# A Prospective, Randomized Comparison of Clinical Outcomes with Different Processing Techniques in Autologous Fat Grafting

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**Background:** Autologous fat grafting is a useful tool in breast reconstruction. The authors have previously demonstrated a difference in the rate of processing adipose grafts in a randomized time and motion clinical trial. The purpose of this study was to compare clinical outcomes in commonly used grafting systems.
**Methods:** Three methods to prepare adipose grafts were compared: a passive washing filtration system (Puregraft system), an active washing filtration system (Revolve system), and centrifugation (Coleman technique). Postoperative complications, rates of fat necrosis, revision procedures, and additional imaging were recorded.
**Results:** Forty-six patients were included in the prospective, randomized study (15 active filtration, 15 passive filtration, and 16 centrifugation). Their mean age was 54 years and mean body mass index was 28.6 kg/m$^2$. The mean length of follow-up was 16.9 ± 4 months. The overall complication rate was 12.1 percent. The probability of fat necrosis was no different between the groups (active filtration, 15 percent versus passive filtration, 14.3 percent] versus centrifugation, 8 percent; $p$ = 0.72). Fat necrosis was highest in patients with breast conservation before grafting (60 percent; $p$ = 0.011). There was no significant difference in contour irregularity (active filtration, 40 percent versus passive filtration, 38 percent versus centrifugation, 36 percent; $p$ = 0.96) or additional grafting (active filtration, 40 percent versus passive filtration, 24 percent versus centrifugation, 32 percent; $p$ = 0.34).
**Conclusions:** This is the first prospective, randomized study to compare clinical outcomes of adipose graft preparation. There was no significant difference in early complications, fat necrosis, or rates of additional grafting among the study groups. There was significantly higher risk of fat necrosis in patients with previous breast conservation treatment regardless of processing technique. (*Plast. Reconstr. Surg.* 150: 955, 2022.)
**CLINICAL QUESTION/LEVEL OF EVIDENCE:** Therapeutic, II.

Autologous fat grafting is a useful tool in cosmetic and reconstructive surgery. In recent years, the indications in soft-tissue reconstruction have expanded beyond volume loss and contour deformity[1–4] to include radiation fibrosis, peripheral neuropathy, complex pain, and lymphedema.[5,6] The underlying mechanisms of these benefits are not fully understood, but the effects of purified adipose tissue are just as likely to be paracrine as physical. With the increase in procedural volume[7] comes increasing interest in optimizing the process, from preparing a more robust graft to reducing operative time and cost. There are three key steps in grafting—harvest, processing,

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*Received for publication August 4, 2020; accepted November 16, 2021.*
*This trial is registered under the name "Autologous Fat Grafting Techniques in Patients Undergoing Reconstructive Surgery," Clinical Trials.gov identification number NCT02677012 (https://clinicaltrials.gov/ct2/show/NCT02677012).*

DOI: 10.1097/PRS.0000000000009613

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

A Video Discussion by Nolan Karp, M.D., accompanies this article. Go to PRSJournal.com and click on "Video Discussions" in the "Digital Media" tab to watch.

and delivery—each of which has several variables that may affect the efficiency and efficacy of the procedure.

The primary objective in processing the lipoaspirate before injection is to remove impurities that have resulted from tissue harvest, such as cellular debris, lipid, or blood. There are several described techniques to prepare a graft with no one method being shown to be superior to others.[8–10] Members of the American Society of Plastic Surgeons were previously surveyed and reported preferred processing techniques including centrifugation (34 percent), filtration (34 percent), and washing or rinsing (28 percent).[11] Since that survey was conducted, device-based processing systems have gained popularity for their streamlined, closed handling.

The Revolve system (LifeCell Corporation, Branchburg, N.J.)[12] is an active filtration system that uses mechanical suction to harvest and filter the lipoaspirate through a closed loop canister. Standard liposuction can be performed and resulting debris is filtered through a 75-μm mesh sieve. The Puregraft 250 system (Cytori Therapeutics, San Diego, Calif.)[13] is a passive filtration system that similarly uses a lactated Ringer washing base step. Lipoaspirate can be harvested through handheld syringe or machine-assisted suction. The collection bag in this system is a double-layer mesh filter with the inner mesh being 50 μm and the outer mesh being 1000 μm. Graft preparation by centrifugation is the most commonly studied in the literature and has been varied by both time and speed. The method used in this study is similar to that described by Coleman[1] of 3000 revolutions per minute for 3 minutes. With either of the filtration devices, intact lobules of graft are preserved and smaller debris is filtered to the waste canister while centrifugation effectively separates the components by density.

