Magnetic Resonance Imaging and Ultrasound Evaluation after Breast Autologous Fat Grafting Combined with Platelet-Rich Plasma

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Background: Breast lipofilling is a fairly simple and safe procedure if it is performed by experienced surgeons.
Methods: The authors evaluated the radiologic findings from 24 breasts (15 women) subjected to a lipofilling procedure (two sessions) for corrective surgery or cosmetic reasons. Mammography, ultrasound, and magnetic resonance imaging were performed before the first lipofilling session (T0) and 12 months after the last session (T12); ultrasound and magnetic resonance imaging were used 3 months after the first session (Ti) and 3 and 6 months after the last session (T3 and T6). Volumetric evaluations were also made through three-dimensional magnetic resonance imaging reconstruction.
Results: Ultrasound showed oily cysts in 66.67 percent of the breasts at Ti, 70.83 percent at T3, 62.5 percent at T6, and 45.83 percent at T12, whereas magnetic resonance imaging detected oily cysts in 8.33 percent at Ti and T3 and T6 months and 4.17 percent at T12. At Ti, T3, and T6, the cytosteatonecrotic areas identified on both ultrasound and magnetic resonance imaging were unchanged (8.33 percent), whereas at T12 those cytosteatonecrotic areas were increased on ultrasound (12.5 percent) and even more on the magnetic resonance imaging scans (16.67 percent). The average resorption percentage of injected volume was 15.36 percent at T6 months and 28.23 percent at T12 months.
Conclusions: Postlipofilling breast changes can be distinguished from malignant alterations by experienced radiologists and need not interfere with early cancer diagnosis if patients are checked regularly. Moreover, magnetic resonance imaging is very useful for breast volume assessments and for detecting possible changes during longitudinal study. (*Plast. Reconstr. Surg.* 132: 498e, 2013.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

Many procedures of "oncoplastic" surgery have been developed recently. They combine the radicality of oncologic surgery (wide resection) with plastic surgery techniques, and allow for adequate aesthetic results even where there is an unfavorable ratio between tumor size and gland dimensions.[1–3] Moreover, these procedures are less expensive.

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In particular, lipofilling has awakened a great interest for its considerable advantages: outpatient procedure, easy availability of donor tissue, absence of scar and complications related to implants, and the possibility to change the results obtained by repeating the procedure.[4] Moreover, apart from lipofilling, no other technique has given such satisfactory results in correcting breast-conserving surgery results.[5] However, this technique has been criticized, either because a certain degree of fat resorption may occur or because, according to some authors, it can result in breast changes that can make the early diagnosis of cancer difficult.[4]

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Patient	Age (years)	Breast	Pre-lipofilling anamnesis	RT	BMI (Kg/m^2)
01	38	right	BCS with residual scar	yes	23,15
02	74	right	BCS, prosthesis and retracted scar	yes	24,77
		left	Mastopexy	no	
03	63	right	Mastectomy and reconstruction with prosthesis	Yes	24,65
		left	Breast augmentation with prosthesis	no	
04	52	right	Breast augmentation with prosthesis	no	22,03
		left	Breast augmentation with prosthesis	no	
05	63	right	Mastectomy and reconstruction with prosthesis	yes	22,89
		left	Mastectomy and reconstruction with prosthesis	no	
06	68	right	Breast augmentation with prosthesis	no	21,36
		left	Breast augmentation with prosthesis	no	
07	55	right	BCS with residual scar	yes	24,83
		left	BCS with residual scar	no	
08	43	right	BCS with residual scar	no	22,59
		left	BCS with residual scar	yes	
09	21	right	Hypomastia, no surgery	no	21,97
10	51	right	BCS with residual scar	no	22,06
11	28	right	Removal of prosthesis for rejection	no	21,3
		left	Removal of prosthesis for rejection	no	
12	22	right	Reduction mammaplasty	no	23,22
		left	Prosthesis for hypomastia	no	
13	42	right	BCS and burn scar due to home accident	no	20,7
14	38	left	Mastectomy and reconstruction with prosthesis	yes	22,48
15	36	left	BCS, prosthesis and retracted scar	yes	18,87
	mean: 46,27				

Fig. 1. Patient data. Patient, age, breast selected for lipofilling, prelipofilling anamnesis and treatment, radiotherapy, and body mass index for the 15 patients subjected to autologous fat grafting to correct the results of breast-conserving surgery or mastectomy in breast with previous cancer (*white rows*) or simply for cosmetic reasons (*gray rows*). *RT*, radiotherapy; *BMI*, body mass index; *BCS*, breast-conserving surgery.

In this preliminary study, we evaluated radiologic findings in 24 breasts subjected to lipofilling by mammography, ultrasound, and magnetic resonance imaging. A volumetric evaluation of the breast was also made through three-dimensional magnetic resonance imaging reconstruction.

PATIENTS AND METHODS

Population Study

From September of 2009 to May of 2012, we evaluated the radiologic aspects of 24 breasts of 15 female patients (Fig. 1) who underwent lipofilling to correct surgery results or solely for cosmetic reasons. In all patients, the procedure was carried out in two sessions.

All patients underwent the following examinations: mammography, ultrasound, and magnetic resonance imaging before the first lipofilling session and 12 months after the last lipofilling session; and ultrasound and magnetic resonance imaging 3 months after the first lipofilling session (before beginning the second) and then 3 and 6 months after the last lipofilling session.

The study received the ethics committee's approval, and after a clear explanation of the benefits and potential risks, all patients gave their informed consent. They also consented to preoperative and postoperative examinations. They were advised to undergo regular checkups during their lifetime with radiologic imaging.

Autologous Fat Grafting

Before and after each procedure, we performed a careful anamnesis and a clinical examination and took photographs to document improvement or the disappearance of defects (Fig. 2, *left*). Before the first lipofilling session, mammography, ultrasound, and magnetic resonance imaging were performed to rule out signs of tumor recurrence and to have an initial point of comparison to identify new lesions. Only patients who showed no signs of malignancy were included in this study. All procedures were performed under general anesthesia at least 3 months after surgery and at least 6 months after the end of radiotherapy/chemotherapy. Only one 21-year-old patient underwent lipofilling directly, without prior surgery.

The donor site was chosen based on the patient's natural fat deposition.[6–8] Before adipose tissue was harvested, 200 ml of Klein solution was injected into the donor site using a specific cannula (Coleman Kit, Tucson, Ariz.).[9–11] The adipose tissue was then purified by centrifugation (3000 rpm for 4 minutes) and combined with platelet-rich plasma. It was then reinjected aseptically with a specific microcannula (Coleman Kit), using the drop-to-drop technique in small pulses (0.2 to 1 ml), in a radial retrograde manner, on different planes into multiple areas of the breast. According to the patient's needs, in each of the two session, 50 to 150 ml (average, 93.54 ml) was injected, for a total of 187 ml (range, 110 to 250 ml) per patient.

