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Breast

Volumetric Symmetry after Unilateral Autologous Breast Reconstruction: A Reasonable Goal

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Background: With growing concerns about the overuse of contralateral prophylactic mastectomy, optimizing unilateral mastectomy reconstruction outcomes becomes a priority. However, there remains a paucity of objective data that describe volumetric symmetry between a natural and autologous-reconstructed breast.
Methods: We evaluated patients who underwent unilateral mastectomy reconstruction with free-flap abdominal tissue transfer from 04/2006 to 01/2015, and had at least 2 postoperative magnetic resonance images (MRIs; n = 28). Using these MRI data, volumetric measurements of the reconstructed and natural breast were performed at the first postoperative MRI (after all revisions were complete) and the most recent MRI. Relationships were analyzed using Spearman correlation coefficients. A symmetry score (SS) was calculated such that values closer to 1.0 reflected volumetric symmetry.
Results: The mean age (years) and BMI of the patients was 44.8 and 26.8, respectively. The mean interval time between the MRIs was 3.03 years (range 0.43–6.6). After surgical revisions were complete, volumetric symmetry between reconstructed and nonreconstructed breasts was typically achieved (mean SS 0.92). This symmetry was also retained at the end of follow-up (mean SS 0.96), despite a mean change in BMI of 3.9% (range 1.1–7.7). Additionally, the mean number of flap revisions was 0.75 (range 0–2), and 39% of patients had a procedure performed on the natural breast.
Conclusion: In patients undergoing unilateral abdominal-based breast reconstruction, volumetric symmetry is attainable; however, it can require flap revisions and procedures to natural breast. Interestingly, this study does show that initial symmetry is retained postoperatively, regardless of changes in BMI. *(Plast Reconstr Surg Glob Open 2019;7:2362; doi: 10.1097/GOX.0000000000002362; Published online 30 September 2019.)*

INTRODUCTION

The proportion of women undergoing breast reconstruction after mastectomy has increased from as low as 8%, in 1995, to 54%, in 2014.[1–4] Increased rates of breast reconstruction have been paralleled by an increased emphasis on patient-reported and objective outcomes following breast reconstruction. While patient satisfaction and clinical outcomes have been thoroughly evaluated in the context of bilateral autologous breast reconstruction, there is a paucity of data which evaluate these parameters with respect to unilateral breast reconstruction.

Approximately 30% of patients undergoing oncologic breast resection will receive a unilateral mastectomy.[1,5] Despite recently increasing rates of contralateral prophylactic mastectomy (CPM), 90% percent of women with unilateral disease forego the contralateral prophylactic procedure.[6,7] Furthermore, while CPM is considered standard for genetic and high risk patients, recent data call into questions its utility for others.[8] As surgeons continue to become less inclined to broadly offer CPM, unilateral breast reconstruction and its outcomes will remain relevant.

For unilateral reconstruction, surgeons and patients must choose between autologous and implant-based pathways. As previously published, many surgeons would agree that symmetry and patient satisfaction is easier to attain with the former rather than later.[9] Additionally, patients often inquire about the impact of weight change on breast

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Fig. 1. Graphical depiction of the design and timeline of the study

symmetry. As the implant has a static volume, the autologous tissue offers the best chance at symmetric volume distribution; however, up until this point, the effect of weight change on flap volume has not been studied.

The aim of this study is to provide surgeons with objective data regarding the achievement and retention of volumetric symmetry after unilateral autologous breast reconstruction and subsequent revision procedures. The results of this study will allow surgeons to more appropriately counsel patients on postoperative expectations and the possible need for revision surgery to obtain symmetry after the initial reconstructive procedure. The authors' hypothesis was that volumetric symmetry between the reconstructed and nonreconstructed breast would be achieved after all surgical revisions were complete; furthermore, this symmetry would be retained throughout the postoperative course despite changes in BMI.