We previously performed a prospective, randomized time and motion study comparing the operative outcomes of three commonly used processing techniques.[14] There was significant difference in the rate of processing the tissue graft in each system, favoring the active filtration device. The purpose of the current study is to compare short-term and 1-year clinical outcomes of the three commonly used systems for graft preparation. Our hypothesis was that preparation with centrifugation will have higher rates of fat necrosis and additional grafting compared with the devices that include washing and filtration.

## PATIENTS AND METHODS

### Study Design

The authors conducted a randomized, prospective parent study to compare outcomes in processing techniques for fat grafting.[14] The protocol was approved by the authors' institutional review board (P2015-0006) as well as the Clinical Oncology Research system (CORe) and registered with the U.S. National Library of Medicine at ClinicalTrials.gov (no. NCT02677012). The parent study was designed, and therefore powered, to identify a difference in rate of processing the adipose graft among the three study arms.[15] Overall, 46 participants were included: 15 per arm with one who failed final screening. Exclusion criteria were age younger than 18 years, inability to give consent, active chemotherapy or cancer treatment, pregnancy, body mass index less than 18, or lacking an anticipated minimum volume of 100 mm of lipoaspirate.

Consecutive patients were stratified by a core group of participating surgeons and randomized by technique 1:1:1 for each arm. Once the eligible participant was registered with the CORe system, CORe randomly assigned the patient to one of three fat grafting techniques using one of five surgeon blocks as the allocation stratum.

Patient information collected included age, body mass index, previous medical and surgical history, oncologic history including tumor characteristics, surgery, chemotherapy or irradiation, and reconstructive characteristics. Follow-up information included early complications such as seroma or hematoma diagnosed on examination or ultrasound but not necessarily requiring drainage or cellulitis of the donor or recipient site treated with antibiotics within 30 days after grafting. Long-term outcomes included any palpable mass appreciated on physical examination persistent for more than 3 months, contour irregularity noted by physical examination and persistent for more than 3 months, fat necrosis identified by imaging (mammography or ultrasound), other radiographic abnormality such as calcifications or oil cyst, need for tissue biopsy in the grafted breast, or development of cancer in the grafted breast. Contour irregularity was a subjective assessment made by the plastic surgeon at the follow-up visits. It is proposed by Delay and colleagues[2] that "steady state" volume and contour effects of grafting are achieved by approximately 3 months and therefore "persistent" contour irregularity referred to a difference in the contour of the area grafted that was present beyond 3 months when we would expect soft-tissue edema to resolve postoperatively. This was most commonly a contracted scar or upper pole step-off deformity that did not fully improve with grafting. In reference to the donor site, this refers to a contour irregularity from the liposuction that was present more than 3 months postoperatively, again when we would expect to see the resolution of tissue edema from the procedure. Additional grafting procedures that occurred in the follow-up period were recorded.

### Statistical Methods

Descriptive statistics, such as means and standard deviations, were used to summarize continuous variables. Frequency counts and percentages were used for categorical variables. One-way analysis of variance was applied to evaluate the difference of age and body mass index among the three groups. Kruskal-Wallis tests were used to compare the tumor size and volume injected to breasts. Post hoc comparisons were performed to identify individual groups. The Tukey studentized range (honestly significant difference) test was used to adjust multiple comparisons. The chi-square or Fisher exact test was employed to assess the associations between oncologic characteristics, procedures, autologous fat grafting procedure, and postoperative complications and the techniques. Univariate logistic regression model was used to estimate the effect of techniques and clinical factors on probability of fat necrosis. The Hosmer and Lemeshow test was performed to examine the goodness of fit for the logistic regression model. The area under the receiver operating characteristic curve was used to evaluate the predictive probability. All significance tests were two-sided and $p$ value less than 5 percent was considered statistically significant. All data analyses were performed using SAS 9.4 software (SAS Institute, Cary, N.C.).

