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Is Unilateral Implant or Autologous Breast Reconstruction Better in Obtaining Breast Symmetry?

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Abstract: Unilateral breast reconstruction poses a special set of challenges to the reconstructive breast surgeon compared to bilateral reconstructions. No studies to date provide an objective comparison between autologous and implant based reconstructions in matching the contralateral breast. This study compares the quantitative postoperative results between unilateral implant and autologous flap reconstructions in matching the native breast in shape, size, and projection using three-dimensional (3D) imaging. Sixty-four patients who underwent unilateral mastectomy with tissue expander (TE)-implant ($n = 34$) or autologous microvascular free transverse rectus abdominus myocutaneous (TRAM; $n = 18$) or deep inferior epigastric artery perforator (DIEP; $n = 12$) flap ($n = 30$) reconstruction from 2007 to 2010 were analyzed. Key patient demographics and risk factors were collected. Using 3D scans of patients obtained during pre and postoperative visits including over 1 year follow-ups for both groups, 3D models were constructed and analyzed for total breast volume, anterior-posterior projection from the chest wall, and 3D comparison. No significant differences in mean age, body mass index, or total number of reconstructive surgeries were observed between the two groups (TE-implant: 52.2 ± 10, 23.9 ± 3.7, 3 ± 0.9; autologous: 50.7 ± 9.4, 25.4 ± 3.9, 2.9 ± 1.3; $p > 0.05$). The total volume difference between the reconstructed and contralateral breasts in the TE-implant group was insignificant: 27.1 ± 22.2 cc, similar to the autologous group: 29.5 ± 24.7 cc, as was the variance of breast volume from the mean. In both groups, the reconstructed breast had a larger volume. A-P projections were similar between the contralateral and the reconstructed breasts in the TE-implant group: 72.5 ± 3.21 mm versus 71.7 ± 3.5 mm ($p > 0.05$). The autologous reconstructed breast had statistically insignificant but less A-P projection compared to the contralateral breast (81.9 ± 16.1 mm versus 61.5 ± 9.5 mm; $p > 0.05$). Variance of A-P projection from the mean was additionally insignificant between the contralateral and reconstructed breasts. Both groups produced similar asymmetry scores based on global 3D comparison (TE-implant: 2.24 ± 0.3 mm; autologous: 1.96 ± 0.2 mm; $p > 0.05$). Lastly, when the autologous group was further subdivided into TRAM and DIEP cohorts, no significant differences in breast volume, A-P projection or symmetry existed. Using 3D imaging, we demonstrate that both TE-implant and autologous reconstruction can achieve symmetrical surgical results with the same number of operations. This study demonstrates that breast symmetry, while an important consideration in the breast reconstruction algorithm, should not be the sole consideration in a patient' decision to proceed with autologous versus TE-implant reconstruction. ■

Key Words: 3D imaging, autologous reconstruction, breast projection, breast reconstruction, breast symmetry, breast volume, DIEP, implant, tissue-expander, TRAM, unilateral reconstruction

Post-mastectomy breast reconstruction has been shown to improve patient body image and self-esteem leading to better overall psychologic well-being and quality of life (1–3). More women with breast cancer are electing to undergo breast reconstruction today. In fact, more than 90,000 women underwent breast reconstruction in 2011, an increase of 22% since 2000 (4). The decision as to which reconstructive strategy to undertake is an individualized and personal decision dependent on myriad factors. Patient desires, comorbidities, surgical history, prior radiation, body habitus, and the surgeon preference all play a role in the decision-making algorithm (5). Surgical approaches to breast reconstruction employ autologous free or pedicle tissue transfer, prosthetic breast reconstruction with tissue expanders (TE) and implants, or a combination of both.

Many surgeons believe that compared with implant-based reconstruction, autologous reconstruction eliminates the need for alloplastic materials, creating a breast that feels and appears more natural, responds to weight changes, and better retains shape and volume in the face of radiation therapy (6).

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Others, however, advocate for the use of implant-based reconstructions with shorter operating times, no additional donor site morbidity, and faster recovery times.

