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ORIGINAL ARTICLE

Breast

Natural Breast Symmetry in Preoperative Breast Cancer Patients

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Background: Plastic surgeons aim to achieve breast symmetry during cosmetic and reconstructive breast surgery. They rely on measures of breast size, position, and projection to determine and achieve breast symmetry, but normative data on symmetry in preoperative breast reconstruction patients are scarce.
Methods: A statistical evaluation was performed to examine the relationship of breast symmetry to demographic and clinical factors such as age, body mass index (BMI), race, and cancer status in a sample population of 87 patients who were scheduled to undergo mastectomy and breast reconstruction. The sternal notch to nipple (SN-N) distance and breast volume were measured on three-dimensional images, and distance and volume ratios across the left and right breasts were compared to determine symmetry. Ptosis grades were recorded and grade agreement (match) across the left and right breasts was assessed to determine shape symmetry.
Results: A substantial portion of women (41.4%) showed SN-N distance differences >5 mm and 50.6% exhibited a volume difference >50 mL between their right and left breasts. Multiple linear regression modeling did not show any association between age, BMI, and cancer status and the SN-N and volume ratios. Race showed an association with volume symmetry but not with SN-N symmetry. A higher BMI increased the likelihood of ptosis disagreement. Additionally, tumor size did not impact overall breast symmetry.
Conclusion: This study provides normative data on the extent of breast asymmetry in preoperative patients that can guide physicians in setting realistic goals for reconstruction procedures and manage patients' expectations related to outcomes. *(Plast Reconstr Surg Glob Open 2019;7:e2297; doi: 10.1097/GOX.0000000000002297; Published online 26 July 2019.)*

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Received for publication December 13, 2018; accepted April 17, 2019.

Presented at the San Antonio Breast Cancer Symposium 2018, San Antonio, TX, December 3–8, 2018.

This work was supported by grants from the US National Institutes of Health (R01CA143190 and R01CA203984).

The data in this study come from a prospective Institutional Review Board–approved research project (Protocol Number 2010-0321) at The University of Texas MD Anderson Cancer Center, Houston, Texas.

DOI: 10.1097/GOX.0000000000002297

INTRODUCTION

Most cosmetic and reconstructive breast surgery procedures are aimed at enhancing breast aesthetics. Breast aesthetics, however, are not clearly defined because breast shape perception may vary across individuals and cultures. Breast shape is affected by age, weight change, breast volume, smoking, pregnancy and lactation, and bra use.[1] Moreover, due to its soft tissue anatomy, breast shape can change with body position and posture. Still, plastic surgeons employ several anthropometric measurements of breast size, position, projection, and ptosis[2] to assess breast aesthetics. For example, to determine symmetry, breast volume[3–6] and the distances between key fiducial points[3,7–9] are often compared between the left and right breasts. Most women have some degree of bilateral differences, and emergent or worsening breast asymmetry has been linked to hormonal changes[10] and breast cancer risk.[6,9,11]

Previous normative data on breast symmetry are limited. Most studies on breast aesthetics (see Table 1) have examined either women with mostly ideal breast aesthetics[12,20,21] or particular subpopulations of women, such as college-aged women[3] or a specific racial group.[5]