METHODS

Study Design

This retrospective study was approved by the Institutional Review Board at Duke University Health System. Data were collected for all patients who underwent a procedure with the CPT code 19364 (breast reconstruction with free flap) at Duke University Health System from January 1, 2006 to December 31, 2016. Only patients who underwent unilateral reconstruction were included in this study. In addition, only those who underwent a minimum of 2 bilateral breast magnetic resonance images (MRIs) with or without contrast (identified by the CPT code 77059) were included for analysis in this study (n = 28). It should be noted that obtaining postoperative MRIs is not the current practice of the reconstructive surgeon; all MRIs obtained were done so for breast cancer surveillance, and ordered by the oncological services. The timeline of the study is depicted in Figure 1.

Volumetric Analysis

To compare changes in volumetric symmetry of the reconstructed and nonreconstructed breasts, breast volumes were obtained via MRI at 2 time points for each patient: (1) after all surgical revisions were complete and (2) the most recent MRI data available. The MRI machines used in the study were both 1.5 and 3.0 tesla with 1-mm slice thickness. Volumetric analyses of the reconstructed and nonreconstructed breast were performed using OsiriX Pro (v.3.0.2; Pixmeo; Bernex, Switzerland).

The methodology used to obtain breast volumes was adopted and modified from Herold et al[10] and is summarized as follows. The superior border of the breast was defined by the clavicle and the inferior border of the breast was defined by the inframammary crease. The medial border of the breast was then defined by the sternum and the lateral border was defined at the lateral thoracic wall. Fifteen representative slices of a biaxial bilateral MRI were marked using these borders. The region of interest functionality was then used to interpolate markings of the breast on all slices of the MRI. To account for software error, these interpolated markings were then adjusted to better fit the radiographic contours of the breast in each slice of the MRI; the marked breast borders were then used to calculated the breast volume (Fig. 2). To account for observer error, the radiographic measurements for 5 random patients were repeated by another author, and the inter-observer variability was calculated.

Statistical Analysis

A "symmetry score" (SS) was calculated as a ratio between the volumes of the reconstructed versus nonreconstructed breast at a given time point. Scores closer to 1.0 were indicative of increasing symmetry. Spearman correlation coefficients were used to show the correlation between pairwise variables. In the instances where breast volumes were assessed at multiple time points, the intraclass correlation coefficient is used to assess the correlation between the volume of the reconstructed and nonreconstructed breasts. Statistical analyses were conducted using SAS v. 9.4 software (SAS Institute, Inc., Cary, N.C.).

RESULTS

A total of 28 patients met the inclusion criteria for this study; all of whom were operated on by 1 of 2 senior surgeons (S.T.H. and M.R.Z.). The demographic characteristics of the cohort are represented in Table 1, and the reconstructive details of the cohort are summarized in Table 2. At the time of initial reconstructive surgery, the median patient BMI was 25.5 (interquartile range: 23.5–28.3). The mean number of flap revisions (excluding nipple reconstruction and tattooing) was 0.75 (range 0–2). The mean number of procedures performed on the natural breast for symmetry purposes was 0.39. Fifty-seven percent of patients underwent revision surgery on their reconstructed breast whereas 39% of patients underwent procedures on their nonreconstructed breast.

After all surgical revisions were complete, the median SS between the reconstructed and nonreconstructed breast was calculated to be 0.92, denoting a high degree of volumetric symmetry between the sides (the median volume of the reconstructed and nonreconstructed breast was 742 and 777 cc, respectively) (Table 3). At the most recent MRI, the median SS was 0.96, signifying retention of the symmetry achieved immediately after revisions were complete (median volume of the reconstructed and nonreconstructed breast was 828 and 839 cc, respectively) (Table 3).