Plastic surgery outcomes studies typically evaluate satisfaction, complications, or aesthetic results as markers for surgical success (7, 8). Such studies comparing post-mastectomy autologous versus implant breast reconstruction have demonstrated equivocal results. Tzafetta et al. reported no significant difference in patient satisfaction or aesthetic scores between patients who underwent autologous versus TE/implant reconstruction (9), findings corroborated by several other investigations (10, 11). On the other hand, other studies have shown greater patient satisfaction and aesthetic results with autologous-based reconstruction compared to prosthetic reconstruction. For example, in the Michigan Breast Reconstruction Outcome Study, Alderman et al. reported 78% of transverse rectus abdominus myocutaneous (TRAM) patients were generally satisfied compared with 61% of expander/implant patients, and that "aesthetic satisfaction" was 75% for TRAM patients compared to 40% of prosthetic reconstruction patients (12–14). Moreover, in a recent publication by Craft et al., patients undergoing unilateral breast reconstruction demonstrated higher patient satisfaction with autologous compared to implant reconstruction (15); a result substantiated by Yueh et al. (16). These conflicting findings necessitate a more quantitative method for evaluation of post-mastectomy breast reconstruction outcomes.

Unilateral breast reconstruction presents both the surgeon and the patient with a great challenge. For the surgeon, creating a breast matching in shape, size, projection, feel, and movement is difficult, even with a full armamentarium of implant choices and expertise in implant and free flap reconstruction. For the patient undergoing unilateral breast reconstruction, the contralateral breast serves as a daily reminder of the ablative treatment she received due to her breast cancer.

There are limited studies that quantitatively compare postoperative size, shape, contour, and symmetry following breast reconstruction. Recent work from our group and others has demonstrated the utility of three-dimensional (3D) breast imaging to obtain well-established breast measurements, as well as guide operative planning, analyze surgical results, and document postoperative changes over time (17–22).

This study reports the application of 3D breast imaging to compare the postoperative results of unilateral prosthetic or autologous flap reconstruction in matching contralateral breast volume, shape, and overall symmetry. The study aims to quantitatively measure the symmetry of the reconstructed breast to the contralateral breast.

MATERIALS AND METHODS

Patient Enrollment

Patients undergoing unilateral TE-implant or autologous microvascular free flap (TRAM flap and deep inferior epigastric artery perforator flap [DIEP]) reconstruction by one of two senior authors (MC, NK) were offered enrollment into the study. Informed consent was obtained in accordance with the guidelines set forth by the New York University Medical Center Institutional Review Board.

A complete series of 3D images were obtained between 2007 and 2010 of 64 patients: 34 TE-implant reconstructions and 30 autologous free TRAM (n = 18)/DIEP (n = 12) reconstructions. Key demographic information was collected for each patient including age, body mass index (BMI), smoking, and history of radiation. The total number of reconstructive surgeries each patient underwent during the reconstructive period was additionally documented. As per our group's standard practice, patients were excluded from the study if they did not undergo preoperative imaging or if they had less than 1 year total postoperative follow-up. In addition, patients who underwent direct implant reconstruction were excluded.

3D Scans

Three-dimensional scans were obtained at each postoperative visit using a previously validated Canfield Vectra scanner (19). The lens of the camera was placed 3 feet from the patient at the level of the breasts, and scans obtained with the patient facing +90, +45, 0, −45, and −90 degrees. The camera was then lowered to knee-level to obtain inferior views at the aforementioned positions. Each scan converted the surface shape to a polygon lattice of approximately 300,000 points. The polygons from each view were then merged by region to create a single 3D model. 3D models were exported for analysis using Geomagic software (Geomagic, Morrisville, NC).

Breast Volume Measurement

Total breast volume was calculated for every patient at each postoperative visit according to our group's previously described protocols. Each breast was isolated and overlaid on a customized chest wall template for each patient. First, the chest wall template, a curved plane that matches the curvature of the patient's torso with the breasts removed, was created. This was done by tracing the breast superiorly at the level at which it projects off the chest, then laterally with inclusion of the axillary tail, inferiorly to the inframammary fold, and medially. This breast tissue was removed to yield the chest wall template. The complete volume of each breast was subsequently determined by overlaying the previously isolated breast onto the chest wall and creating a closed 3D object. A software-based Boolean operation of the two overlapping images was performed, and calculating the volume of this closed object determined breast volume. Total breast volume of the reconstructed breast and contralateral, native breast were calculated at each postoperative visit.