Mammography

Digital mammographic examinations were performed with the GE Senographe DS system (General Electric, Milwaukee, Wis.). Bilateral mammograms with craniocaudal, mediolateral oblique, and mediolateral views were acquired. If necessary, the examinations were completed with additional projections, details, and mammographic magnification.

Ultrasound

Ultrasound studies were performed using a 7- to 15-MHz transducer (ATL HDI 5000; Philips Healthcare, Best, The Netherlands).

Fig. 2. Photographs (*left*) and axial T2-weighted magnetic resonance imaging scans (*right*) obtained before the first lipofilling session (*above*) and 6 months after the last lipofilling session (*below*), of a 21-year-old patient, subject to no prior surgery, on whom the lipofilling procedure was performed to correct right hypomastia. Lipofilling was carried out on the right breast only, where there was an obvious increase in volume at 6 months after the last lipofilling session compared with before the first lipofilling session.

Magnetic Resonance Imaging

Dynamic magnetic resonance imaging was performed with a 1.5-T (Intera; Philips Healthcare) magnetic resonance imaging apparatus with SENSE technology between days 7 and 14 of the menstrual cycle in fertile women. The patient was placed in prone position with both breasts inside the dedicated bilateral breast surface coil, to avoid any compression. The images were acquired on axial and sagittal planes (Figs. 2 and 3). The magnetic resonance imaging protocol consisted of the following: T1–turbo spin echo (repetition time, 6.8 msec; echo time, 3.3 msec; thickness, 3 mm; gap, 0), T2–turbo spin echo (repetition time, 3800 msec; echo time, 140 msec; thickness, 3 mm; gap, 0), three-dimensional T2–turbo spin echo (repetition time, 2000 msec; echo time, 200 msec; voxel size: anteroposterior, 1 mm; right-to-left, 1 mm; foot-to-head, 1.5 mm), T2–short tau inversion recovery (repetition time, 4000 msec; echo time, 42 msec; inversion time, 155 msec; thickness, 3.0 mm; gap, 0), and T1 dynamic sequence (two-dimensional) (fast field echo) (repetition time, 290 msec; echo time, 4.6 msec; flip angle, 90 degrees; thickness, 3 mm; 8 dynamics; with 50-second time resolution for each), after gadolinium bolus injection [gadopentetic acid and dimeglumine salt (Magnevist; Schering, Berlin, Germany), 0.1 mM/kg at 2 ml/second] followed by saline solution (20 ml). The presence of any lesions and/or enhancement characteristics was studied. Based on magnetic resonance imaging scans acquired, volumetric assessments of the breasts were also calculated, taking as edges the anterior axillary line, anterior margin of the pectoral muscle, mediosternal line, skin, and nipple. They were assessed using a three-dimensional reconstruction on a separate workstation (ADW 4.0; GE Medical Systems, Milwaukee, Wis.). Finally, at 6 and 12 months after the last lipofilling session, the resorption percentage for each breast was evaluated. Then, we calculated their overall average, and the average for the breasts with oily cyst resorption and for those remaining without resorption. All examinations were performed and analyzed in a blinded fashion by two radiologists experienced in interpreting breast imaging.

Statistical Analysis

The McNemar test was performed to compare ultrasound and magnetic resonance imaging in finding oily cysts and cytosteatonecrosis at 3 months after the first lipofilling session and at 3, 6, and 12 months after the last lipofilling session. A value of $p < 0.05$ was considered statistically significant. Because of the small sample size of this preliminary study, a statistical analysis on volumetric data was not feasible.

RESULTS

Radiologic Findings

No pathologic alterations were found in any of the examined breasts on mammography,

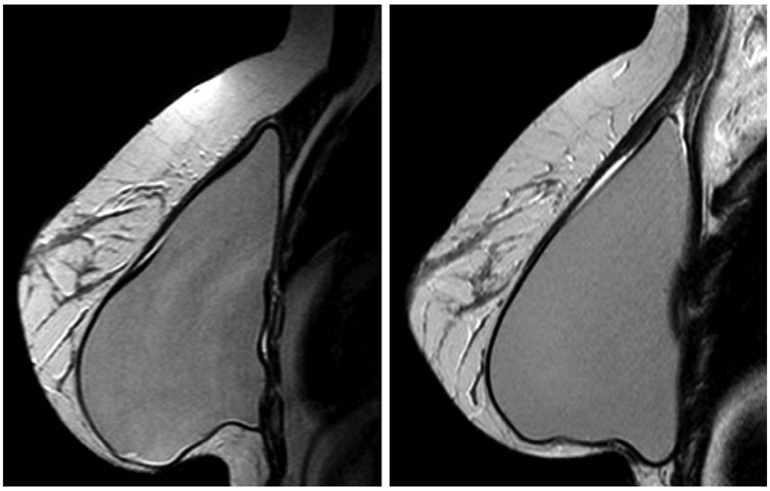

Fig. 3. Sagittal T2-weighted magnetic resonance imaging scans of the left breast obtained before the first lipofilling session (*left*) and 3 months after the first lipofilling session (*right*), of a 22-year-old patient on whom the lipofilling procedure was performed, to correct left hypomastia, after an augmentation mammaplasty with prosthesis.

Table 1. Findings from Radiologic Examinations

Findings	Ti (%)	T3 (%)	T6 (%)	T12 (%)
Mx				
Microcalcification	—	—	—	5/24 (20.83)
Macrocalcification	—	—	—	3/24 (12.5)
Liponecrosis	—	—	—	3/24 (12.5)
US				
Oily cysts (5–10 mm)	16/24 (66.67)	17/24 (70.83)	15/24 (62.5)	11/24 (45.83)
Cytosteatonecrosis (>20 mm)	2/24 (8.33)	2/24 (8.33)	2/24 (8.33)	3/24 (12.5)
MRI				
Oily cysts	2/24 (8.33)	2/24 (8.33)	2/24 (8.33)	1/24 (4.17)
Cytosteatonecrosis	2/24 (8.33)	2/24 (8.33)	2/24 (8.33)	4/24 (16.67)

Ti, 3 months after the first lipofilling session; T3, 3 months after the last lipofilling session; T6, 6 months after the last lipofilling session; T12, 12 months after the last lipofilling session; Mx, mammography; US, ultrasound; MRI, magnetic resonance imaging.