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

Table 1. Breast Symmetry Studies in the Literature

Author	No. subjects/ Breasts	Race/ Origin	Age, Mean ± SD (Range)	BMI, Mean ± SD (Range)	Subject Type	SN-N (cm) Mean ± SD (Range)	SN-N (cm) Sig. Test ($P < 0.05$)	Breast Volume (mL) Method	Breast Volume (mL) Mean ± SD (Range)	Breast Volume (mL) Sig. Test ($P < 0.05$)	Ptosis Measured
Penn[12]	20/40	—	25.3 ± 6.0 (18–39)	21.3 ± 1.6 (18.2–24.5)	Women with aesthetically perfect breasts	Left: 20.8 ± 1.1 (19.1–22.2) Right: 20.8 ± 1.0 (19.1–22.2)	ns	N/M	N/M		No
Smith et al.[13]	55/110	—	18–31	—	Female volunteers	N/M		Plaster cast filled with sand	Left: 292 ± 168 Right: 275 ± 173	ns	No
Brown et al.[14]	Control: 60/120 BR: 25/50 BA: 6/12	—	Control: 38 (15–88) BR: 31 BA: 33	Control: 24.1 ± 5 BR: 28.4 BA: 20.5	Normal women and women undergoing BR or BA	Control Left: 22.3 ± 4.6 Right: 22.3 ± 4.5 BR: 26.9 BA: 16.9 (vertical length)	ns	N/M	N/M		No
Losken et al.[15]	87/174	Mostly Caucasian	49.6 (19–77)	25 (18.5–36.7)	Healthy women with natural breasts	Left: 24.3 Right: 23.8	—	N/M	N/M		No
Avşar et al.[3]	385/770	Turkish	19.6 ± 1.6 (18–26)	21.6 ± 1.6 (20–25)	Student volunteers	Left: 19.7 ± 2.2 Right: 19.6 ± 2.2	Yes	Formula by Qiao et al.[16]	Left: 399 ± 270 Right: 415 ± 265	Yes	Yes
Agbenorku et al.[7]	438/876	West African	17.43 (16–22)	20.3	Student volunteers	Left: 20.97 (19–21) Right: 20.31 (19–21)	—	N/M	N/M		No
Kim et al.[17]	250/500	Korean	37.1 ± 8.7 (20–50)	22 ± 2.6	Healthy women with natural breasts	Left: 19.5 ± 1.7, 20.5 ± 2.3, 21.9 ± 2.6 Right: 20.0 ± 1.8, 21.0 ± 2.4, 22.4 ± 2.6 (Age groups)	ns	Formula by Qiao et al.[16]	Left: 393 ± 347 Right: 386 ± 343	ns	Yes
Kayar and Çilengiroğlu[11]	Control: 446/892 Cancer: 201/402	—	Control: 40.9 ± 11.8 (18–77) Cancer: 50.4 ± 11.4 (23–79)	Control 25.61 ± 5.16 Cancer 28.57 ± 5.1	Healthy women and women with cancer	N/M		Grossman-Roudner Disc	Control: Left: 443 ± 193 Right: 444 ± 204 Cancer: Left: 600 ± 332 Right: 610 ± 346	—	No
Huang et al.[18]	605/1210	Chinese	48.8 ± 11.7	22.9 ± 3.0	Breast cancer patients	21.6 ± 2.8 (12.5–34.5) (n = 1196)	—	Breast volume described by Longo et al.[19]	340 ± 109 (92–919)	—	Yes

—, not stated; BA, breast augmentation; BR, breast reduction; N/M, not measured; ; ns, not significant ($P > 0.05$); Sig. Test, statistical significance test to evaluate measurement differences between left and right breasts.

Notably, most of these studies do not report demographic factors, such as body mass index (BMI), nor do they include breast shape features, such as ptosis,[3,7,16,22] and are too limited in scope to be normative.

The purpose of this study was to obtain normative data about breast symmetry in breast reconstruction patients in relation to the demographic and clinical factors of age, BMI, race, and cancer status. Our study reports data from women seeking breast cancer reconstruction at a US tertiary cancer center that provides a broad representation of breast cancer patients. The data presented here fill a gap that has not been addressed by other studies outlined in Table 1. The majority of the previous literature reporting normative data come from participants who either do not need surgery (for aesthetic reasons), or those seeking cosmetic procedures, and are thus limited in body habitus, ethnicity, medical conditions, and prior pregnancies, or other factors that may affect breast shape and symmetry. A few studies, such as those by Huang et al.,[18] Kayar and Çilengiroğlu,[11] and Longo et al.,[19] have examined patients with breast cancer. However, although these studies recorded some breast measurements such as volume, they did not evaluate breast symmetry. Also, these studies are limited in population ethnicity and their approach in computing breast volume. Data presented here can guide physicians in setting realistic goals for breast surgery and manage patients' expectations related to outcomes.

Using 3D image data,[23–25] we utilize breast volume, sternal notch to nipple (SN-N) distances, and ptosis to assess the incidence of asymmetry and determine its association with demographic and clinical factors. Although other measures could also be used to evaluate breast shape symmetry, we decided to focus on volume and SN-N measures as they have been widely reported in literature.

PATIENTS AND METHODS

The study sample consisted of adult female breast cancer patients undergoing treatment at the Center for Reconstructive Surgery at The University of Texas MD Anderson Cancer Center between 2011 and 2014. The data in this study come from a prospective Institutional Review Board–approved research project that enrolled patients at various stages of breast reconstruction. Participants provided written informed consent.

