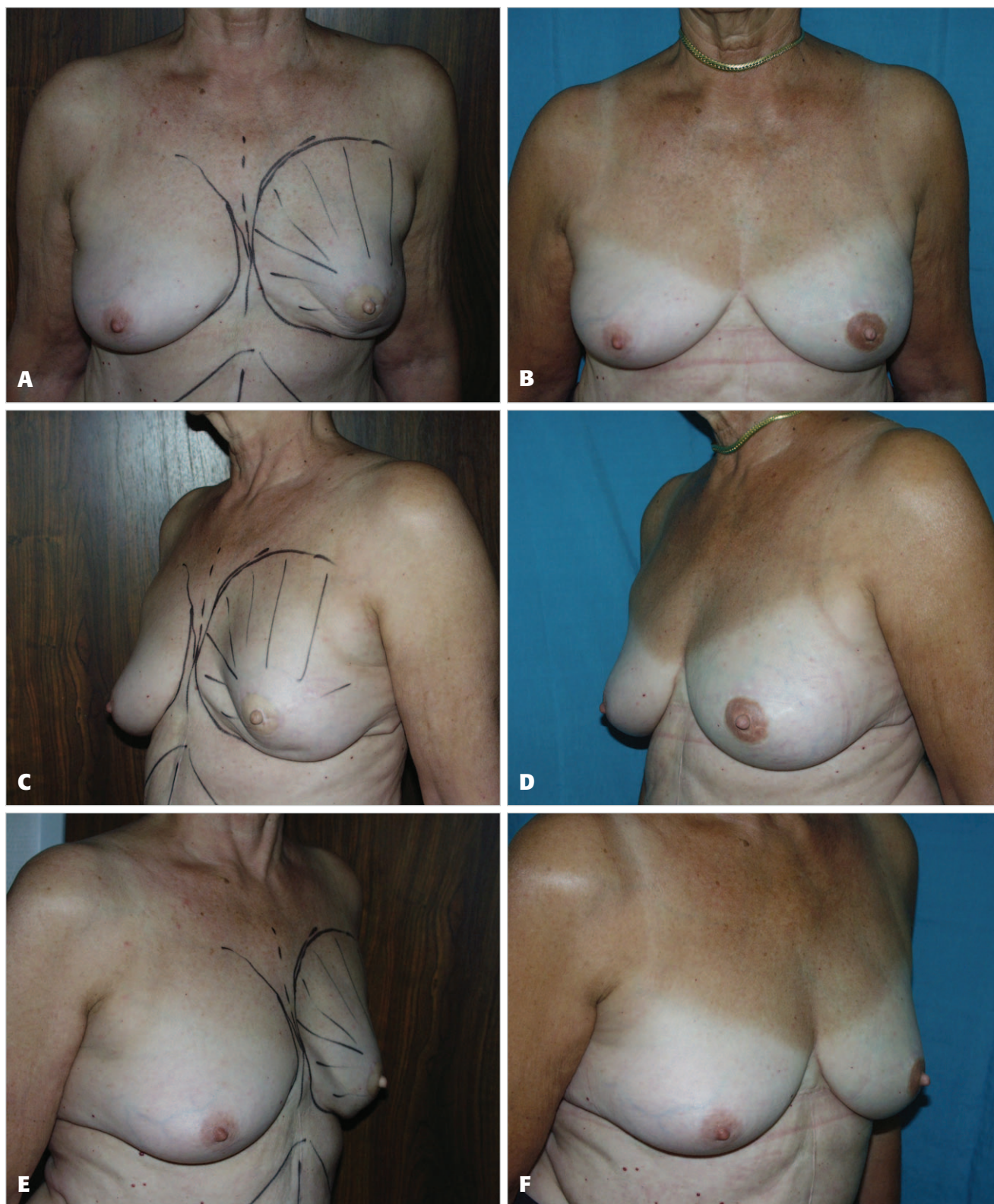


Figure 3. **A, C, E,** Preoperative views of a 68-year-old woman who had previously undergone latissimus dorsi flap reconstruction. The left breast is too small. **B, D, F,** One year after lipomodeling with injection of 315 mL of fat in a single session.

the pectoralis major muscle). Because the tissue is less well-vascularized than the autologous latissimus dorsi, it must be slightly less saturated with fat to ensure satisfactory survival of the transplant.