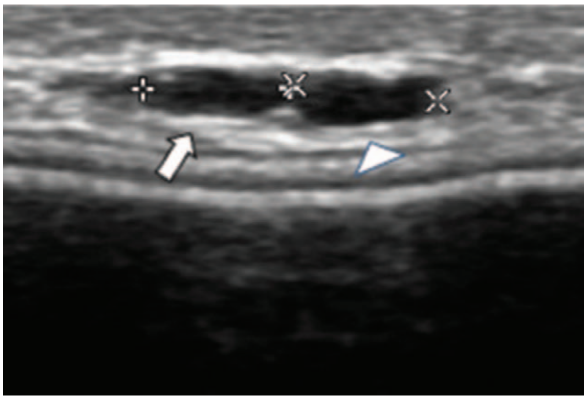

Fig. 4. Ultrasound image of the right breast of a 22-year-old patient that shows two oily cysts, with oval hypoechoic/anechoic areas with a well-defined regular wall and sizes of 4.6 (*arrow*) and 4.5 mm (*arrowhead*), respectively.

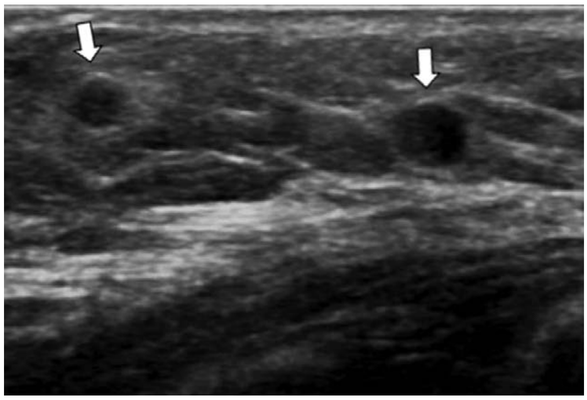

Fig. 5. Ultrasound image of the right breast of a 42-year-old patient that shows oily cysts (*arrows*), with round hypoechoic/anechoic areas with a well-defined regular wall and sizes ranging between 5 and 10 mm.

ultrasound, or magnetic resonance imaging before the first lipofilling session. In 23 breasts, the previous surgery outcomes were visible. With regard to postlipofilling examinations, we report below only those findings that were not present before the lipofilling (Table 1).

On ultrasound, oily cysts (round hypoechoic/anechoic areas with a well-defined regular wall and sizes up to 10 mm) (Figs. 4 and 5) were found in 66.67 percent of the breasts at 3 months after the first lipofilling session, in 70.83 percent at 3 months after the last lipofilling session, in 62.5 percent at 6 months after the last lipofilling session (showing oily cyst resorption in two breasts), and in 45.83 percent at 12 months after the last lipofilling session (showing oily cyst resorption in four other breasts); whereas on magnetic resonance imaging, they were detected in 8.33 percent at 3 months after the first lipofilling session and 3 and 6 months after the last lipofilling session, and in 4.17 percent at 12 months after the last lipofilling session (showing oily cyst resorption in only one breast). At 3 months after the first lipofilling session and 3 and 6 months after the last lipofilling session, the cytosteatonecrotic areas (anechoic areas, >20 mm) (Figs. 6 and 7)

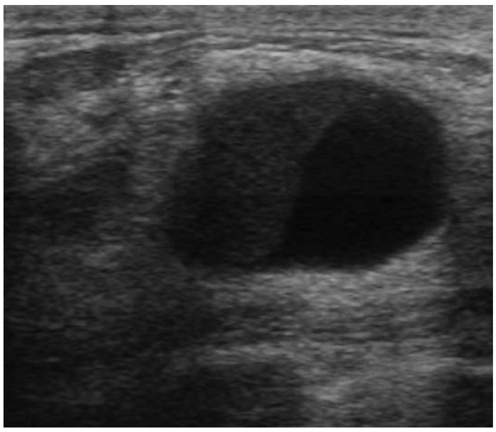

Fig. 6. Ultrasound image of the right breast of a 38-year-old patient that shows a cytosteatonecrotic area (hypoechoic/anechoic area) of approximately 4 cm.

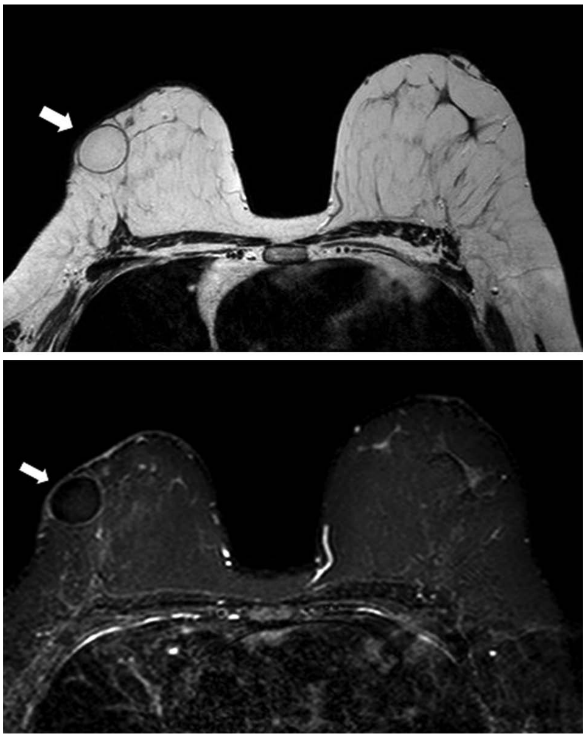

Fig. 7. Axial T2-weighted (*above*) and short tau inversion recovery (*below*) magnetic resonance imaging scans of the breasts obtained at 6 months after the last lipofilling session, of a 55-year-old patient on whom the lipofilling procedure was performed to correct bilateral scarring. On the right breast, a cytosteatonecrotic area clearly appears: a round area of approximately 28 mm, hyperintense on T2-weighted images (*arrow*), and the signal of which is suppressed on short tau inversion recovery sequences (*arrow*).

identified on both ultrasound and magnetic resonance imaging were unchanged (8.33 percent), whereas at 12 months after the last lipofilling session the breasts with cytosteatonecrotic areas were increased on ultrasound (12.5 percent) and even more on magnetic resonance imaging (16.67 percent).

At 12 months after the last lipofilling session, the mammograms showed microcalcifications in 20.83 percent: in three cases, they had typical benign features (scattered and under various guises), and in two cases, they are clustered. Six months later, the latter were subjected to follow-up mammography and reclassified as benign. Macrocalcifications were found in 12.5 percent and fat necrosis (areas of radiolucency with a thin, dense, regular rim) was found in 12.5 percent. Subsequent to the lipofilling procedure, no solid mass or opacity was found in any patient.