We utilized data collected from 87 patients during the preoperative study visit, when the patient had two native breasts. Patients with a BMI > 41 kg/m^2, congenital breast abnormalities, previous radiation therapy, or major breast surgeries were excluded. Due to the increased risk of complications,[26] most Class 3 Obese patients (BMI > 40) are not considered for surgery, until they have lost weight. Patients with previous biopsies were included only if the procedure did not change the shape or natural contour of the breast and did not cause an obvious deviation of the nipple and areola as determined by an experienced plastic surgeon. Patient characteristics are presented in Table 2. Fourteen patients who underwent prophylactic surgery did not have cancer. Tumor information for 73 breast cancer patients was obtained from Breast Cancer Management, and the Tumor Registry Database at MD Anderson Cancer Center (Table 3).

Table 2. Patient Baseline Characteristics

Variable	Statistics
Age, yr	
Mean ± STD	48.6 ± 10.5
Median (range)	47 (28–73)
BMI, kg/m^2	
Mean ± STD	26.7 ± 5.1
Median (range)	25.6 (18–41)
Variable	**N (%)**
Race	
Caucasian	65 (74.7)
African American	6 (6.9)
Asian	4 (4.6)
Other	4 (4.6)
Not available	8 (9.2)
Ethnicity	
Hispanic	13 (14.9)
Not Hispanic	64 (73.6)
Not available	10 (11.5)
Diagnosis	
Unilateral breast cancer	68 (78.2)
Bilateral breast cancer	5 (5.7)
No cancer	14 (16.1)
Preoperative chemotherapy	
Yes	34 (39.1)
No	53 (60.9)

Race (Other), self-identified as Costa Rican, Hispanic, or Latino; No Cancer, of the 14 patients without cancer, 12 were positive for the BRCA1 or BRCA2 gene mutation, one had a related family member who had breast cancer, and one had benign fibrocystic breast disease.

Symmetry Measurements

3D images of the female torso were obtained using the 3dMDTorso System (3dMD LLC, Atlanta, Ga.). Using software developed by our team,[23] the lowest point of the SN and the center of the nipple (N) were manually identified on the 3D images by a trained graduate student, and the linear (straight line) and contour (along the surface) distances between the two points were measured as shown in Figure 1A. Two ratios were calculated: relative SN-N ratio (left breast distance divided by the right breast distance) and absolute SN-N ratio (shorter distance divided by the longer distance). Although both ratios provide similar information in terms of symmetry, they have different benefits in statistical analyses. Relative ratios, which are centered around 1.0 (perfect symmetry), were used for statistical testing of directional asymmetry (skew from 1.0), and for assessing whether the side (left or right) with the larger value correlated with the cancerous breast. On the other hand, absolute ratios are a monotonic measurement of symmetry (maximum value is 1.0). Higher values of the absolute ratio indicate symmetrical breasts, making it better suited for use in linear regression analyses. In this study, the SN-N ratio based on the linear distance, which is widely published, was used and was not significantly different from the contour distance ratio (<2.5% difference, paired t-test P value = 0.506).

Volume was also computed using customized software,[27] as shown in Fig. 1B. Similar to the SN-N analyses, both the relative and absolute ratios were calculated from the volume measurements. Statistical analysis was per-

Table 3. Baseline Clinical Characteristics of the Cancer Patients

Variable	N	(%)
Tumor type (N = 78)		
DCIS	18	(23.1)
Lobular carcinoma in situ	1	(1.3)
IDC	52	(66.7)
Invasive lobular carcinoma	4	(5.1)
DCIS and IDC	3	(3.8)
Position of the tumor* (N = 73)		
Lower-inner quadrant	2	(2.7)
Upper-inner quadrant	11	(15.1)
Upper-outer quadrant	19	(26)
Lower-outer quadrant	10	(13.7)
Central	3	(4.1)
Nipple	1	(1.4)
Overlapping lesion	15	(20.5)
NOS (excludes skin)	12	(16.4)
Tumor size (N = 78)		
T1 (gd ≤ 20 mm)	46	(59)
T1mi (gd <1 mm)	2	(2.6)
T1a (1 mm < gd ≤ 5 mm)	4	(5.1)
T1b (5 mm <gd ≤ 10 mm)	13	(16.7)
T1c (10 mm < gd ≤ 20 mm)	27	(34.6)
T2 (20 mm < gd ≤ 50 mm)	19	(24.4)
T3 (gd > 50 mm)	6	(7.7)
Not measurable	6	(7.7)
Unknown	1	(1.3)
Variable	**Statistics**	
Tumor size, cm (N = 77)		
Mean ± STD	2.08 ± 2.07	
Median (range)	1.4 (0 to 11)	