Breast Projection Measurement

Breast projection, or anterior-posterior projection, was additionally determined at each postoperative visit. A-P projection was calculated by creating a vector that originated from the chest wall template and extended anteriorly to the "A" point, or anterior-most point of each breast, giving the maximal projection of the breast in millimeters. Like breast volume, A-P projection was measured for the reconstructed breast and contralateral, native breast, for each postoperative image throughout the course of reconstruction (Fig. 1).

Breast Symmetry

At the end of each patient's reconstructive treatment, the reconstructed breast was compared to the contralateral, native breast to determine overall breast symmetry. By creating a mirror image of the reconstructed breast and overlaying it onto the contralateral breast, the Geomagic software global 3D compare function calculated the average deviation between points and generated topographical maps representing these average deviations. These deviations were then analyzed and a symmetry score calculated (Fig. 2).

Statistical Analysis

All data are presented as the mean ± SEM. Each reconstructed breast was compared to the contralateral breast for every postoperative visit. Paired *t*-test was used to assess for statistical significance between means. In addition, a two-sample *f*-test was used to compare variances from the mean of total breast volume and A-P projection measurements in the TE-implant and autologous reconstruction groups. A p-value less than 0.05 determined statistical significance.

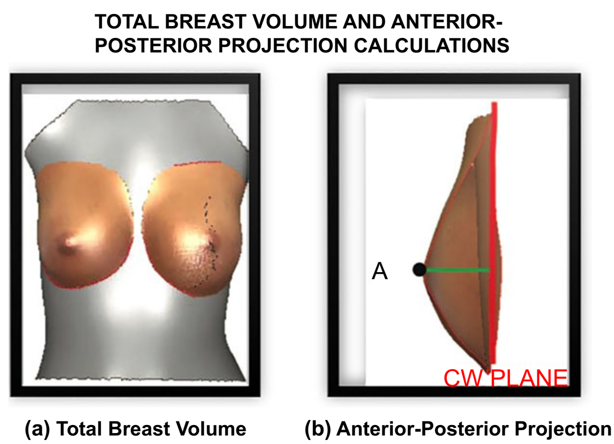

Figure 1. Breast volume and projection. (a) Breast Volume: Each breast is isolated and overlaid on a customized chest wall template to calculate breast volume. (b) Anterior-Posterior Projection: Anterior-posterior breast projection is measured by creating a vector that extends from the chest wall (C-W plane) to the anterior-most point of the breast (A-point).

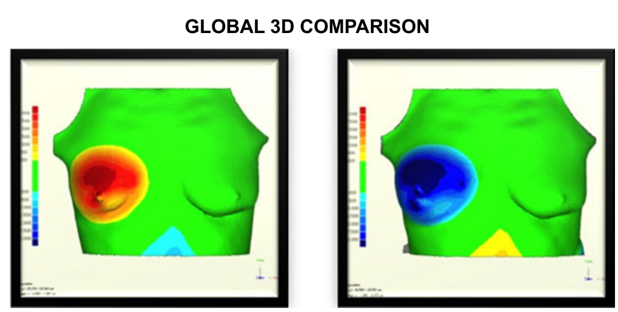

Figure 2. Global 3D compare. The global 3D compare function creates a topographical map of the reconstructed and non-reconstructed breast, which are compared in their derivation from one another. In the figure, red denotes the negative direction and blue the positive direction.