Volumetric Assessment at 6 and 12 Months after the Last Lipofilling Session

At 6 months after the last lipofilling session, the average resorption of the injected volume was 15.36 ± 1.76 percent (range, 9.95 to 17.55 percent) for all the breasts and 14.40 ± 0.68 percent (range, 13.92 to 14.88 percent) for only the two breasts with oily cyst resorption and 15.94 ± 1.31 percent (range, 13.88 to 17.55 percent) for only the breasts without oily cyst resorption (Fig. 8). At 12 months after the last lipofilling session, the average resorption was 28.23 ± 1.55 percent (range, 25.47 to 31.99 percent) for all the breasts, 27.84 ± 1.15 percent (range, 26.72 to 29.88 percent) for the six breasts with oily cyst resorption, and 28.23 ± 1.96 percent (range, 25.47 to 31.99 percent) for the breasts without oily cyst resorption.

Statistical Analysis

Using the McNemar test, we found a statistically significant ($p < 0.05$) difference between the oily cysts detected with ultrasound and those identified with magnetic resonance imaging, at any time (Fig. 9). However, we have not found a statistically significant difference for the cytosteatonecrotic areas (Fig. 10).

DISCUSSION

Autologous fat transplantation was initially performed by Neuber to fill a depressed scar.[12] Since then, some plastic surgeons have applied this procedure in almost all body regions.[8] Breast lipofilling should be performed only by well-trained and skilled surgeons to avoid major complications, which are mainly attributable to technical errors.[13–15]

One of the main reasons why this technique was questioned is that there may be lipofilling resorption. Therefore, the results are unpredictable.[7,16–18] In the literature, the resorption rate reported over the first year is highly variable (20 to 90 percent), most evidently between the fourth and sixth months.[7,18–24] However, so far, in many studies, the evidence of breast lipofilling survival was based on patient satisfaction and plastic surgeons' evaluations.[10,17,25–29] In a study where mammary volumes were calculated by computed tomography using a three-dimensional program, a resorption rate of 47.5 percent at 9 months was reported.[26] However, computed tomography is not indicated for longitudinal studies because it can cause tumors induced by radiation. Instead, magnetic resonance imaging allows for a good volume estimate[20,30] and does not pose this risk.

PATIENTS	BREAST	INITIAL BREAST VOLUME (ml)	INJECTED VOLUME (ml)	BREAST VOLUME AT T_6.	RESORPTION % AT T_6.	BREAST VOLUME AT T_{12}.	RESORPTION % AT T_{12}.
01	right	364,59	120	463,60	17,49	448,15	30,37
02	right	713,18	180	861,87	17,39	835,59	31,99
	left	810,50	110	901,20	17,55	887,56	29,94
03	right	812,68	220	996,83	16,30	967,25	29,74
	left	1078,29	180	1230,02	15,71	1209,00	27,38
04	right	1063,46	200	1231,98	15,74	1208,00	27,73
	left	965,99	250	1173,81	16,87	1148,22	27.11
05	right	612,30	200	780,56	15,87	758,12	27.09
	left	690,88	200	858,72	16,08	831,12	29,88
06	right	1003,53	200	1174,23	14,65	1145,36	29,08
	left	1072,28	200	1238,74	16,77	1215,35	28,46
07	right	754,64	200	926,44	14,10	900,22	27,21
	left	811,59	200	978,53	16,53	957,74	26,92
08	right	560,00	200	726,64	16,68	702,55	28,72
	left	541,92	200	713,42	14,25	690.98	25,47
09	right	367,18	180	521,98	14,00	498,11	27,26
10	right	247,44	200	417,68	14,88	394,00	26,72
11	right	198,89	200	365,57	16,66	342,87	28,01
	left	226,53	200	395,03	15,75	371,85	27,34
12	right	1056,57	150	1187,58	12,66	1161,64	29,95
	left	1020,62	150	1149,74	13,92	1128,06	28,37
13	left	311,64	150	446,72	9,95	418,11	29.02
14	left	799,82	200	972,06	13,88	948,12	25,85
15	right	593,42	200	763,56	14,93	737,58	27,92

Fig. 8. Transplanted fat resorption percentage 6 and 12 months after the last lipofilling session. *Light gray*, patients with oily cysts; *dark gray*, patients with oily cyst resorption; *Injected Volume*, total fat volume injected in the two lipofilling sessions; T_6, 6 months after the last lipofilling session; T_{12}, 12 months after the last lipofilling session.

Serial magnetic resonance imaging offers a quantitative measure of fat resorption and survival.[31,32] We found a total average resorption percentage of 15.36 percent at 6 months after the last lipofilling session and of 28.23 percent at 12 months after the last lipofilling session. Evaluation at 3 months after the last lipofilling session may be too early and incomplete.

To prevent, or rather minimize, resorption, it is crucial to perform each step of the procedure carefully, paying close attention to the technical details. We injected 200 ml of Klein solution into the donor site before liposuction. The lipoaspirate must then be purified in various ways: washed with different solutions,[19,33–35] filtered, centrifuged, and left to decant.[15,36] Its injection causes an inflammatory response that can be reduced by injecting only adipocytes.[37,38] An inverse relationship has been observed between the blood amount in the lipoaspirate and the viable number of adipocytes.[39,40] Furthermore, the fat must be in contact with air as little as possible,[19] as this may cause lysis of the adipocytes.[36–41]

In our patients, the lipoaspirate was purified by centrifugation and combined with platelet-rich plasma. Platelet-rich plasma has no impact on the diagnostic images but improves lipofilling results and reduces the resorption rate, increasing fat-graft survival.[42] Then, the lipoaspirate was injected using the drop-to-drop technique and in multiple sessions to maximize the contact surface between the lipoaspirate and the host's capillaries.[18] Diffusion of nutrients from neighboring capillaries is essential for adipocyte survival and favors their integration with the surrounding tissue.[15,24,25] The need for multiple sessions of extended treatment is the main factor that discourages patients.[15] Finally, the problem of fat resorption may be resolved by injecting a total volume of fat greater than the desired volume.[7,19]

Other possible lipofilling complications are swelling, bruising, infection, granuloma or abscess,