*Only the position of the largest tumor per patient was recorded; Overlapping lesion, lies across more than one zone of the breast; NOS (excludes Skin), multiple sites of the breast; gd, greatest diameter of tumor; Not measurable, some patients underwent neoadjuvant therapy in which their tumors shrunk to a negligible size (too small to detect).
DCIS, Ductal Carcinoma In Situ; IDC, Invasive Ductal Carcinoma

formed to test directional asymmetry (skew from a mean ratio of one), and multiple linear regression was used to assess age, BMI, race (Caucasian versus non-Caucasian), and cancer status (presence or absence of tumor) as possible factors to breast symmetry.

Ptosis grading (grades 0–3) was performed for each individual breast by an experienced plastic surgeon. Agreement between the ptosis grades of the left and right breasts was used to determine the shape symmetry for each patient. Ptosis agreement was defined as having the same ptosis grade for both the right and left breasts. Logistic regression modeling was used to assess age, BMI, race, and cancer status as possible factors to ptosis agreement.

Statistics

Descriptive statistics were used to summarize the SN-N and volume measurements, and frequencies and percentages were used to summarize the categorical clinical characteristics. The one-sample t-test was used to evaluate the symmetry measurements, and multiple linear regression models were used to evaluate the association between the symmetry ratios and demographic and clinical factors. The weighted kappa test was used to evaluate ptosis agreement between the left and right breasts, with weights calculated using the Cicchetti-Allison method.[28] Univariate and multivariable logistic regression models were used to evaluate the effect of demographic and clinical factors on probabilities of ptosis disagreement. All tests were two-sided, with a P value <0.05 considered significant. The analyses were performed in MATLAB R2015a, Excel 2013, and SAS 9.4.

RESULTS

Symmetry Measurements

Descriptive analyses of the SN-N and volume ratios are presented in Table 4. SN-N symmetry was defined as a difference <5 mm between the two breasts (Fig. 2A), consid-