RESULTS

Patient Demographics

The TE-implant and autologous reconstruction groups exhibited no significant differences in mean age, BMI, or total number of reconstructive surgeries. The average age of patients undergoing unilateral TE-implant and autologous breast reconstruction was 52.2 ± 10.0 years versus 50.7 ± 9.4 years, respectively ($p = 0.54$). Average BMI was 23.9 ± 3.7 in the TE-implant group and 25.4 ± 3.9 in the autologous group ($p = 0.12$). Twelve percent of patients had a history of smoking in the TE-implant group versus 16.6% in the autologous group ($p = 0.49$). Moreover, 5.9% of patients had a history of radiation therapy in the TE-implant group versus 33.3% in the autologous reconstruction group ($p < 0.05$; Table 1). Postoperative analysis was performed on mean postoperative day 469.2 (1 year, 104 days) in the TE-implant group and day 630.2 (1 year, 265 days) in the autologous group ($p = 0.2$). This postoperative date represents the number of days from initial reconstruction.

Interestingly, both reconstructive modalities required an average of three total reconstructive surgeries: TE-implant 3 ± 0.9, autologous 2.9 ± 1.3 ($p = 0.72$), with no statistically significant difference in the timing of the secondary and tertiary reconstructive surgeries between the TE-implant and autologous groups. In the TE group, patients underwent TE-insertion followed by TE-implant exchange with a contralateral symmetrizing procedure (mastopexy, reduction mammoplasty). This secondary reconstructive surgery was performed at mean postop day 162 ± 16.6 from initial TE-insertion. The tertiary procedure often involved nipple reconstruction, scar revision, and in many, fat grafting at an average postop day 311 ± 11 from initial TE-insertion. Of note, implants chosen by the operating surgeon on a case-by-case basis, were all round implants ranging in profile from moderate to high profile (Natrelle Collection; Allergan, Irvine, CA).

Patients in the autologous group generally underwent three surgeries as well. The first surgery involved mastectomy with autologous reconstruction. In the second, nipple reconstruction as well as a contralateral symmetrizing procedure was often performed. This secondary reconstruction was performed at mean postop day 174 ± 22.9. Some patients underwent fat grafting at the time of this second procedure. In a third procedure, many patients underwent fat grafting to increase the volume of the autologous breast. This tertiary procedure took place at mean postop day 322 ± 18.3 from initial autologous reconstruction (Table 2). A summary of the TE-implant and autologous reconstruction patients can be seen in Tables 1 and 2 with corresponding p-values.

Breast Volume Analysis

Both TE-implant and autologous reconstruction were analyzed for their abilities to achieve similar breast volume between the affected, reconstructed breast and the contralateral breast. The total breast volume of patients who underwent unilateral TE-implant reconstruction was 466.3 ± 29 cc in the reconstructed breast and 439.2 ± 24.6 cc in the contralateral breast, of no statistical significance ($p = 0.48$). Similarly, the total breast volume of the affected breast after autologous reconstruction was 460.9 ± 36.2 cc versus 431.3 ± 33.2 cc in the unaffected, unreconstructed breast volume, again of no statistical significance ($p = 0.55$; Fig. 3). In both reconstructive modalities, the reconstructed breast had a larger volume compared to the contralateral, unaffected breast (TE-implant: average of 27.1 ± 22.2 cc

Table 1. Patient Demographics

	TE-implant (n = 34)	Autologous (n = 30)	p-value
Age	52.2 ± 10.0	50.7 ± 9.4	0.54
Body mass index	23.9 ± 3.7	25.4 ± 3.9	0.12
Number of procedures	3.0 ± 0.9	2.9 ± 1.3	0.72
Smoking	4/34 = 12%	5/30 = 16.6%	0.49
Prior radiation	2/34 = 5.9%	10/30 = 33.3%	0.0004

The TE-implant and autologous reconstruction group exhibited no statistically significant differences in mean age, BMI, total number of reconstructive procedures, or smoking history.

Table 2. Timing of Secondary and Tertiary Reconstructive Surgeries

Prosthetic reconstruction	TE-implant (n = 34)	Autologous reconstruction	Autologous (n = 30)	p-value
Secondary reconstructive surgery	162 ± 16.6	Secondary reconstructive surgery	174 ± 22.9	0.66
Tertiary reconstructive surgery	311 ± 11	Tertiary reconstructive surgery	322 ± 11	0.49

The TE-implant and autologous reconstruction groups exhibited no statistically significant difference in timing of secondary and tertiary reconstructive procedures following initial TE or autologous reconstruction.

larger, and autologous: average of 29.5 ± 24.7 cc larger), however, the difference was not statistically significant (p = 0.94; Fig. 4).