## RESULTS

### Patient Characteristics

A total of 46 patients were enrolled in the parent study.[14] Fifteen were randomized to active filtration, 15 were randomized to passive filtration, and 16 were randomized to centrifugation, with one failing the initial screen. There were no statistical differences in patient characteristics among the three groups (Table 1). All patients were women who had undergone fat grafting for reconstruction related to breast cancer. Their mean age was 54 ± 10 years and their mean body mass index was 28.6 ± 4.1 kg/m². There were similar rates of tobacco use and comorbidities. All patients were treated previously for breast cancer. The most common diagnosis of participants was ductal carcinoma in situ (40.9 percent), with an average overall tumor size of 1.9 ± 2.1 cm. There was no difference in histology, stage, or tumor location among the processing groups (Table 2).

### Surgical Characteristics

Reconstructive characteristics are summarized in Table 3 and analysis was performed on the breast level. The majority of patients had previously undergone mastectomy with two-stage reconstruction. Just over half had definitive autologous reconstruction (53 percent) and only five patients had breast-conserving therapy including whole breast irradiation (7.6 percent). Regarding the fat grafting procedures (Table 4), operations

**Table 1. Patient Characteristics by Technique and Overall Intention-to-Treat Population***

| Variable | All ($n$ = 46) | Active Filtration System ($n$ = 15) | Passive Filtration System ($n$ = 15) | Centrifugation ($n$ = 16) | $p$ |
|---|---|---|---|---|---|
| Age at AFG, yrs | 54.0 ± 10.10 | 55.5 ± 10.2 | 52.7 ± 11 | 53.9 ± 9.6 | 0.79 |
| BMI, kg/m² | 28.6 ± 4.1 | 30.2 ± 4.3 | 28.4 ± 3.3 | 27.2 ± 4.3 | 0.03† |
| Race | | | | | 0.45 |
| White | 33 (71.7) | 10 (66.7) | 11 (73.3) | 12 (75) | |
| Black | 6 (13) | 4 (26.7) | 1 (6.7) | 1 (6.3) | |
| Hispanic | 7 (15.2) | 1 (6.7) | 3 (20) | 3 (18.8) | |
| Tobacco use | | | | | 0.21 |
| Never | 36 (78.3) | 10 (66.7) | 12 (80) | 14 (87.5) | |
| Current | 1 (2.2) | 0 (0) | 0 (0) | 1 (6.3) | |
| Former | 9 (19.6) | 5 (33.3) | 3 (20) | 1 (6.3) | |
| Comorbidity | 27 (58.7) | 11 (73.3) | 9 (60) | 7 (43.8) | 0.25 |
| DM | 3 (6.5) | 2 (13.3) | 1 (6.7) | 0 (0) | 0.30 |
| HTN | 15 (32.6) | 7 (46.7) | 6 (40) | 2 (12.5) | 0.08 |
| Cardiac | 13 (28.3) | 7 (46.7) | 5 (33.3) | 1 (6.3) | 0.03† |
| Pulmonary | 2 (4.3) | 1 (6.7) | 0 (0) | 1 (6.3) | 1.000 |
| Digestive | 11 (23.9) | 4 (26.7) | 3 (20) | 4 (25) | 1.000 |

AFG, autologous fat grafting; BMI, body mass index; DM, diabetes mellitus; HTN, hypertension.
*Values are expressed as mean ± SD or $n$ (%).
†Statistically significant.