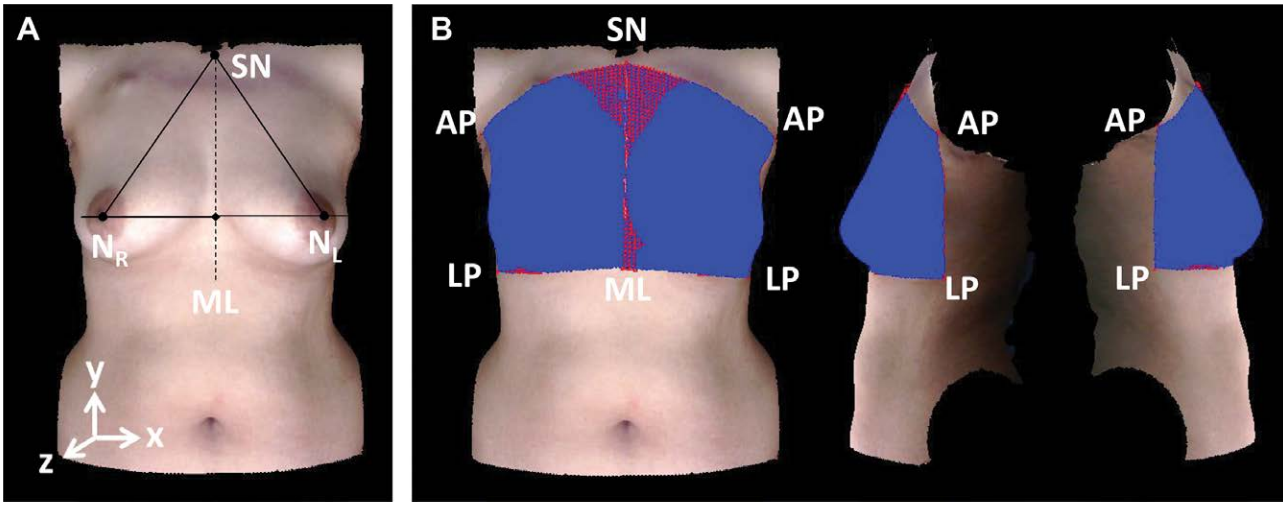

Fig. 1. Front and side views of distance and volume measurements on a patient. A, SN-N measurement. B, Volume measurement (front and side views). Four landmark points—the SN, the anterior axillary point (AP), the lateral point (LP) located just below the lowest visible point of the breast and on the lateral side of the breast, and the midline (ML) point—were used to delineate the region encompassing the left and right breast mound. The blue regions show the surface area selected for breast volume determination in the front, right lateral, and left lateral views. As specified by an experienced plastic surgeon, these 4 points were manually marked to capture the breast volume. A Coons patch to estimate the chest wall was generated from the four landmark points, and the volume of the space enclosed between the patch and the breast surface was computed as the breast volume.[27]

Table 4. Descriptive Statistics

Parameter	N	Minimum	Median	Maximum	Mean	SD
SN-N distance (cm)	174	17.8	23.7	34.1	24.1	3.3
Left SN-N distance (cm)	87	18.0	23.8	34.0	24.1	3.3
Right SN-N distance (cm)	87	17.8	23.7	34.1	24.2	3.3
Difference (cm)	87	−1.91	−0.07	1.81	−0.09	0.80
Ratio	87	0.935	0.997	1.09	0.997	0.034
Absolute ratio	87	0.927	0.981	1.00	0.975	0.020
Breast volume (mL)	166	197	730	1946	794	323
Left breast volume (mL)	82	197	763	1900	803	328
Right breast volume (mL)	84	219	724	1946	785	320
Difference (mL)	79	−219	20.4	213	15.6	89.4
Ratio	79	0.754	1.04	1.31	1.02	0.118
Absolute ratio	79	0.754	0.935	0.999	0.914	0.065

Difference, left minus right breast measurement; Ratio, left over right breast measurement.

ered to be imperceptible to the human eye, as suggested by Liu et al.[22] Differences between 5 and 10 mm were categorized as moderate asymmetry and differences greater than 10 mm as high asymmetry.

We found that 58.6% (51 of 87) of the patients had a difference of less than 5 mm, 17.3% (15 of 87) had a difference between 5 mm and 10 mm, and 24.1% (21 of 87) had a difference greater than 10 mm (Figure 3A). Perfect symmetry occurs when the SN-N and volume ratios are equal to one. When assessing the SN-N ratio at the 95% threshold, 19.5% (17 of 87) of the patients were below the threshold (Fig. 3C). Patients with ratios below the threshold were associated with greater asymmetry. No patients had SN-N ratios less than 90%. Previous studies defined volume differences between the two breasts of at least 20, 25, and 50 mL[11,22] as volume asymmetry. In this study, we divided breast volume asymmetry differences into 50 mL intervals (Fig. 2B), which was within the standard error (±60 mL) of our breast volume measurement algorithm. When comparing left and right breast volumes, 49.4% (39 of 79) of the patients had a less than 50 mL difference, 21.5% (17 of 79) had a difference between 50 and 100 mL, and 29.1% (23 of 79) had a difference of more than 100 mL (Fig. 3B). For volume ratio thresholds at 95%, 90%, 85%, and 80%, 63.3% (50 of 79), 31.6% (25 of 79), 17.7% (14 of 79), and 8.9% (7 of 79) of the patients, respectively, were below the threshold (Fig. 3D).

The one-sample t-test was used to test directional asymmetry. It was found that the means of SN-N and volume ratios were not significantly different from one ($P = 0.425$, $P = 0.061$). Therefore, neither the left nor the right breast was significantly larger than the other based on the two ratios.

Data on ptosis agreement between the left and right breasts are presented in Table 5. Seventy-seven percent of the patients had matching left and right breast ptosis grades, whereas 23% had different ptosis grades. At most, the left and right breasts differed only by one grade (weighted kappa, 0.74; 95% CI, 0.63–0.84).