The results in our series revealed no complication inherent to this technique, bearing in mind that if lipo-

modeling has come close to the implant, we advise systematically replacing the implant to avoid the risk of leaving in place an implant that could have been damaged by the transfer cannula.^{15,22,23,29} We have found that the technique is well-accepted by both patients and surgeons. It does, in fact, enable results that could not be obtained

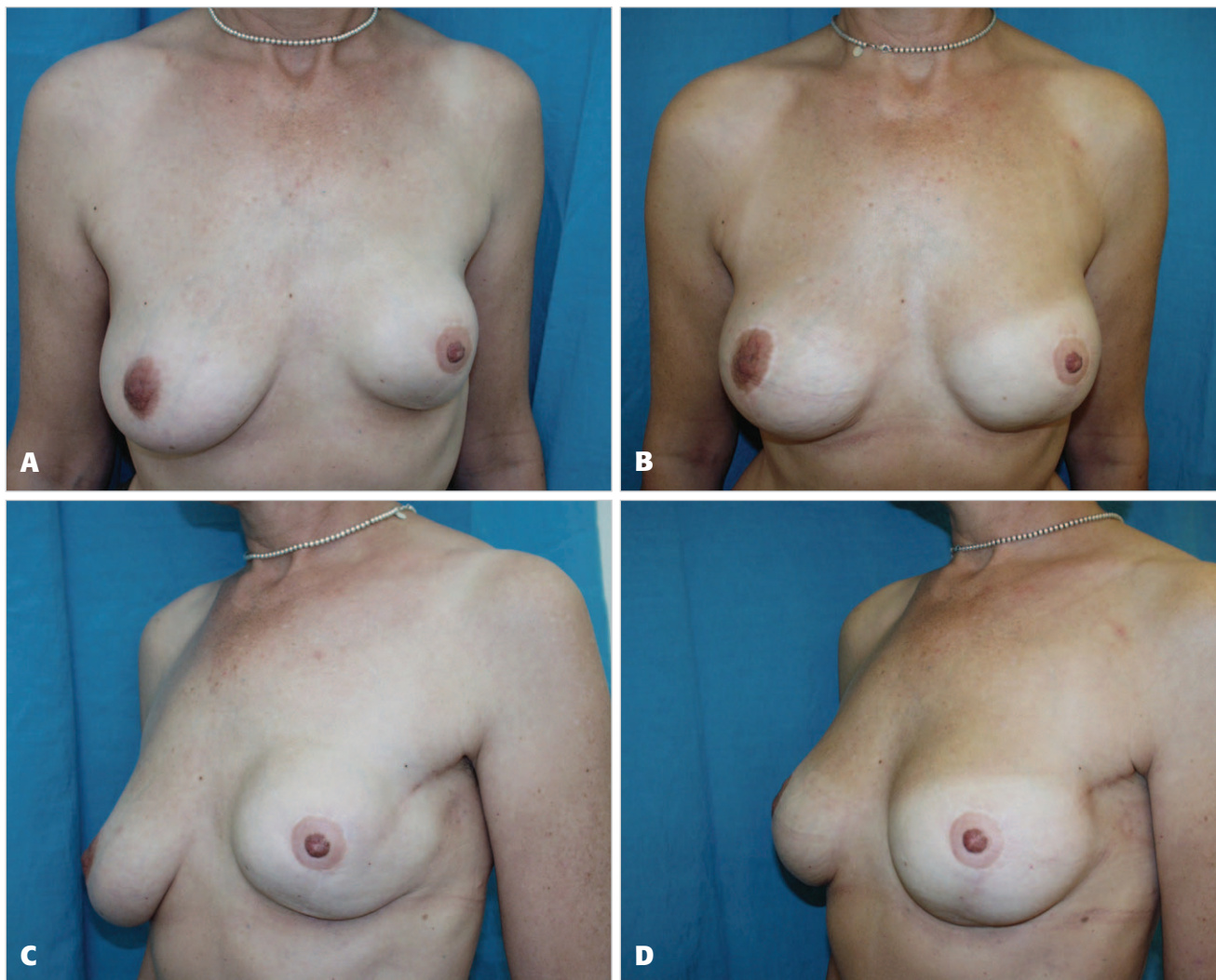


Figure 4. A, C, Preoperative views of a 53-year-old woman who requested improvement after implant reconstruction of the left breast. B, D, One year after injection of 145 mL of fat in the left breast and replacement of the implant in a single session.

by use of an implant alone. Lipomodeling seems to reduce the risk of capsular contracture, but as yet we have no statistical evidence to document this impression.