When the variances in breast volume, or average of differences from the mean, were analyzed for both the TE-implant and autologous reconstruction groups, no statistically significant difference was identified between the two groups. In the TE-implant group, the variance from the mean was 28,664.9 in the affected breast and 20,493.1 in the unaffected breast (F-value 1.39, F-crit 2.0; p-value 0.33). Similarly, in the autologous group the variance in breast volumes of the affected breast was 39,617.2 compared to 26,448.6 in the unaffected breast (F-value 0.89, F-crit 2.1; p-value 1.23). Therefore, both TE-implant and autologous reconstruction effectively create a breast mound of total volume that matches to that of the contralateral breast.

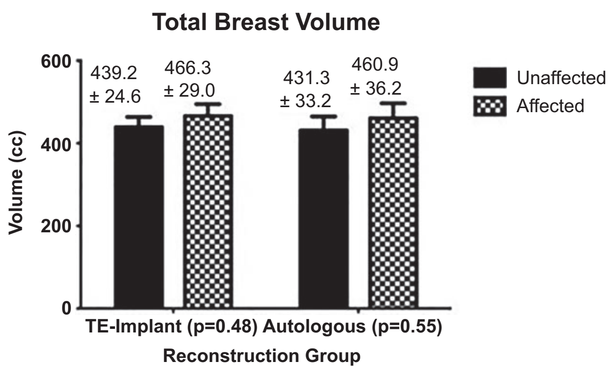

Figure 3. Total breast volume measurements. Both TE-implant and autologous reconstruction effectively create a breast mound of total volume that matches to that of the contralateral breast.

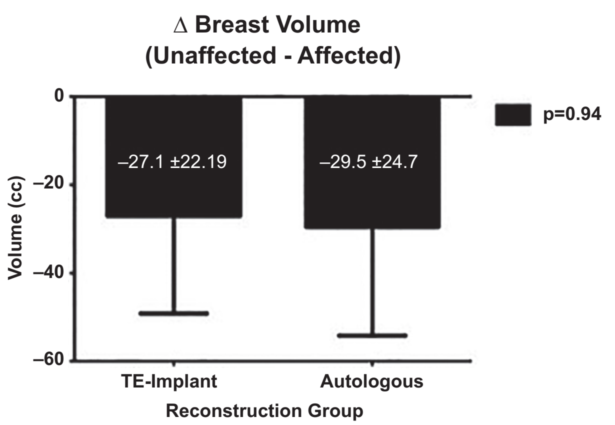

Figure 4. Delta breast volume measurements. In both reconstructive modalities, the reconstructed breast had a larger volume compared to the contralateral, unaffected breast, however, the difference was not statistically significant.

Breast Projection Analysis

Both TE-implant and autologous reconstruction achieved A-P projections that were similar between the unaffected and affected breast. In the TE-implant group, the unaffected breast had an average A-P projection of 71.7 ± 3.5 mm versus 72.5 ± 3.21 mm in the affected, reconstructed breast (p = 0.87). In other words, there was a statistically insignificant difference of 0.8 ± 0.3 mm between the reconstructed and contralateral breast. In the autologous group, while the A-P projection was slightly less in the reconstructed breast, the observation was not statistically significant: unaffected and affected breasts had similar breast projections: 81.9 ± 16.1 mm versus 61.5 ± 9.5 mm, respectively (p = 0.28). The difference in A-P projection between the reconstructed and contralateral breasts was again insignificant: 4.4 ± 1.2 mm (Fig. 5).