**Table 2. Summary of Oncologic Characteristics per Breast by Technique***

| Variable | All (*n* = 66) | Active Filtration System (*n* = 20) | Passive Filtration System (*n* = 21) | Centrifugation (*n* = 25) | *p* |
|---|---|---|---|---|---|
| Histology | | | | | 0.47 |
| IDC | 23 (34.8) | 5 (25) | 8 (38.1) | 10 (40) | |
| DCIS | 27 (40.9) | 12 (60) | 7 (33.3) | 8 (32) | |
| ILC | 4 (6.1) | 2 (10) | 1 (4.8) | 1 (4) | |
| Mixed | 7 (10.6) | 1 (5) | 3 (14.3) | 3 (12) | |
| LCIS | 4 (6.1) | 0 (0) | 1 (4.8) | 3 (12) | |
| Other | 1 (1.5) | 0 (0) | 1 (4.8) | 0 (0) | |
| Stage | | | | | 0.34 |
| 0 | 30 (45.5) | 5 (25) | 12 (57.1) | 13 (52) | |
| 1 | 8 (12.1) | 2 (10) | 2 (9.5) | 4 (16) | |
| 2 | 16 (24.2) | 8 (40) | 4 (19) | 4 (16) | |
| 3 | 12 (18.2) | 5 (25) | 3 (14.3) | 4 (16) | |
| Location | | | | | 0.82 |
| UOQ | 22 (33.3) | 6 (30) | 6 (28.6) | 10 (40) | |
| UIQ | 20 (30.3) | 5 (25) | 7 (33.3) | 8 (32) | |
| LOQ | 5 (7.6) | 2 (10) | 2 (9.5) | 1 (4) | |
| LIQ | 2 (3) | 1 (5) | 0 (0) | 1 (4) | |
| Multicentric | 3 (4.5) | 2 (10) | 0 (0) | 1 (4) | |
| Upper central | 3 (4.5) | 0 (0) | 1 (4.8) | 2 (8) | |
| Lower central | 11 (16.7) | 4 (20) | 5 (23.8) | 2 (8) | |
| Chemotherapy | 31 (47) | 12 (60) | 10 (47.6) | 9 (36) | 0.28 |
| Radiation | 20 (30.3) | 9 (45) | 4 (19) | 7 (28) | 0.19 |
| *BRCA* | 12 (18.2) | 6 (30) | 0 (0) | 6 (24) | 0.03† |
| Tumor size, cm | 1.5 (0–8.9) | 2 (0–8.9) | 1.5 (0–7.5) | 0.8 (0–8) | 0.34 |

AFG, autologous fat grafting; DCIS, ductal carcinoma in situ; IDC, invasive ductal carcinoma; ILC, invasive lobular carcinoma; LCIS, lobular carcinoma in situ; LIQ, lower inner quadrant; LOQ, lower outer quadrant; UIQ, upper inner quadrant; UOQ, upper outer quadrant.
*Values are expressed as *n* (%) or median (range).
†Statistically significant.

**Table 3. Summary of Oncologic Procedure per Breast by Technique***

| Characteristic | All (*n* = 66) | Active Filtration System (*n* = 20) | Passive Filtration System (*n* = 21) | Centrifugation (*n* = 25) | *p* |
|---|---|---|---|---|---|
| Side | | | | | 0.71 |
| Left | 46 (69.7) | 15 (75) | 15 (71.4) | 16 (64) | |
| Right | 20 (30.3) | 5 (25) | 6 (28.6) | 9 (36) | |
| Breast conservation | 5 (7.6) | 2 (10) | 1 (4.8) | 2 (8) | 0.86 |
| Mastectomy | 61 (92.4) | 18 (90) | 20 (95.2) | 23 (92) | 0.86 |
| Prophylactic | 22 (33.3) | 6 (30) | 6 (28.6) | 10 (40) | 0.67 |
| Reconstruction | | | | | |
| Oncoplastic | 5 (7.6) | 2 (10) | 1 (4.8) | 2 (8) | 0.86 |
| TE/implant | 25 (37.9) | 5 (25) | 7 (33.3) | 13 (52) | 0.16 |
| ADM | 24 (36.4) | 5 (25) | 6 (28.6) | 13 (52) | 0.12 |
| Autologous | 34 (51.5) | 12 (60) | 12 (57.1) | 10 (40) | 0.34 |

ADM, acellular dermal matrix; AFG, autologous fat grafting; DIEP, deep inferior epigastric perforator; TE, tissue expander; TRAM, transverse rectus abdominus myocutaneous.
*Values are expressed as *n* (%).

were more commonly bilateral and performed with additional procedures. The average volume injected per breast was 89.7 ± 63.9 ml with slightly less in the centrifugation cohort (96.8 ml active filtration versus 99.8 ml passive filtration versus 75.7 ml centrifugation; $p = 0.44$). The majority of cases were performed with other procedures, commonly scar revision, contralateral mastopexy for symmetry, or tissue expander to implant exchange.