Lipomodeling of the TRAM Flap Reconstructed Breast

Although numerous authors consider the TRAM flap to be the optimal technique for breast reconstruction, defects may also develop after its use. These include asymmetry of volume, lack of projection, or a defect of the décolleté related to atrophy of the upper part of the pectoralis major muscle following the joint effect of axillary dissection and radiotherapy of the chest wall.

Putting to good use the experience gained with autologous latissimus dorsi reconstructions, we applied lipomodeling to breasts reconstructed with a TRAM flap both in our own patients and those treated by others. During secondary revision, we now perform intrapectoral lipomodeling and lipomodeling of the flap, concentrating on the areas that lack fullness. In some cases, lipomodeling to increase the overall volume of the flaps was performed without any particular difficulty. It

should be borne in mind that, in cases involving the TRAM flap, a little less fat should be injected than in those involving an autologous latissimus dorsi flap, because the former is not as well-vascularized and the risk of fat necrosis may be higher.

In the first author's (ED) experience, improvement of the overall shape of the breast and improvement of the upper décolleté area was attained without any complications inherent to this technique. Lipomodeling is particularly pertinent to treatment of the TRAM flap reconstructed breast because harvesting of fat from the abdomen and flanks provides the finishing touches to those areas, with better overall contouring of the chest and the thoracic and abdominal regions. Above all, this technique avoids displacing the flap in secondary cases with a defect of the upper part of the breast, so it reduces the real danger of necrotic complications that is always present after secondary displacement.

Breast Reconstruction by Repeated Lipomodeling

We are developing a protocol for breast reconstruction using lipomodeling alone. This protocol examines the

possibility of reconstructing the breast over several fat transfer sessions. At the present time, it is exclusively applied to patients with a small opposite breast and with suitable fat deposits (typically a patient with a slim upper body and a fatter lower body). The technique consists of reconstructing the breast in several operative stages using only fat injection (Figure 5). In the indications defined above, three to four lipomodeling sessions are required to reconstruct a breast that matches the volume of the opposite breast. This therapeutic protocol is being evaluated and will no doubt be reserved for particular reconstructions in patients with small breasts or for the repair of failed reconstruction.

Other Applications in Breast Reconstruction

The lipomodeling technique also has other applications in breast reconstruction. When the skin is very thin or has been very damaged by radiotherapy and skin necrosis is feared during breast reconstruction, it is possible to carry out preparatory lipomodeling a few months beforehand, injecting 80 to 120 mL of fat in the thin, damaged thoracic tissue. This improves skin trophicity and avoids necrosis, a complication that is always difficult to manage, even in autologous breast reconstruction. Along the same lines, the skin can be prepared and the subcellular tissue thickened in order to allow implant reconstruction in borderline indications for other cases. Another application is the reconstruction of preexisting chest wall deformities, such as lateral pectus excavatum. In such cases and in the second stage of reconstruction, lipomodeling enables made-to-measure reconstruction of higher quality. Lastly, in some cases, lipomodeling can create a symmetric opposite breast, notably improving the décolleté by injecting fat intrapectorally and into the upper part of the breast, or even by very slightly enhancing the volume of the opposite breast. In this indication, detailed preoperative imaging investigations are carried out (mammography and ultrasound) and repeated at one year postoperatively.

Lipomodeling for the Correction of Sequelae of Conservative Treatment

While lipomodeling performed after total mastectomy is now considered a valid treatment, it is subject to a very strict protocol when performed to correct the sequelae of conservative treatment (after lumpectomy and radiotherapy). In this indication, there is in fact a high risk of a coincident new cancer or local recurrence of the primary cancer,³⁰ which could potentially lead to medicolegal consequences if the patient has not been satisfactorily informed.³⁰ The protocol includes a detailed imaging investigation²⁵ with mammographic, ultrasound, and MRI assessment by a radiologist specializing in breast imaging.