Again, when variances of A-P projection from the mean were compared between the two reconstruction groups, no statistically significant difference was identified. In the TE-implant group, the variance of A-P projection from the mean was 349.5 in the affected breast and 412.5 in the unaffected breast (F-value 0.85, F-crit 1.78; p-value 1.36). Similarly, in the autologous group the variance in A-P projections of the affected breast was 538.0 compared to 600.3 in the unaffected breast (F-value 0.89, F-crit 2.1; p-value 1.23). These data suggest that both TE-implant and autologous reconstruction are effective in achieving

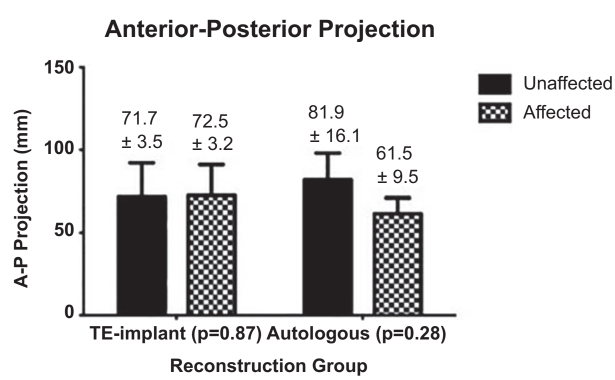

Figure 5. Anterior-posterior projection. Both TE-implant and autologous reconstruction achieved A-P projections that were similar between the unaffected and affected breast.

breast projection that matches the unaffected contralateral breast, with no statistically significant differences among them.

Breast Symmetry

The two reconstructive modalities were compared in their ability to achieve overall symmetry between the unilateral reconstructed breast and contralateral breast. When comparing the topographical map of the two breasts, both TE-implant and autologous reconstruction produced similar results with no statistically significant difference between them (TE-implant: 2.24 ± 0.3 versus autologous: 1.96 ± 0.2; p = 0.41; Fig. 6). This finding suggests that both TE-implant and autologous reconstruction can achieve symmetrical surgical results.

TRAM versus DIEP Reconstruction

The autologous group was further subdivided into TRAM and DIEP subsets and analyzed for any differences in demographics and the aforementioned breast measurements of breast volume, A-P projection, and symmetry. In our analysis of patient demographics, the TRAM group demonstrated significantly longer postoperative follow-up (mean postoperative day 755.3 versus 254.9 (p = 0.03) and involved a younger patient subset (TRAM: 47.7 ± 1.47 years old versus DIEP 55.0 ± 3.3 years old; p = 0.03). Otherwise, no statistically significant differences were seen between the two groups in BMI, history of smoking, or prior radiation. In addition, both TRAM and DIEP subgroups required a total of three reconstructive surgeries (Table 3).

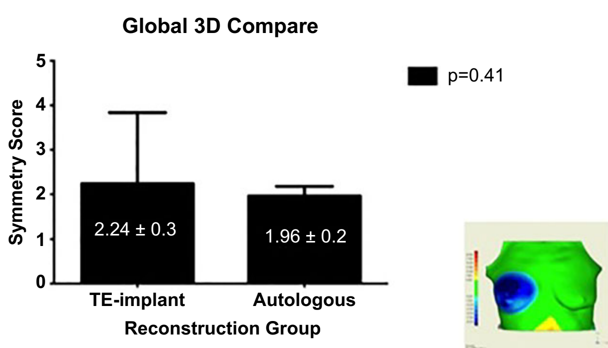

Figure 6. Global symmetry score. Both TE-implant and autologous reconstruction can achieve symmetrical surgical results.

When the two subgroups were analyzed for differences in breast volume, A-P projection, and global symmetry, no statistically significant differences were identified between the reconstructed and contralateral breast (Table 4).

DISCUSSION

With various surgical options for breast reconstruction available to patients today, patient satisfaction reports are increasingly used as corollaries for surgical results. Previous reports have retrospectively examined overall patient satisfaction between autologous and prosthetic reconstruction. One study by Saulis et al. reported a lower patient satisfaction rate among TE-implant patients compared to patients undergoing autologous TRAM flap reconstruction (14). Moreover, a comparative analysis of psychosocial, functional, and cosmetic outcomes of TRAM flap versus implant reconstruction by Cederna et al. reported a greater level of satisfaction in patients who underwent TRAM flap reconstruction specifically relating to the way

Table 3. Autologous Reconstruction Patient Demographics

	TRAM (*n* = 18)	DIEP (*n* = 12)	p-value
Age	47.7 ± 1.5	55.0 ± 3.3	0.03
Body mass index	24.7 ± 0.8	26.4 ± 1.3	0.27
Number of procedures	3 ± 0.3	2.8 ± 0.3	0.73
Smoking	4/18 = 22.2%	1/12 = 8.3%	0.32
Prior radiation	4/18 = 22.2%	6/12 = 50%	0.11

The TRAM versus DIEP autologous reconstruction groups exhibited no statistically significant differences in mean BMI, total number of reconstructive procedures, smoking history, or history of prior radiation. Patients who underwent TRAM reconstruction were younger than patient's undergoing DIEP reconstruction, of statistical significance.