### Complications and Long-term Outcomes

The overall complication rate was 12.1 percent, all of which was fat necrosis, with similar incidence among the processing techniques (Table 5; 15 percent active filtration versus 14.3 percent passive filtration versus 8 percent centrifugation; $p = 0.72$). There was no occurrence of cellulitis, hematoma, or seroma within 30 days of grafting. There was no occurrence of locoregional recurrence, metastatic disease, or development of new cancer (invasive or in situ) during the study period. More than one-third of patients had persistent contour irregularity at the breast level (40 percent active filtration versus 38.1 percent passive filtration versus 36 percent centrifugation; $p = 0.3$) with statistically similar rates of additional fat grafting (20 percent active filtration versus 14.3 percent

**Table 4. Summary of Autologous Fat Grafting Procedure per Breast by Technique***

| Characteristic | All | Active Filtration System ($n$ = 20) | Passive Filtration System ($n$ = 21) | Centrifugation ($n$ = 25) | $p$ |
|---|---|---|---|---|---|
| Unilateral AFG† | 26 (39.4) | 10 (50) | 9 (42.9) | 7 (28) | 0.30 |
| Bilateral AFG | 40 (60.6) | 10 (50) | 12 (57.1) | 18 (72) | 0.30 |
| Previous AFG | 17 (25.8) | 2 (10) | 6 (28.6) | 9 (36) | 0.13 |
| Donor site | | | | | |
| Abdomen/flanks | 52 (78.8) | 16 (80) | 19 (90.5) | 17 (68) | 0.17 |
| Thigh | 45 (68.2) | 13 (65) | 14 (66.7) | 18 (72) | 0.87 |
| Buttocks | 2 (3) | 0 (0) | 0 (0) | 2 (8) | 0.33 |
| Additional procedures | | | | | |
| TE implant or exchange | 12 (18.2) | 3 (15) | 0 (0) | 9 (36) | 0.004‡ |
| Mastopexy | 19 (28.8) | 5 (25) | 6 (28.6) | 8 (32) | 0.88 |
| Scar revision | 52 (78.8) | 17 (85) | 19 (90.5) | 16 (64) | 0.09 |
| Other | 20 (30.3) | 6 (30) | 9 (42.9) | 5 (20) | 0.24 |
| AFG volume, ml | | | | | |
| Total procedure | 112 (33–385) | 109.5 (60–265) | 114 (60–385) | 112 (33–260) | 0.79 |
| Per breast | 77 (17–385) | 108 (17–215) | 75 (30–385) | 70 (25–150) | 0.44 |

AFG, autologous fat grafting; TE, tissue expander.
*Values are expressed as $n$ (%) or median (range).
†Unilateral autologous fat grafting to the cancer-affected breast.
‡Statistically significant.

**Table 5. Summary of Postoperative Complications per Breast by Technique***

| Complication | All ($n$ = 66) | Active Filtration System ($n$ = 20) | Passive Filtration System ($n$ = 21) | Centrifugation ($n$ = 25) | $p$ |
|---|---|---|---|---|---|
| Any | 8 (12.1) | 3 (15) | 3 (14.3) | 2 (8) | 0.72 |
| Hematoma | 0 (0) | 0 (0) | 0 (0) | 0 (0) | — |
| Seroma | 0 (0) | 0 (0) | 0 (0) | 0 (0) | — |
| Cellulitis | 0 (0) | 0 (0) | 0 (0) | 0 (0) | — |
| Fat necrosis | 8 (12.1) | 3 (15) | 3 (14.3) | 2 (8) | 0.72 |
| Palpable mass | 7 (10.6) | 2 (10) | 3 (14.3) | 2 (8) | 0.88 |
| Contour change | | | | | |
| Breast | 25 (37.9) | 8 (40) | 8 (38.1) | 9 (36) | 0.30 |
| Donor site | 1 (1.5) | 1 (5) | 0 (0) | 0 (0) | 0.35 |
| Recurrence | 0 (0) | 0 (0) | 0 (0) | 0 (0) | |
| Metastasis | 0 (0) | 0 (0) | 0 (0) | 0 (0) | |
| New cancer | 0 (0) | 0 (0) | 0 (0) | 0 (0) | |
| Additional AFG | 15 (22.7) | 4 (20) | 3 (14.3) | 8 (32) | 0.35 |

AFG, autologous fat grafting.
*Values are expressed as $n$ (%).