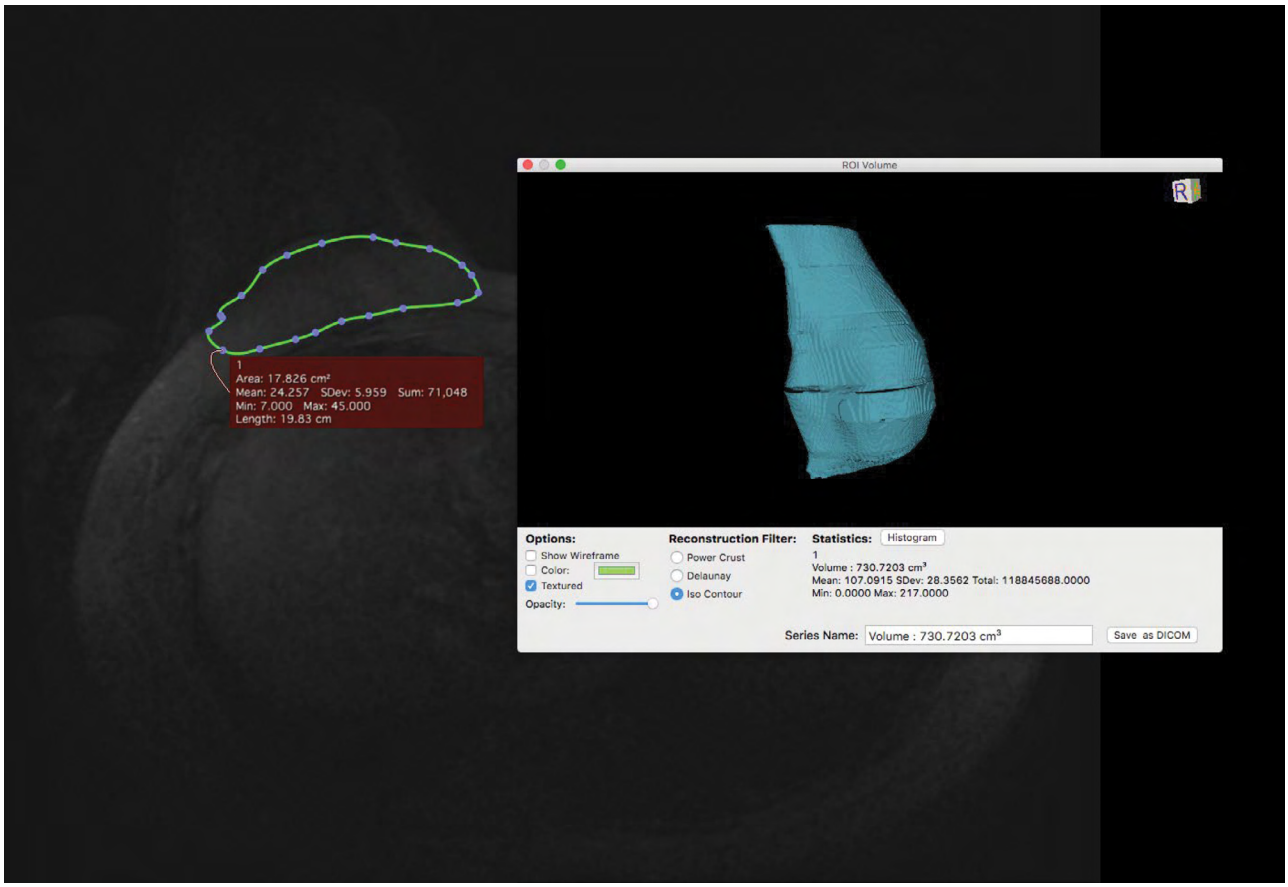

Fig. 2. Depiction of a representative breast MRI analysis using Osirix software to reconstruct a three-dimensional model of a patient's breast. This model is then used to obtain the volume of the breast. The left portion of the figure depicts a single MRI slice where the observer has delineated the breast borders (green tracing). After defining the borders on multiple slices, as explained in the methods, the software then creates a three-dimensional model of the breast (depicted on the right of the figure in teal) including the calculated volume.