Lipomodeling is generally performed subject to the agreement of the specialized radiologist and the cancer specialist who follows the patient (who usually has referred the patient to us for correction of the aesthetic sequelae of conservative treatment). Similarly, one year

after lipomodeling, further imaging is performed using mammography and ultrasound. If any suspicious image is present, the radiologist performs a microbiopsy. Two studies^{24,31}—including one of 42 patients with sequelae of conservative treatment who underwent lipomodeling and were included in a detailed radiologic protocol—concluded that lipomodeling was a considerable advancement in the therapeutic arsenal for the management of moderate sequelae of conservative treatment.³¹ It restores breast curvature and suppleness that no other surgical technique had previously achieved (Figure 6). Breast imaging is not compromised by this technique; the injected fat does not interfere with surveillance if lipomodeling has been performed according to the rules of the art and if breast imaging is carried out by a radiologist with specialized experience.²⁵ This is, however, the most challenging indication to deal with and we recommend that these patients be managed by a multidisciplinary team after the plastic surgeon has completed the learning curve in less demanding indications.³²

Poland Syndrome and Lipomodeling

Correction of the breast and chest wall deformities of Poland syndrome remains a challenge for the plastic surgeon. Lipomodeling appears to be very useful in this setting (Figure 7) and can achieve a breast reconstruction of excellent quality after simple, repeated procedures,^{6,30} along with very limited scarring. We have treated 16 patients using this technique, 14 of them by lipomodeling alone and two by lipomodeling to complement flap surgery. In this series, an average of three sessions was required to obtain the desired result, with a mean of 244 mL of fat injected during each session. The results are very interesting and a breast almost identical to the opposite breast can be reconstructed. This technique appears to revolutionize the management of breast and chest wall deformities in Poland syndrome.^{14,15,22,23}

Pectus Excavatum and Lipomodeling

Pectus excavatum is a complex deformity involving hollowing of the anterior sternocostal wall. It usually has little or no functional impact and, in most cases, the problem is essentially morphologic and aesthetic, with considerable deformity of the bust if the condition is very marked or lateral. Fat transfer techniques provide satisfactory correction when used alone in cases of mild to moderate deformity^{14,15,22,23} or when used in association with placement of a custom-made rigid implant (based on a three-dimensional computed tomographic scan) in more serious cases.

Tuberous Breasts

Tuberous breasts are a deformity of the base of the breast, with onset at puberty. Various surgical approaches have been described and a wide range of techniques exist to obtain the best possible result. Among them, lipomodeling^{14,15,22,23} can correct the lack of volume (especially if this is unilateral) and improve both the base and shape of the breast (Figure