Table 4. A Comparison of TRAM versus DIEP Reconstruction

	TRAM (*n* = 18)	DIEP (*n* = 12)	p-value
Breast volume (cc)			
Affected breast	479.3 ± 41.7	432.9 ± 67.0	TRAM: 0.48
Unaffected breast	439.0 ± 38	422.2 ± 61.5	DIEP: 0.91
Δ breast volume (cc) (affected-unaffected)	42.7 ± 33.3	10.8 ± 37.5	0.54
A-P projection (mm)			
Affected breast	61.5 ± 9.5	55.5 ± 7.7	TRAM: 0.28
Unaffected breast	81.9 ± 16.1	65.9 ± 7.4	DIEP: 0.34
Δ A-P projection (mm)	1.6 ± 2.9	9.3 ± 4.5	0.14
Symmetry score	1.73 ± 0.2	2.29 ± 0.3	0.14

When the TRAM and DIEP subgroups were analyzed for differences in breast volume, A-P projection, and global symmetry, no statistically significant differences were identified between the reconstructed and contralateral breast.

breasts felt to touch as well as overall appearance (23). However, these patients did report increased psychologic, social, and physical impairments resulting from their reconstruction.

While comparing the outcomes of different surgical procedures is valuable, few studies *quantitatively* compare the outcome of TE-implant to autologous breast reconstruction. Using our 3D scanner, we sought to investigate the postoperative results between unilateral prosthetic versus autologous breast reconstruction in matching contralateral breast volume and shape using 3D imaging analysis. Our data demonstrate that both TE-implant and autologous reconstruction effectively create a breast mound of total volume and projection that matches the contralateral breast. Moreover, these symmetrical surgical results are achieved not only with the same number of total operations but also with timing of secondary and tertiary operations similar to achieve final symmetry. In our series, patients in the autologous group were pleased with the effects of fat grafting to both recipient and donor sites performed during the second operation and tended to request the third procedure for further revision, which included fat grafting and scar revision.

Given these results, postoperative symmetry while important in the breast reconstruction algorithm, should not be the only consideration, and the decision as to which reconstructive modality to choose should be based on other clinical parameters.

In terms of the implant types used, we used round silicone implants with high or moderate projection depending on the shape of the contralateral breasts. The form stable implants were not FDA approved during this study period and were not included in the study.

While our data does provide a concrete basis for beginning to assess the outcomes of surgical procedures in a quantitative fashion, more studies need to be performed. For example, this study only examines the postoperative results with 1-year follow-up and therefore does not reflect further changes that the breast may undergo. Thus, we are unable to make definitive statements about the long-term symmetry of the different procedures, or changes in breast appearance over time. Moreover, while 3D imaging does provide us with objective data to compare 3D symmetry, it does not include patient satisfaction, sensibility, or naturalness of the reconstructed breast. Hu et al., for example, evaluated long-term patient-reported aesthetic satisfaction with expander/implant and autologous breast reconstruction. They found that in the long term, TRAM patients when compared with expander/implant patients have significantly greater aesthetic satisfaction (24). However, the parameters of long-term follow and patient satisfaction are outside of the scope of this study.

When considering the great utility that 3D imaging can provide to breast surgery, it is important to realize that this imaging can be used not only for postoperative analysis, but also to guide preoperative planning with the goal of achieving breast symmetry with the least number of operations. The ability of 3D imaging to generate additional measurements of volumetric distribution and breast projection make it a promising method for further elucidating the effectiveness of these reconstructive techniques in achieving breast symmetry.

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