Table 1. Patient Demographics

	Total (%)
Age (y)	44.8
Race/ethnicity	
Caucasian	21 (75%)
African American	4 (14%)
Asian	1 (4%)
Hispanic	0
Other	2 (7%)
Comorbidities	
Diabetes	2 (7%)
Current/past tobacco use	5 (18%)
Hormonal modifiers	
Postmenopausal	16 (57%)
Tamoxifen use postoperatively	17 (60%)

Regardless of when the breast volumes were measured, the nonreconstructed and reconstructed breast volumes were highly correlated (intraclass correlation coefficient 0.902; Fig. 3). The mean interval time between the MRIs was 3.03 years (range 0.43–6.6). A graphical depiction of volumetric changes for each patient can be seen in Figure 4.

From the end of surgical revisions to the most recent patient follow-up, the median change in BMI was 3.9%; however, volumetric symmetry was retained as evidenced by the stable SSs (0.92 and 0.96 at the beginning and end of this period, respectively). Additionally, it should be noted that the breast volumes were not static during this period, but rather changed in congruent amounts: the median volumetric change in the reconstructed and nonreconstructed breast was 7.2% and 10.2%, respectively. BMI at the time of index reconstruction had a negligible correlation with final volumetric symmetry ($r = -0.08$). A larger percentage increase in BMI during the postoperative course was moderately associated with reduced volumetric symmetry ($r = 0.44$).

Lastly, the inter-observer variability for volumetric measurements was calculated to be 2.7% ± 2.1% of the measured volume.

DISCUSSION

This study assessed if volumetric symmetry is obtained between the reconstructed and nonreconstructed breasts after unilateral breast reconstruction and the completion of revision procedures. The authors found that surgeons can reliably produce volumetric symmetry between the reconstructed and nonreconstructed sides after all surgical revisions are complete. Furthermore, this symmetry is retained throughout the postoperative period despite natu-

Table 2. Description of Reconstructive and Postreconstructive Procedures

	Total (%)
Type of flap for reconstruction	
DIEP	7 (25)
TRAM	20 (71)
SIEA	1 (4)
No. surgical revisions (reconstructed side)†	
0	12 (43)
1	11 (39)
2	5 (18)
No. surgical revisions (nonreconstructed side)†	
0	17 (61)
1	11 (39)
2	0
Type of surgical revisions (reconstructed side)*†	
None	12 (43)
Reduction	4 (14)
Scar revision	5 (18)
Liposuction from breast	8 (29)
Mastopexy	1 (4)
Fat grafting to breast	5 (18)
Flap re-inset	1 (4)
Type of surgical revisions (nonreconstructed side)*†	
None	17 (61%)
Reduction	1 (4%)
Mastopexy	9 (31%)
Liposuction	1 (4%)

* Some procedures were done simultaneously with each other.
† Not including isolated nipple areolar complex reconstruction or nipple tattooing.

Table 3. Volumetric Data for Nonreconstructed and Reconstructed Breasts

	Mean (range)
Data at MRI after last surgical intervention:	
BMI_i	27.5 (21.0–36.8)
Volume of reconstructed breast ($V_{i\text{-}R}$)	840 cc (357 –1753 cc)
Volume of nonreconstructed breast ($V_{i\text{-}NR}$)	896 cc (399–1934 cc)
Symmetry score*	0.96
Data at most recent MRI	
BMI_f	28.0 (21.0–36.8)
Volume of reconstructed breast ($V_{f\text{-}R}$)	897 cc (368–1960 cc)
Volume of nonreconstructed breast ($V_{f\text{-}NR}$)	946 cc (385–1758 cc)
Symmetry score*	0.98
Between the 2 time points	
Length of time (y)	3.03
% Change in BMI†	5.29 (0–14.6)
% Change in volume of reconstructed breast‡	11.4 (0.04–38.1)
% Change in volume of nonreconstructed breast§	10.8 (0.04–37.0)