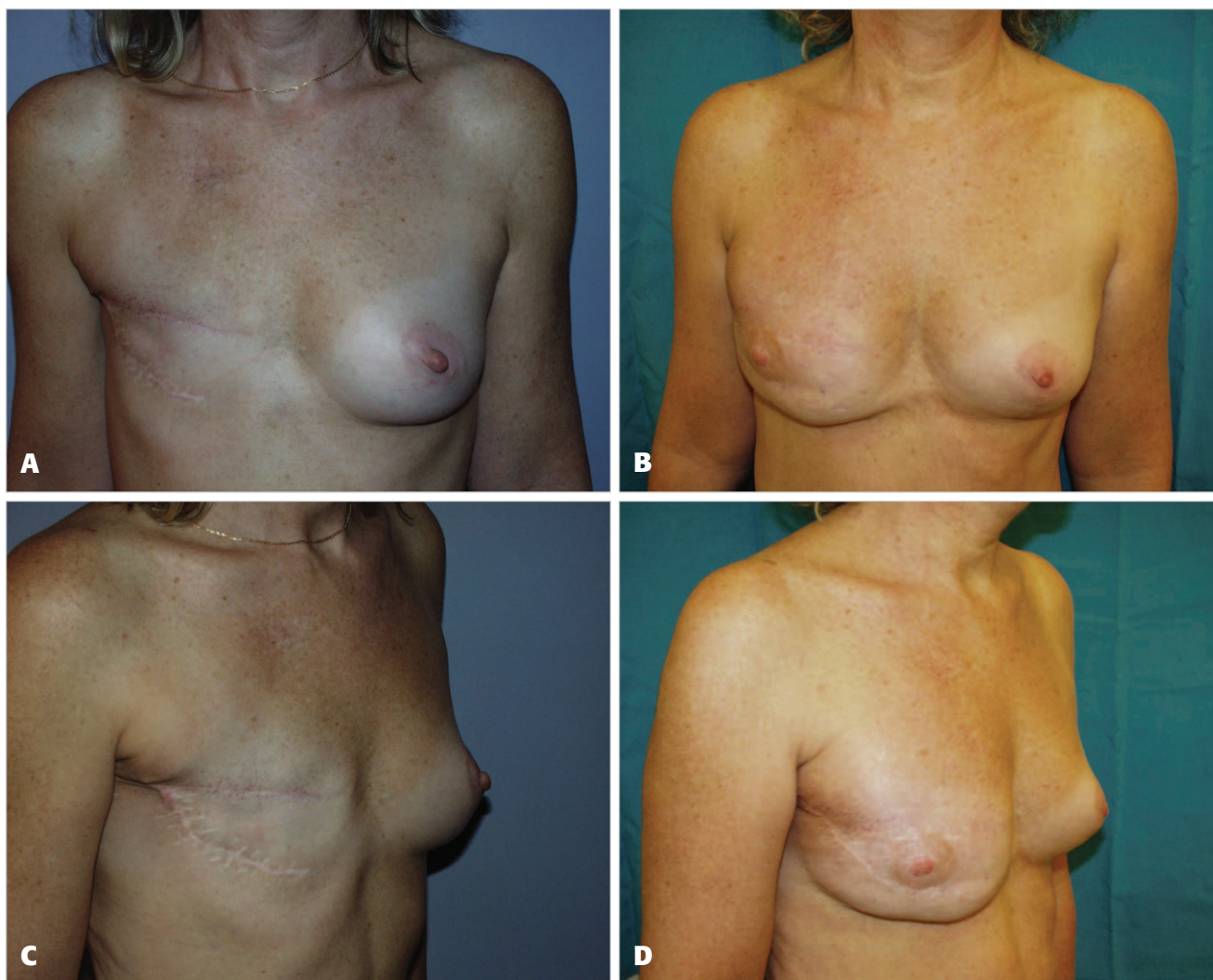


Figure 5. **A, C,** Preoperative views of a 53-year-old woman who underwent mastectomy, radiotherapy, and a failed latissimus dorsi flap procedure. **B, D,** One year after delayed right breast reconstruction by lipomodeling in three sessions, with an interval of three months between sessions (injections of 205, 151, and 122 mL, respectively). The results shown are one year after the third session.

8). It is a very useful adjunct in the treatment of tuberous breasts. Recently, Coleman³³ also showed a very pleasing aesthetic result in tuberous breasts treated by fat injection.

The best indications are the unilateral hypoplastic tuberous breast (which usually requires two fat transfer sessions) and the lack of upper pole fullness in the breast. However, implants are still the treatment of choice for tuberous breasts with bilateral hypoplasia.

Asymmetric Breasts

Asymmetry is a difficult problem when one breast has satisfactory fullness and perfect shape (Figure 9) and the other is hypoplastic. Conventionally, an augmentation implant is inserted in the underdeveloped breast. While the initial result is usually good, asymmetry of shape and volume often reappears several years later. In this indication, lipomodeling yields a breast very similar to the normal breast, which will change naturally over time, in particular with respect to ptosis. Depending on the degree of asymmetry and hypoplasia, one to three fat

transfer sessions will be needed for an optimal result (two sessions are generally sufficient).

Breast Aesthetic Surgery

Lipomodeling in aesthetic surgery is expanding rapidly. Our studies have shown that if lipomodeling is performed according to the technique we have described here, it does not cause any problems related to radiologic imaging that hinder the differential diagnosis of breast cancer or of radiologic follow-up for radiologists who are specialized in breast imaging. The principal radiologic risk is that a breast cancer may occur at the same time as lipomodeling. In order to reduce this risk, imaging investigations (mammography and ultrasound) should be carried out before lipomodeling by a specialized radiologist in order to ascertain the absence of a suspicious lesion. If there is any doubt, lipomodeling is deferred or contraindicated. The radiologist must give his or her agreement before lipomodeling and share responsibility for it. The patient must sign a written agreement to undergo the same investigations by the same radiologist one year after the procedure. If the



Figure 6. A, C, Preoperative views of a 37-year-old woman who required correction of conservative treatment. B, D, One year after the second of two lipomodeling sessions (171 mL and 149 mL six months later).

radiologist observes a suspicious lesion on imaging one year postoperatively, a microbiopsy is performed in order to establish a definitive diagnosis. In this indication, the information given to the patient is particularly comprehensive and she is required to carefully read the special leaflet provided during the preoperative consultations.