Symmetry versus Clinical and Demographic Factors

Age, BMI, race (Caucasian versus non-Caucasian), and cancer status (presence or absence of tumor) were studied as possible factors contributing to breast symmetry. Multiple linear regression modeling was performed using the candidate factors to predict SN-N and volume ratios (Table 6). The model showed that none of the evaluated factors had any significant effect on the SN-N ratio, whereas for the volume ratio, age, BMI, and cancer status were not found to be significantly associated with the breast volume symmetry. However, Caucasian patients had better breast volume symmetry in terms of the volume ratio when adjusting for age, BMI, and cancer status.

Logistic regression modeling of the probability of ptosis disagreement showed that a higher BMI increased

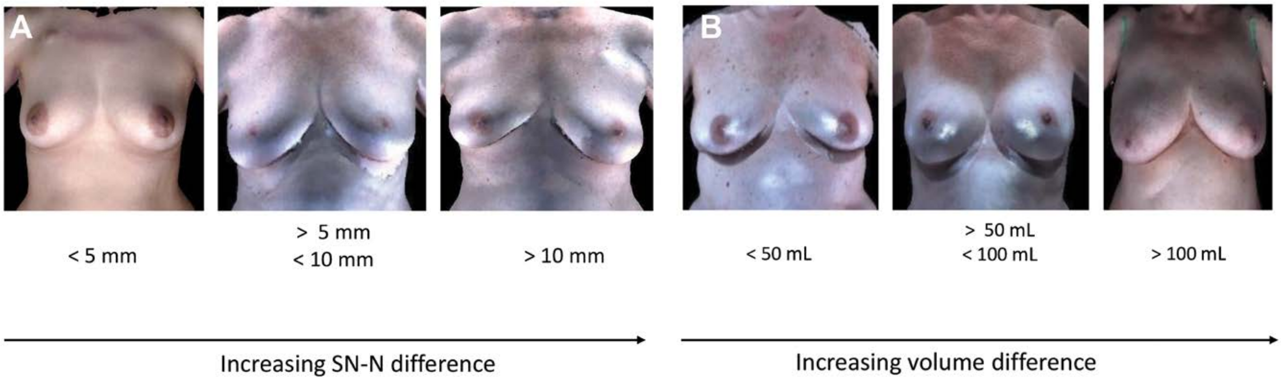

Fig. 2. Images of patients at different symmetry levels based on the SN-N and volume differences between the left and right breasts. A, Patient images representative of an SN-N difference less than 5 mm, between 5 and 10 mm, and more than 10 mm. B, Patient images representative of a volume difference less than 50 mL, between 50 and 100 mL, and more than 100 mL.