*Calculated as a ratio between the volumes of the reconstructed and nonreconstructed breast at that time ($V_{i\text{-}R}/V_{i\text{-}NR}$) and ($V_{f\text{-}R}/V_{f\text{-}NR}$); a value of 1.0 indicates perfect volumetric symmetry.
† Calculated as $([BMI_f - BMI_i]/BMI_i) \times 100$.
‡ Calculated as $([V_{f\text{-}R} - V_{i\text{-}R}]/V_{i\text{-}R}) \times 100$.
§ Calculated as $([V_{f\text{-}NR} - V_{i\text{-}NR}]/V_{i\text{-}NR}) \times 100$.

ral fluctuations in a patients' BMI. While prior studies have examined postoperative outcomes after autologous breast reconstruction, this study is unique in that it focuses on objectively assessing the achievement of volumetric symmetry after unilateral breast reconstruction.[2,11–18] This information may be used when counseling patients on their postoperative expectations following unilateral autologous breast reconstruction.

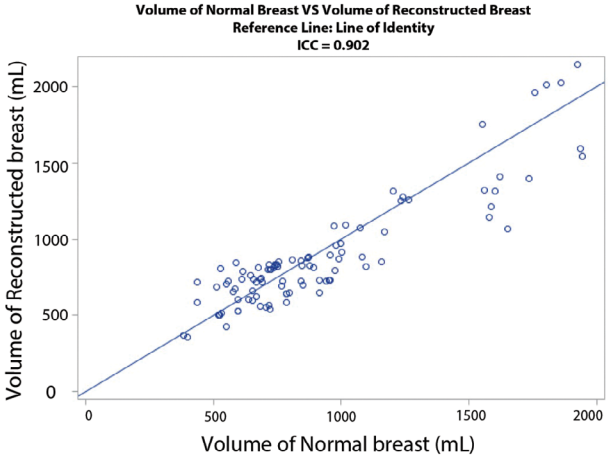

Fig. 3. Volumes of the reconstructed breast and nonreconstructed breast plotted against each other, regardless of the timing of breast volume measurements. Each point represents a patient's breast volumes at a particular MRI. If the volume of the reconstructed breast equals the volume of the nonreconstructed breast then the point falls on the line of identity.

Numerous studies have been published discussing breast symmetry following reconstruction.[9,19] However, the significance of volumetric symmetry to the patient is often called into question: is the discrepancy subtle and only noticed by the trained eye of a surgeon, or does it affect patients' satisfaction with outcomes? A recent study demonstrated that patients are aware of asymmetry between reconstructed breasts.[20] Furthermore, patients who elected to undergo surgical revisions to address asymmetry had a significant increase in satisfaction with their reconstructed breasts.[20] As the importance of symmetry continues to be discussed in the literature, the lack of objective data now limits surgeons in their ability to discuss this issue. The results of this study provide surgeons with evidence to counsel patients that obtaining and maintaining volumetric symmetry following unilateral breast reconstruction is a feasible outcome.

It should be noted that the symmetry obtained after surgical revisions were completed was retained throughout follow-up, despite a median 3.9% change in BMI during this same time period. Additionally, throughout the postoperative course, the breast volumes were not static. That is, breast symmetry was retained despite a median volumetric change in the reconstructed and nonreconstructed breast of 7.2 % and 10.2%, respectively. This implies that as the body's BMI naturally fluctuates, the reconstructed and nonreconstructed breast volumes change in a similar and congruent manner.

The ability of reconstructed and natural breast tissue to similarly respond to BMI fluctuations is intriguing as the reconstructed breast is comprised of abdominal fat, whereas the nonreconstructed breast is comprised of native breast tissue. Additionally, the native breast contains glandular and ductal tissue whereas the reconstructed breast does not. The capacity to symmetrically redistribute volume into both breasts, as BMI fluctuates, warrants future studies to more thoroughly evaluate the behavior