Aesthetic lipomodeling is a treatment option for the correction of imperfections of mammoplasty and the imperfections and complications of implants. It provides aesthetic breast augmentation and enhances the fullness of the décolleté. The indications of lipoaugmentation differ from those of implant augmentations. Lipoaugmentation is suitable for patients who desire a moderate (even very moderate) increase of breast volume, or who desire recovery of the fullness they had before weight loss or pregnancy. The ideal patient is a young woman with a slim upper body, moderately small breasts, and sufficient regional adiposity of the lower body to allow one or even two lipomodeling sessions. In this indication, it is critical that the patient displays visible improvement at the harvesting site and achieves a stable weight. As stated earlier, if

she loses weight, she will also lose many of the benefits of the procedure.

DISCUSSION

Lipomodeling is a major development in plastic, reconstructive, and aesthetic surgery of the breast; we consider it to be one of the major advances of the last 20 years. The technique is now well-codified and the complication rate is very low. Evaluation of the success rate by clinical examination and by interferometry shows that 30% to 40% of the injected fat is resorbed, depending on the case. The final breast volume is attained in three to four months and is stable thereafter if the patient maintains a constant weight. If a second session is performed, the resorption rate is lower (between 20% and 30%).

In breast reconstruction, lipomodeling is an optimal adjunct to reconstruction by autologous latissimus dorsi flap because this flap of muscular and fatty tissue serves as an ideal recipient site for fat injection. By using lipomodeling in association with the autologous latissimus dorsi flap, an entirely autologous breast can be achieved in



Figure 7. **A, C,** Preoperative views of a 22-year-old woman with Poland syndrome. **B, D,** One year after the last of four lipomodeling sessions (injections of 322, 288, 223, and 236 mL, respectively), with an interval of three months between the sessions).

most cases. Only rare patients with no adipose deposits suitable for harvesting cannot benefit from this technique.

Similarly, lipomodeling can be used after implant reconstructions and the best indication is when implant replacement is considered. Lipomodeling can also make a useful contribution to revision after TRAM or deep inferior epigastric perforator (DIEP) flaps and adds the finishing touches to the reconstruction, in the décolleté in particular. In these various settings, lipomodeling is a technique that we use on a daily basis. An interesting line of research is breast reconstruction by repeated lipomodeling alone. This technique has the drawback of multiplying the operative procedures and can only be considered for patients with small breasts and considerable trochanteric fat deposits from which fat can be harvested several times. It is now under evaluation, and its exact clinical role has yet to be established.

The application of lipomodeling to deformities of the chest wall and breast is expanding rapidly. It appears to represent a major advance in the treatment of Poland syndrome and will probably revolutionize the treatment of severe cases, yielding reconstruction of unequalled quality after procedures involving simple

postoperative course and little scarring. Lipomodeling can also be performed to improve the breast and chest wall deformities related to some cases of lateral pectus excavatum and is a useful adjunct to custom-made implants in median pectus excavatum. It represents a new alternative treatment for tuberous breasts and implant-free correction of asymmetry caused by unilateral hypoplasia.

Finally, the use of lipomodeling will no doubt continue to expand considerably in aesthetic surgery for the correction of inadequate mammoplasty, correction of the defects or complications associated with implant placement of implants, and for lipoaugmentation for patients who desire moderate, natural breast enhancement and have sufficient adipose deposits. Pre- and postoperative imaging by a radiologist specialized in breast imaging is necessary to limit the risk that a cancer may occur coincidentally with lipomodeling.

CONCLUSIONS

Because of its low complication rate, the very good results, and the excellent acceptance of the technique



Figure 8. **A, C, E,** Preoperative views of a 28-year-old woman with tuberous breasts. **B, D, F,** Twelve months after the last of two lipomodeling sessions (injections of 250 mL right and 90 mL left during the first session, and 320 mL right and 210 mL left during the second session after an interval of six months).

by the patients, lipomodeling has completely modified our indications in plastic, reconstructive, and aesthetic surgery of the breast. Long-term clinical follow-up shows that the morphologic results with respect to volume remain stable three to four months after the

procedure if the patient's weight remains constant, with a resorption rate of 30 to 40%. The development of focal fat necrosis is strongly operator-dependent and, in our clinical experience, occurs in 15% of cases in the surgeon's early experience (< 50 procedures),