**Table 6. Univariate Analysis of Probability of Fat Necrosis in All Processing Groups Combined***

| Variable | No Fat Necrosis ($n$ = 58) | Fat Necrosis ($n$ = 8) | $p$ |
|---|---|---|---|
| Processing technique | | | 0.715 |
| System active filtration | 17 (85) | 3 (15) | |
| System passive filtration | 18 (85.7) | 3 (14.3) | |
| Centrifugation | 23 (92) | 2 (8) | |
| Chemotherapy | 28 (90.3) | 3 (9.7) | 0.713 |
| Radiation therapy | 17 (85) | 3 (15) | 0.690 |
| Oncologic surgery | | | 0.011† |
| Breast conservation | 2 (40) | 3 (60) | |
| Mastectomy | 56 (91.8) | 5 (8.2) | |
| Prophylactic | 21 (95.5) | 1 (4.5) | 0.252 |
| Reconstruction | | | |
| Oncoplastic | 2 (40) | 3 (60) | 0.020† |
| TE/implant | 24 (96) | 1 (4) | 0.143 |
| ADM | 23 (95.8) | 1 (4.2) | 0.241 |
| Autologous (any flap) | 30 (88.2) | 4 (11.8) | 1.000 |
| Mastopexy | 14 (73.7) | 5 (26.3) | 0.038† |
| Total grafted volume, ml | 111 (33–385) | 130 (75–150) | 0.694 |
| Breast grafted volume, ml | 71 (17–385) | 87.5 (50–130) | 0.330 |

ADM, acellular dermal matrix; TE, tissue expander.
*Values are expressed as $n$ (%) or median (range).
†Statistically significant.

passive filtration versus 32 percent centrifugation; $p$ = 0.35). Univariate analysis of fat necrosis demonstrates significantly higher probability with breast-conserving therapy including irradiation, oncoplastic surgery, or mastopexy irrespective of processing technique (Table 6).

## DISCUSSION

This is the first prospective, randomized comparison of two commonly used closed-system devices and centrifugation for preparation of lipoaspirate for autologous fat grafting. Despite different means of purifying the tissue graft, there was no statistical difference in rates of fat necrosis, residual contour deformity, or additional grafting. However, we demonstrate a higher probability of fat necrosis with breast-conserving therapy, oncoplastic reconstruction, or mastopexy regardless of processing technique.

The indications and procedural volume of fat grafting cases continue to increase, particularly in oncologic reconstruction[16–18]; however, there is no evidence to suggest one technique is clinically better than others.[19] This may be attributable in part to inconsistency in outcome measures, length of follow-up, and reporting. Particularly in breast reconstruction, average complication rates reported are 8.4 percent (95 percent CI, 7.6 to 9.1 percent), most commonly cyst or fat necrosis.[20] Although these outcomes are generally considered benign, any breast abnormality in a patient previously treated for breast cancer may cause stress and lead to additional imaging or biopsy.[17,21–23] Thus, our long-term research goal is to determine optimal techniques and establish best practices to improve outcomes of autologous fat grafting in breast reconstruction.

Rates of fat necrosis in the setting of breast-conserving therapy with more than 6 years follow-up are comparable, with or without fat grafting.[17] This similarity is likely attributable to the changes that occur with any procedure that alters the parenchyma as in reduction mammoplasty, mastopexy, or lumpectomy.[24,25] In the current study, our data demonstrate higher probability of fat necrosis with breast-conserving therapy and parenchymal reshaping procedures including oncoplastic reconstruction or revision mastopexy. Thus, in counseling patients, we know breast conservation has a higher likelihood of fat necrosis of the breast related to the combination of lumpectomy surgery and irradiation. It is important to discuss any fat necrosis before grafting that may have resulted from oncologic treatment.