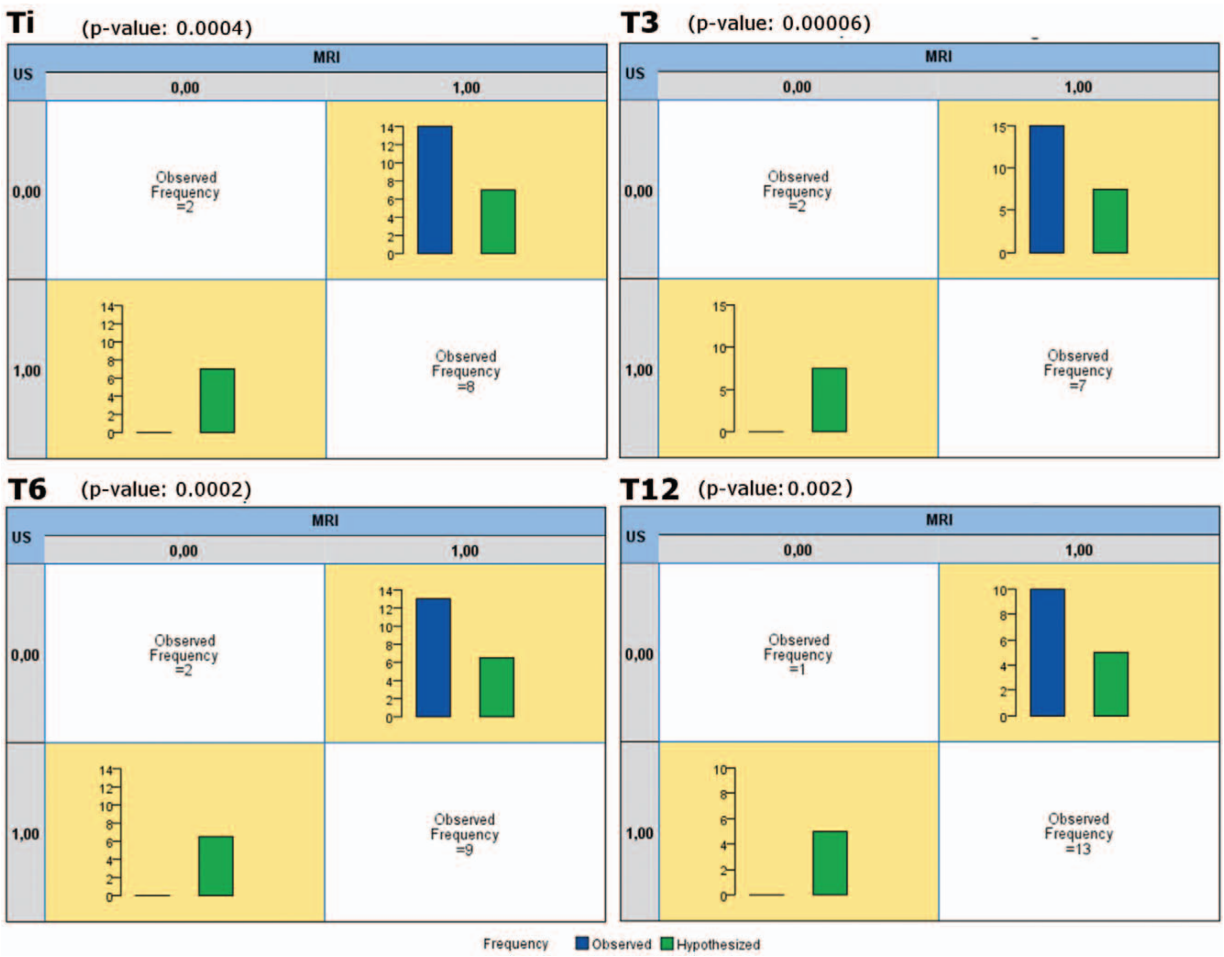

Fig. 9. McNemar tests performed to compare ultrasound and magnetic resonance imaging in finding oily cysts at 3 months after the first lipofilling session (*Ti*) and at 3 (*T3*), 6 (*T6*), and (*T12*) 12 months after the last lipofilling session. A value of $p < 0.05$ was considered statistically significant. We found a statistically significant ($p < 0.05$) difference between the oily cysts detected with ultrasound and those identified with magnetic resonance imaging, at any time.

simple or complicated cysts, fat necrosis, calcification, masses, and rarely nipple retraction caused by fat necrosis.[4,8,43] Microcalcification and liponecrosis are the main reason why this technique was abandoned at the end of the 1980s. It was thought that lipofilling could make the early diagnosis of eventual underlying cancers difficult.[5,6] This is open for discussion. First, liponecrosis, oily cysts, calcification, and focal opacity can be caused by any type of breast surgery (biopsy, reduction mammoplasty,[44,45] breast reconstruction,[46] liposuction[47]) or can occur spontaneously.[46,48,49] In a retrospective study, calcifications were found in 50 percent of cases after reduction mammaplasty.[50] However, they were not held responsible for interfering with early cancer diagnosis and the procedure was not abandoned.[5,6] We found microcalcifications in 20.83 percent, the same value observed in a study where the postlipomodeling incidence of microcalcification was equal to that found following surgery (20 percent), for a total of 40 percent.[5] These data suggest that microcalcifications can be a normal consequence of lipomodeling. Usually, they are easily identified (like the ones formed after breast surgery) because of their typical benign radiologic features (small, round, and regular; isolated or associated with small radiolucent images of lipidic nature, scattered or more rarely clustered; usually classified as Breast Imaging-Reporting and Data System 2), and they are very different from the ones suspected of malignancy or recurrence (because of localization or radiologic aspects).[5,44,46,51–53] Calcifications suspected of being malignant were found in none of our patients. In three breasts, microcalcifications appeared to have typical benign

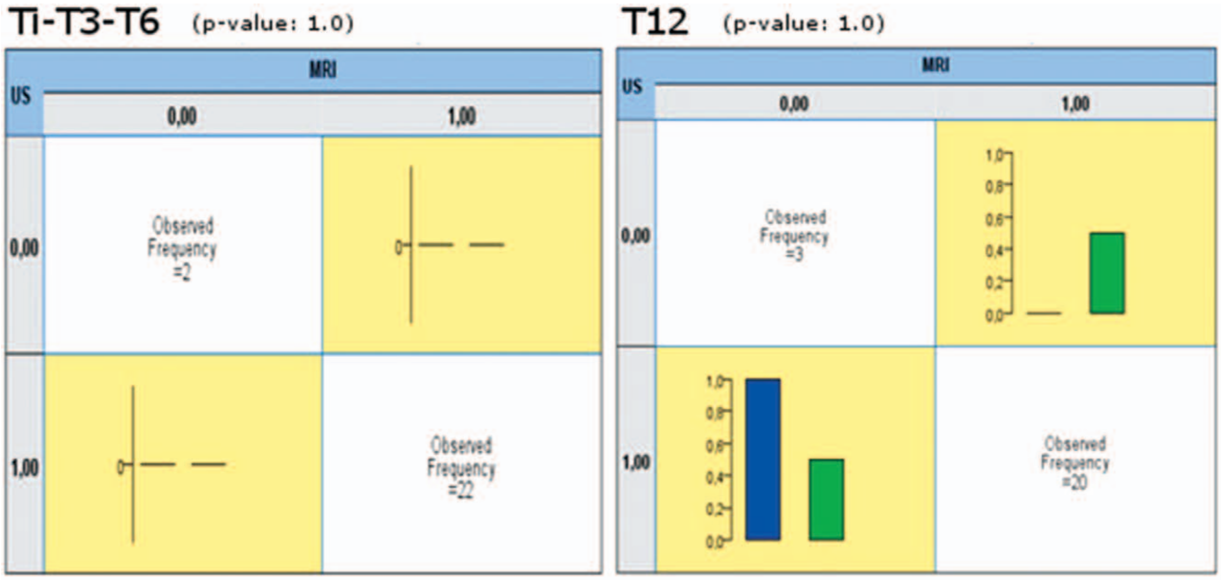

Fig. 10. McNemar tests performed to compare ultrasound and magnetic resonance imaging in finding cytosteatonecrosis at 3 months after the first lipofilling session (*Ti*) and at 3 (*T3*), 6 (*T6*), and (*T12*) 12 months after the last lipofilling session. A value of $p < 0.05$ was considered statistically significant. We have not found a statistically significant difference between the cytosteatonecrotic areas detected with ultrasound and those identified with magnetic resonance imaging.

features. In two other cases, microcalcifications were clustered, although the subsequent control reclassified them as benign.