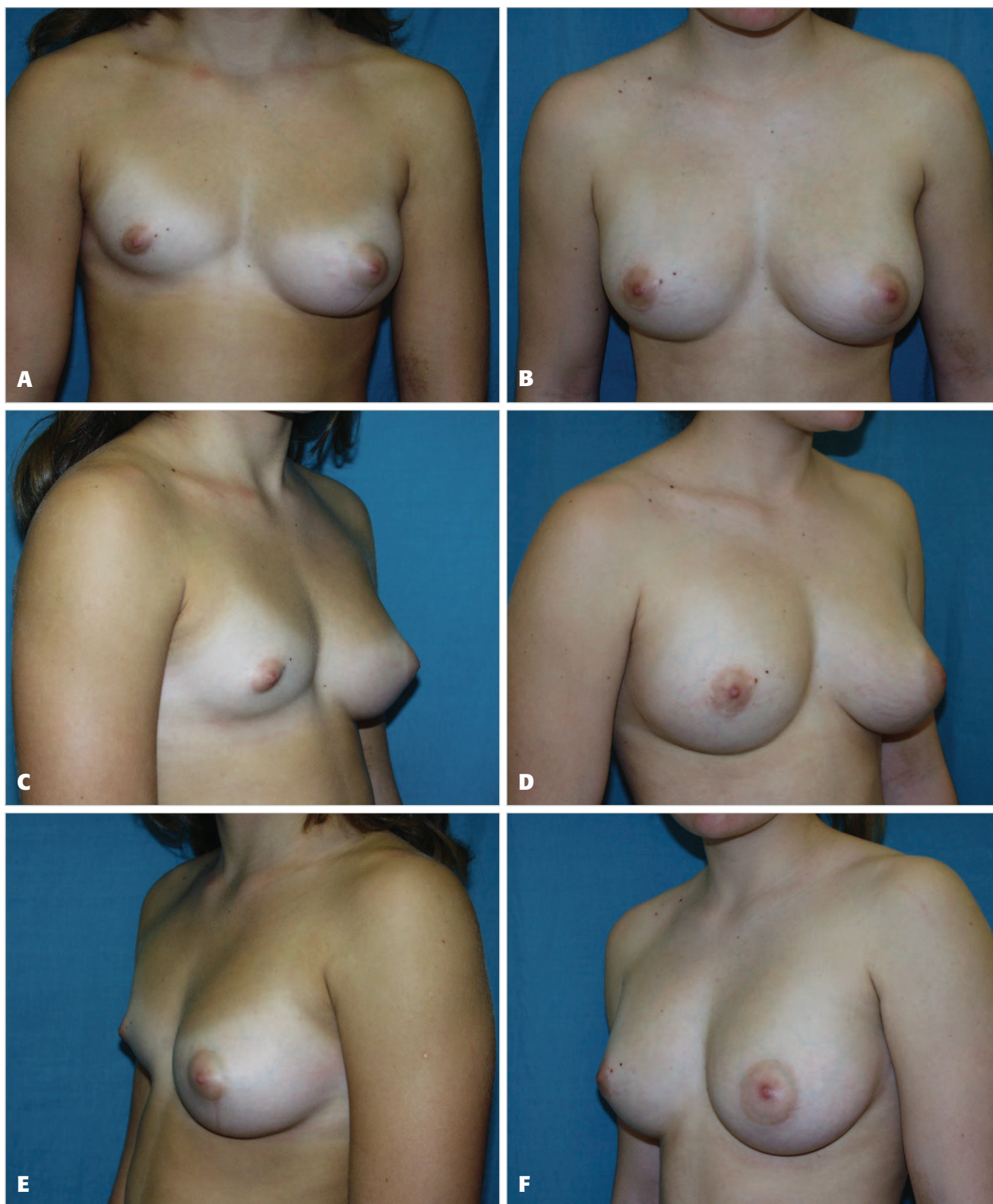


Figure 9. **A, C, E,** Preoperative views of a 17-year-old woman with marked breast asymmetry (severe unilateral hypoplasia). **B, D, F,** One year after the second of two lipomodeling sessions treating the left breast (injections of 304 mL and 212 mL, respectively).

becoming stable at 3% after greater experience. The radiologic appearance of the breasts is usually normal, with images of fat necrosis sometimes seen as oily cysts or, more rarely, as calcifications or complex cysts. None of these imaging results are likely to con-

fuse the diagnosis of cancer for radiologists who are experienced in breast imaging. Oncologic follow-up (now at 10 years for our first patients) shows no increased risk of local recurrence or of development of a new cancer. ■

DISCLOSURES

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