There was no difference in rates of fat necrosis in the setting of irradiation in the current study; however, these data should be scrutinized more thoroughly, particularly in participants who underwent mastectomy. There were no participants in any cohort who had implant-based reconstruction followed by postmastectomy irradiation, nor were there patients with autologous breast reconstruction who then underwent irradiation. This is a reflection of the authors' overall practice favoring autologous reconstruction, especially when radiation treatment is indicated. Although irradiation did not correlate with increased risk of fat necrosis in subsequent fat grafting, all patients in this study who had mastectomy followed by postmastectomy irradiation underwent autologous breast reconstruction. This means that after mastectomy, adipose graft was delivered to a vascularized recipient bed in the autologous tissue flap. Any fat grafting that occurred in the setting of implant-based reconstruction was to nonirradiated mastectomy skin flaps, pointing to the value of a well-vascularized recipient bed in mitigating ischemia in fat grafting outcomes. We can conclude, however, that alloplastic reconstruction including the use of acellular dermal matrix does not carry additional risk of fat necrosis in the absence of breast irradiation regardless of processing technique.

The majority of retrospective studies available include centrifugation or decanting as the processing technique.[2,4,18,20,26–28] As the popularity of autologous fat grafting expands, numerous methods of harvesting, processing, and reinjecting fat have evolved, most notably devices or systems to streamline the process.[29] Few studies have evaluated the outcomes specific to tissue processing technique. A recent retrospective review compared clinical outcomes in fat grafting cases to the breast among centrifugation, Telfa rolling (in which the tissue is gently rolled along a gauze sponge to remove fluid), and Revolve (or the active filtration system employed in this study).[30] The study included 267 cases with 12-month follow-up and found overall complication rates were highest in the centrifugation group, at 25.6 percent, compared with 4.5 percent with Telfa and 10.9 percent with the Revolve filtration system ($p = 0.001$); rates of fat necrosis were similar and oil cysts accounted for the difference. The average volume of fat injected was significantly higher in the Revolve group (160 ml) compared with Telfa (120 ml) and centrifugation (70 ml). The authors' multivariate analysis found more "adverse events" with higher graft volume and centrifugation technique. Although our data show less volume of graft per breast with the centrifugation group (75 ml) compared with active filtration (99.5 ml) and passive filtration (96 ml), this did not achieve statistical significance. Overall, the volume of graft and processing technique did not have an effect on rates of fat necrosis in our prospective study.

Although our study was prospective with randomized study cohorts, the primary limitation is the sample size. The source time and motion study was powered to demonstrate a statistical difference in techniques based on time and motion methodology and clearly favored the active filtration system.[14] Given that reported rates of fat necrosis are low in autologous fat grafting, one would need to enroll nearly 1000 patients to achieve adequate statistical power to demonstrate a significant difference. Although the focus of this study was objective clinical outcomes, another limitation may be the lack of a validated patient-reported outcome survey. The authors believed that because there are no patient-reported outcomes specific to fat grafting, the BREAST-Q elements would be confounded by the fact that the majority of the participants in this study had grafting included with additional reconstructive procedures such as scar revision or tissue expander to implant exchange. Finally, we did not include specific volumetric analysis in this study. Graft retention is attributed to graft purity, recipient site preparation, optimal delivery technique, and ischemia.[31–34] Furthermore, graft retention is reported as ranging from 20 to 90 percent[8]; however, there are no reliable methods to quantify graft volume over time and most studies lack adequate follow-up to demonstrate long-term volume changes. For this reason, the authors included clinically relevant outcomes of complications and additional grafting. Optimal detection of graft volume and breast shape over time are under investigation at our institution.

## CONCLUSIONS

This is the first randomized prospective study of autologous fat grafting for oncologic breast reconstruction to compare techniques to process lipoaspirate. The authors found no statistical difference in complications or fat necrosis among centrifugation, an active filtration device (Revolve), or a passive filtration system (Puregraft 250). Instead, the data demonstrate a significantly higher probability of fat necrosis with breast-conserving therapy, including irradiation, oncoplastic surgery, or revision mastopexy.

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## ACKNOWLEDGMENTS

*This is an investigator-initiated study funded in part by the University of Texas M. D. Anderson Cancer. The parent study was sponsored in part by LifeCell Corporation, Inc. (Branchburg, N.J.).*

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