Oily cysts and cytosteatonecrotic areas are manifestations of liponecrosis. Therefore, it is important to understand their etiopathogenesis, both to prevent them and to distinguish their manifestations from malignancies. The etiopathogenesis of liponecrosis seems to be complex and multifactorial. Besides surgery, the most common causes of fat necrosis are ischemia, radiotherapy, trauma, and sometimes anticoagulant therapy.[49,53–60] Postlipofilling liponecrosis has been correlated to mechanical trauma caused by the blunt cannula used for fat injection and to a higher tendency to fat graft necrosis.[53] According to others, liponecrosis is caused by an inadequate blood supply of the transplanted fat. Adipocyte suffering results in lysis, releasing fatty acids and glycerol, which may affect the osmotic balance and promote edema, thus worsening the capillary perfusion. Then, there is an inflammatory response of the host tissue to the degenerated fat, subsequently replaced by fibrosis.[25,61] When a peripheral fibrosis ("capsule") develops, cysts are often visible only with ultrasound (Figs. 4 and 5).[25,53] After a few months, the subtle fibrotic capsule can thicken and calcify; therefore, cysts become visible also on mammography, sometimes with the typical "soap-bubble" feature (a radiolucent lesion confined by a thin calcified rim) (Fig. 11). Furthermore, in the liponecrotic areas, microcalcifications or macrocalcifications (visible with mammography) can form (Fig. 12).[62] However, the fibrosis can mostly extend, forming a spiculated mass, that can be suspected of being malignant.[53] In our patients, no solid masses were found.

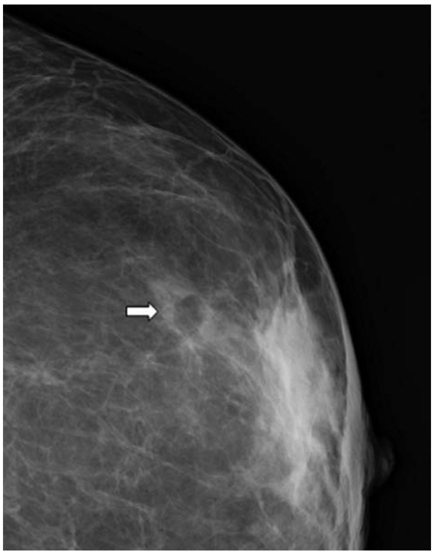

Fig. 11. Mammogram of a 51-year-old patient that clearly shows the typical soap bubble feature: a radiolucent lesion confined by a thin calcified rim (*arrow*).

Fig. 12. Lateral (*above*) and mediolateral oblique (*below*) bilateral mammograms of a 43-year-old patient that show calcifications of the liponecrotic areas.

If patients are checked regularly, experienced radiologists are able to identify postlipofilling breast changes and distinguish them from malignant alterations so that lipofilling does not make early diagnosis of cancer difficult. Although there is still no postlipomodeling screening protocol,[5] it is important to perform closer checks during the first year (e.g., ultrasound and magnetic resonance imaging at 3, 6, and 12 months after the last lipofilling session, and mammography at 12 months after the last lipofilling session) and follow-up annually, even in the absence of alterations, especially in patients who have already had cancer. Mammography, ultrasound, and magnetic resonance imaging before the first lipofilling session are necessary to rule out any signs of tumor recurrence and to have an initial point of comparison, whereas at 3 months after the first lipofilling session, the examinations do not seem to add important data.

In patients who have had cancers or are aged 35 years and older, it is important to perform prelipofilling mammography and follow-up annually or perform closer checks (the frequency of which depends on the type of alteration found). Mammography, though still the criterion standard,[53,63] may result in false-positives (18 percent).[64,65] Mammography detects only two-thirds of recurrences, and in approximately 45 percent of cases, the recurrences (in situ or invasive) occur as microcalcifications.[63] Mammography is the only examination that can clearly identify microcalcifications and distinguish them from those that are malignant.[5] In addition, mammography allows us to identify the typical soap bubble, macrocalcifications, and breast opacity. It is therefore a key examination in postlipofilling monitoring; however, alone, it is not enough.[5,53,62] In patients younger than 35 years who have undergone lipofilling solely for aesthetic reasons, mammography is not indicated.

Ultrasound is more reliable than magnetic resonance imaging for detecting small cysts (thus, it is more sensitive), but it cannot distinguish the oily cyst from the normal cyst (less specific). The small oily cysts are best seen by ultrasound, because they behave like small fluid formations. In our patients, small oily cysts appeared on a much higher percentage of breast ultrasound images as opposed to their magnetic resonance imaging scans (as confirmed by the McNemar test), highlighting also their reabsorption (Table 1). However, the oily cysts cannot be differentiated from normal cysts on ultrasound. In one of our patients, normal cysts mistaken at first for oily cysts on ultrasound were correctly identified through the subsequent magnetic resonance imaging scan.

Ultrasound is also extremely useful in the evaluation of "dense breasts,"[66] surgical scars and complex cysts, and in the differentiation between cysts and solid masses. Finally, when in doubt, it can be used to perform ultrasound-guided microbiopsy.[5]

The role of magnetic resonance imaging, although emphasized in recent studies, is not yet clear. In magnetic resonance imaging, oily cyst signal intensity is suppressed in sequences with fat suppression because they are composed of fat even if necrotic. However, small oily cysts cannot be seen properly because of their small size, the result of which is that they are easily confused with native fat (also suppressed). In those two breasts where the oily cysts were visible also on magnetic resonance imaging, the oily cysts were larger compared with those of other patients. Even though magnetic resonance imaging does not always detect small oily cysts, it can positively differentiate the normal cysts because they are hypointense on T1-weighted sequences, hyperintense on T2-weighted sequences, and not suppressed on the sequences with fat suppression. Moreover, because of the sequences where fat suppression occurs, magnetic resonance imaging is able to highlight large cytosteatonecrotic areas. Magnetic resonance imaging seems to be at least as effective as ultrasound and mammography in demonstrating large cytosteatonecrotic areas, as confirmed by the McNemar test. However, these data need to be confirmed using a wider test population.