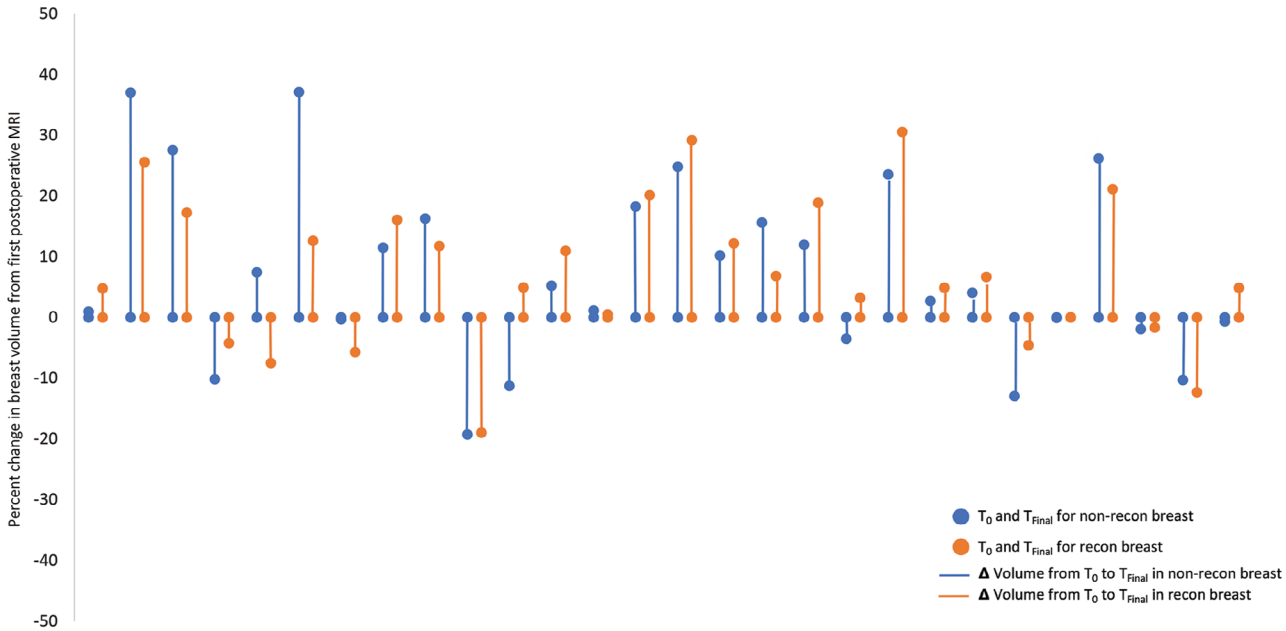

Fig. 4. Graphical depiction of the volumetric change experienced by each patient during their postoperative course. Each patient is represented by a pair of orange/blue points and the quantitative volumetric change of each breast is represented by the length of the color-coded line. The direction of the point translation represents either a gain or loss in volume from the end of their surgical revisions to the end of the postoperative course.

and transformation of transplanted autologous abdominal tissue.

This study is not without limitations. As a retrospective review at a single institution, there are inherent limitations. The small sample size of this study, due to availability of MRI data, limited the authors' ability to include predictors of symmetry such as BMI, type of flap, and number of revisions. A larger population would offer more power to better predict postoperative outcomes.

It is important to note that this study focused on *volumetric* symmetry. While the reconstructed and nonreconstructed breasts were volumetrically symmetric, they may not have been subjectively symmetric. Specifically, the authors have noticed that the nonreconstructed breast is often more ptotic than the reconstructed breast. This observation is substantiated by the results of this study in that 81% of the patients undergoing procedures to their native breast had symmetrizing mastopexy procedures. Unfortunately, due to the retrospective nature of this study, subjective assessment of breast shape symmetry, in the lying or standing position, was not possible.

CONCLUSIONS

This study evaluates the ability to achieve and maintain volumetric symmetry after unilateral autologous breast reconstruction. The results of this study revealed that surgeons can reliably achieve volumetric symmetry once surgical revisions have been completed; additionally, this symmetry is maintained in the postoperative period despite natural fluctuations in patients' BMI. These findings can be used to address patients' concerns regarding symmetry following breast reconstruction.

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