In addition, magnetic resonance imaging is extremely useful in cases of suspected recurrence, namely, clinical signs of recurrence together with negative or equivocal standard radiologic examinations, and scar alteration. In fact, it has excellent sensitivity and specificity (>90 percent) in the diagnosis of infiltrating recurrence, but because of large variation in angiogenesis, it remains limited in pure intraductal forms (sensitivity between 60 and 85 percent).[67] Dynamic studies with contrast agents, fat saturation, and image subtraction improve the specificity of breast magnetic resonance imaging.[5] It would be optimal to perform magnetic resonance imaging at least 1 year after radiotherapy because, as a result of inflammation and posttreatment edema, there may be benign enhancements.[66]

Furthermore, magnetic resonance imaging can be used for breast volume assessment and for possible changes in longitudinal studies.[20,30] Thus, it can be very useful for better understanding the behavior of transplanted fat and the mechanisms that underlie its reabsorption.

In some patients, probably because of resorption, we found a reduction of oily cysts over time (in number and size). In these patients, the fat resorption percentage was similar to that of others. However, in these patients, a better aesthetic result was obtained. These data need confirmation and further investigation on a wider test population.

CONCLUSIONS

In addition to ultrasound and mammography, magnetic resonance imaging is very useful for evaluation of medium- and long-term complications. It is also very useful for a quantitative breast-volume assessment and provides early information on fat resorption.

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REFERENCES

1. Clough KB, Lewis JS, Couturaud B, Fitoussi A, Nos C, Falcou MC. Oncoplastic techniques allow extensive resections for breast-conserving therapy of breast carcinomas. *Ann Surg.* 2003;237:26–34.
2. Baildam AD. Oncoplastic surgery of the breast. *Br J Surg.* 2002;89:532–533.
3. Asgeirsson KS, Rasheed T, McCulley SJ, Macmillan RD. Oncological and cosmetic outcomes of oncoplastic breast conserving surgery. *Eur J Surg Oncol.* 2005;31:817–823.
4. Pulagam SR, Poulton T, Mamounas EP. Long-term clinical and radiologic results with autologous fat transplantation for breast augmentation: Case reports and review of the literature. *Breast J.* 2006;12:63–65.
5. Gosset J, Guerin N, Toussoun G, Delaporte T, Delay E. Radiological evaluation after lipomodelling for correction of breast conservative treatment sequelae (in French). *Ann Chir Plast Esthet.* 2008;53:178–189.
6. Delay E, Garson S, Tousson G, Sinna R. Fat injection to the breast: Technique, results, and indications based on 880 procedures over 10 years. *Aesthet Surg J.* 2009;29:360–376.
7. Delay E. Lipomodeling of the reconstructed breast. In: Spear SL, Willey SC, Robb GL, Hammond DC, Nahabedian MY, eds. *Surgery of the Breast: Principles and Art.* Vol. 1, 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2006:930–946.
8. ELFadl D, Garimella V, Mahapatra TK, McManus PL, Drew PJ. Lipomodelling of the breast: A review. *Breast* 2010;19:202–209.
9. Coleman SR. Structural fat grafting: More than a permanent filler. *Plast Reconstr Surg.* 2006;118(Suppl):108S–120S.
10. Coleman SR. Long-term survival of fat transplants: Controlled demonstrations. *Aesthetic Plast Surg.* 1995;19:421–425.
11. Coleman SR. Structural fat grafts: The ideal filler? *Clin Plast Surg.* 2001;28:111–119.
12. Neuber GA. *Verhandlungen der Deutschen Gesellscahft fur Chirurgie.* 1893;66.
13. Hyakusoku H, Ogawa R, Ono S, Ishii N, Hirakawa K. Complications after autologous fat injection to the breast. *Plast Reconstr Surg.* 2009;123:360–370; discussion 371.
14. Zocchi ML, Zuliani F. Bicompartmental breast lipostructuring. *Aesthetic Plast Surg.* 2008;32:313–328.
15. Illouz YG, Sterodimas A. Autologous fat transplantation to the breast: A personal technique with 25 years of experience. *Aesthetic Plast Surg.* 2009;33:706–715.
16. Billings E Jr, May JW Jr. Historical review and present status of free fat graft autotransplantation in plastic and reconstructive surgery. *Plast Reconstr Surg.* 1989;83:368–381.
17. Kaufman MR, Miller TA, Huang C, et al. Autologous fat transfer for facial recontouring: Is there science behind the art? *Plast Reconstr Surg.* 2007;119:2287–2296.
18. Coleman SR, Saboeiro AP. Fat grafting to the breast revisited: Safety and efficacy. *Plast Reconstr Surg.* 2007;119:775–785; discussion 786–787.
19. Niechajev I, Sevćuk O. Long-term results of fat transplantation: Clinical and histologic studies. *Plast Reconstr Surg.* 1994;94:496–506.

20. Hörl HW, Feller AM, Biemer E. Technique for liposuction fat reimplantation and long-term volume evaluation by magnetic resonance imaging. *Ann Plast Surg.* 1991;26:248–258.
21. Chajchir A. Fat injection: Long-term follow-up. *Aesthetic Plast Surg.* 1996;20:291–296.
22. Ersek RA. Transplantation of purified autologous fat: A 3-year follow-up is disappointing. *Plast Reconstr Surg.* 1991;87:219–227; discussion 228.
23. Lewis CM. The current status of autologous fat grafting. *Aesthetic Plast Surg.* 1993;17:109–112.
24. Chan CW, McCulley SJ, Macmillan RD. Autologous fat transfer: A review of the literature with a focus on breast cancer surgery. *J Plast Reconstr Aesthet Surg.* 2008;61:1438–1448.
25. Zheng DN, Li QF, Lei H, et al. Autologous fat grafting to the breast for cosmetic enhancement: Experience in 66 patients with long-term follow up. *J Plast Reconstr Aesthet Surg.* 2008;61:792–798.
26. Amar O, Bruant-Rodier C, Lehmann S, Bollecker V, Wilk A. Fat tissue transplant: Restoration of the mammary volume after conservative treatment of breast cancers, clinical and radiological considerations (in French). *Ann Chir Plast Esthet.* 2008;53:169–177.
27. Illouz YG. The fat cell "graft": A new technique to fill depressions. *Plast Reconstr Surg.* 1986;78:122–123.
28. Pereira LH, Sterodimas A. Free fat transplantation for the aesthetic correction of mild pectus excavatum. *Aesthetic Plast Surg.* 2008;32:393–396.
29. Guerrerosantos J. Autologous fat grafting for body contouring. *Clin Plast Surg.* 1996;23:619–631.
30. Herold C, Reichelt A, Stieglitz LH, et al. MRI-based breast volumetry-evaluation of three different software solutions. *J Digit Imaging* 2010;23:603–610.
31. Murillo WL. Buttock augmentation: Case studies of fat injection monitored by magnetic resonance imaging. *Plast Reconstr Surg.* 2004;114:1606–1614; discussion 1615.
32. Wolf GA, Gallego S, Patrón AS, et al. Magnetic resonance imaging assessment of gluteal fat grafts. *Aesthetic Plast Surg.* 2006;30:460–468.
33. Ersek RA, Chang P, Salisbury MA. Lipo layering of autologous fat: An improved technique with promising results. *Plast Reconstr Surg.* 1998;101:820–826.
34. Fournier PF. Fat grafting: My technique. *Dermatol Surg.* 2000;26:1117–1128.
35. Spear SL, Wilson HB. Fat injection to correct contour deformities in the reconstructed breast. In: Spear SL, Willey SC, Robb GL, Hammond DC, Nahabedian MY, eds. *Surgery of the Breast: Principles and Art.* Vol. 1, 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2006:960–967.
36. Mojallal A, Foyatier JL. The effect of different factors on the survival of transplanted adipocytes (in French). *Ann Chir Plast Esthet.* 2004;49:426–436.
37. Goodpasture JC, Bunkis J. Quantitative analysis of blood and fat in suction lipectomy aspirates. *Plast Reconstr Surg.* 1986;78:765–772.
38. Carpaneda CA. Study of aspirated adipose tissue. *Aesthetic Plast Surg.* 1996;20:399–402.
39. Novaes F, dos Reis N, Baroudi R. Counting method of live fat cells used in lipoinjection procedures. *Aesthetic Plast Surg.* 1998;22:12–15.
40. Boschert MT, Beckert BW, Puckett CL, Concannon MJ. Analysis of lipocyte viability after liposuction. *Plast Reconstr Surg.* 2002;109:761–765; discussion 766.
41. Aboudib Júnior JH, de Castro CC, Gradel J. Hand rejuvenescence by fat filling. *Ann Plast Surg.* 1992;28:559–564.
42. Gentile P, Di Pasquali C, Bocchini I, et al. Breast reconstruction with autologous fat graft mixed with platelet-rich plasma. *Surg Innov.* 2013;20:370–376.
43. Millard GF. Liponecrotic cyst after augmentation mammaplasty with fat injections. *Aesthetic Plast Surg.* 1994;18:405–406.
44. Brown FE, Sargent SK, Cohen SR, Morain WD. Mammographic changes following reduction mammaplasty. *Plast Reconstr Surg.* 1987;80:691–698.
45. Isaacs G, Rozner L, Tudball C. Breast lumps after reduction mammaplasty. *Ann Plast Surg.* 1985;15:394–399.
46. Hogge JP, Robinson RE, Magnant CM, Zuurbier RA. The mammographic spectrum of fat necrosis of the breast. *Radiographics* 1995;15:1347–1356.
47. Abboud M, Vadoud-Seyedi J, De Mey A, Cukierfajn M, Lejour M. Incidence of calcifications in the breast after surgical reduction and liposuction. *Plast Reconstr Surg.* 1995;96:620–626.
48. Leibman AJ, Styblo TM, Bostwick J III. Mammography of the postreconstruction breast. *Plast Reconstr Surg.* 1997;99:698–704.
49. Danikas D, Theodorou SJ, Kokkalis G, Vasiou K, Kyriakopoulou K. Mammographic findings following reduction mammoplasty. *Aesthetic Plast Surg.* 2001;25:283–285.
50. Brown FE, Sargent SK, Cohen SR, Morain WD. Mammographic changes following reduction mammaplasty. *Plast Reconstr Surg.* 1987;80:691–698.
51. Bircoll M. Reply. *Plast Reconstr Surg.* 1987;80:647.
52. Bircoll M. Autologous fat transplantation to the breast. *Plast Reconstr Surg.* 1988;82:361–362.
53. Carvajal J, Patiño JH. Mammographic findings after breast augmentation with autologous fat injection. *Aesthet Surg J.* 2008;28:153–162.
54. Haj M, Loberant N, Salamon V, Cohen I. Membranous fat necrosis of the breast: Diagnosis by minimally invasive technique. *Breast J.* 2004;10:504–508.
55. Destounis S. Imaging of the post-surgical breast. *Contemp Diagn Radiol.* 2005;28:1–6.
56. Spear SL, Wilson HB, Lockwood MD. Fat injection to correct contour deformities in the reconstructed breast. *Plast Reconstr Surg.* 2005;116:1300–1305.
57. Schmidth M, Wiele K. Imaging of benign breast lesions. *Probl Gen Surg.* 2003;20:1–16.
58. Mellul SD, Dryden RM, Remigio DJ, Wulc AE. Breast reduction performed by liposuction. *Dermatol Surg.* 2006;32:1124–1133.
59. Coyne JD, Parkinson D, Baildam AD. Membranous fat necrosis of the breast. *Histopathology* 1996;28:61–64.
60. Stephens T, Withman G, Stelling C. Typical benign calcifications of the breast that do not require biopsy. *Radiology* 2003;10:1–9.
61. Taboada JL, Stephens TW, Krishnamurthy S, Brandt KR, Whitman GJ. The many faces of fat necrosis in the breast. *AJR Am J Roentgenol.* 2009;192:815–825.
62. Veber M, Tourasse C, Toussoun G, Moutran M, Mojallal A, Delay E. Radiographic findings after breast augmentation by autologous fat transfer. *Plast Reconstr Surg.* 2011;127:1289–1299.
63. Solomon B, Orel S, Reynolds C, Schnall M. Delayed development of enhancement in fat necrosis after breast conservation therapy: A potential pitfall of MR imaging of the breast. *AJR Am J Roentgenol.* 1998;170:966–968.
64. Sardi A, Eckholdt G, McKinnon WM, Bolton JS. The significance of mammographic findings after breast-conserving therapy for carcinoma of the breast. *Surg Gynecol Obstet.* 1991;173:309–312.
65. Coady AM, Mussurakis S, Owen AW, Turnbull LW. Case report: MR imaging of fat necrosis of the breast associated with lipid cyst formation following conservative treatment for breast carcinoma. *Clin Radiol.* 1996;51:815–817.
66. Standards, Options and Recommendations for the management of ductal carcinoma in situ of the breast (DCIS): Update 2004 (in French). *Bull Cancer* 2005;92:155–168.
67. Kinoshita T, Yashiro N, Yoshigi J, Ihara N, Narita M. Fat necrosis of breast: A potential pitfall in breast MRI. *Clin Imaging* 2002;26:250–253.