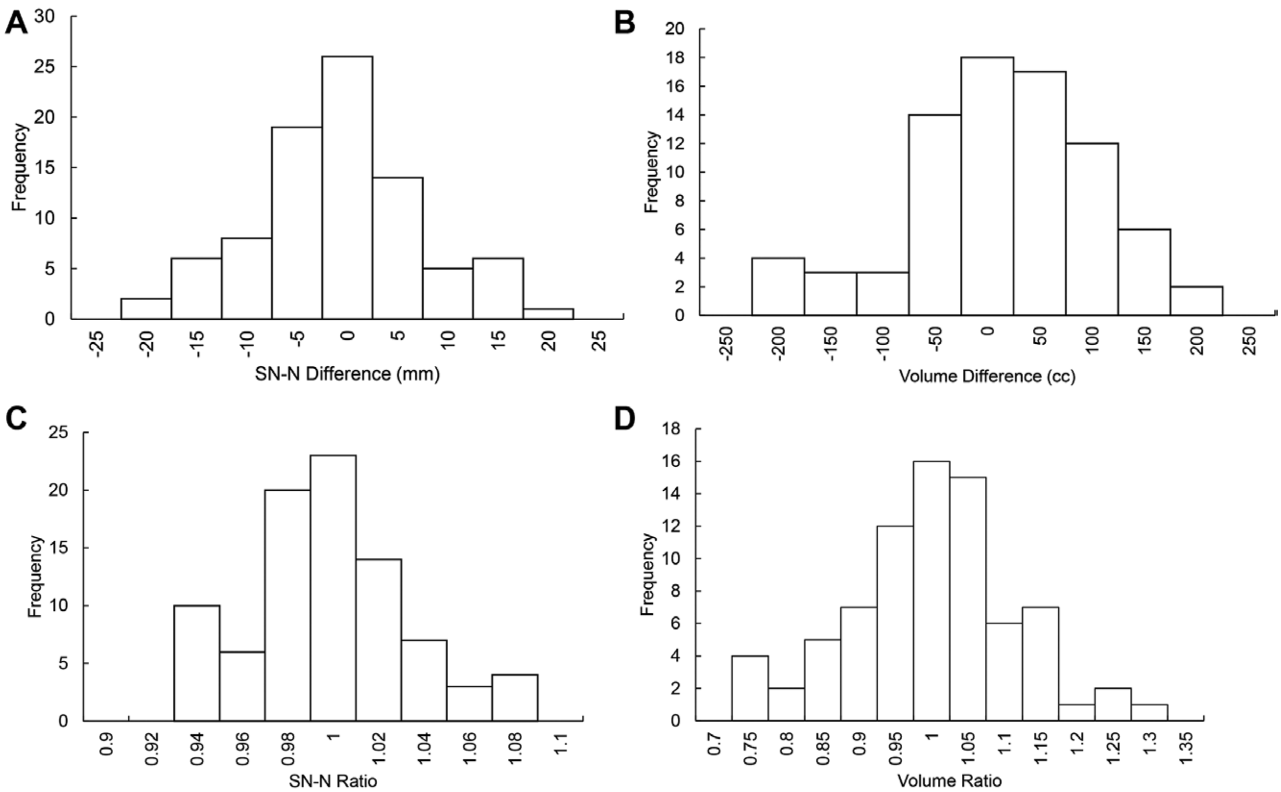

Fig. 3. Histograms of the (A) SN-N difference (bin size, 5 mm; N = 87), (B) volume difference (bin size, 50 mL; N = 79), (C) SN-N ratio (bin size, 0.02; N = 87), and (D) volume ratio (bin size, 0.05; N = 79) between the left and right breasts. The SN-N and volume differences are positive if the left breast is larger and negative if the right breast is larger. Similarly, the ratios are >1 if the left breast is larger and <1 if the right breast is larger.

Table 5. Ptosis Grades

	Left Breast				Weighted Kappa (95% CI)
Right Breast	0	1	2	3	0.74 (0.63–0.84)
0	44	6	0	0	
1	5	14	4	0	
2	0	2	6	2	
3	0	0	1	3	

the probability of ptosis disagreement between the left and right breasts (odds ratio, 1.16; 95% CI, 1.05–1.29; $P = 0.005$) (Table 7). Age, cancer status, and race were not significant factors affecting ptosis disagreement.

Tumor Size

To assess whether the presence of tumors affected SN-N and volume asymmetry, we performed a tumor size

Table 6. Multiple Linear Regression Model

	SN-N Ratio			Volume Ratio		
Variable	Parameter Estimate	Standard Error	*P*	Parameter Estimate	Standard Error	*P*
Age	−0.0004	0.0002	0.077	−0.0008	0.0007	0.237
BMI	0.0002	0.0004	0.675	0.0002	0.001	0.890
Cancer	0.002	0.005	0.636	−0.013	0.015	0.384
Race	0.004	0.005	0.477	0.036	0.017	0.043

Table 7. Logistic Regression Model for Determining the Probability of Ptosis Disagreement

	Univariate Analysis		Multivariable Analysis	
Variable	OR (95% CI)	*P*	OR (95% CI)	*P*
Age	1.02 (0.97–1.07)	0.450	1.01 (0.96–1.06)	0.738
BMI	1.16 (1.05–1.29)	0.004	1.16 (1.05–1.29)	0.005
Cancer	0.90 (0.32–2.57)	0.851	0.98 (0.31–3.13)	0.971
Race	1.02 (0.32–3.23)	0.973	1.24 (0.33–4.66)	0.749

OR, odds ratio.

analysis. Our dataset of N = 73 patients (68 unilateral and 5 bilateral), contained T_U = 68 unilateral and T_B = 10 bilateral tumors (total; T = 78) (Table 3). One bilateral tumor was of unknown size (T = 77, T_U = 68, T_B = 9). The median tumor size was 1.4 cm (range, 0–11 cm) (Figure 4A). Next, we determined the percentage of breast volume occupied by tumors. Breast volume was indeterminable for 6 unilateral breasts, thus the median percentage of the tumor volume (assuming spherical tumors) relative to breast volume was 0.19% (range, 0%–42.8%, T = 71, T_U = 62, T_B = 9). The histogram of the percentage of tumor volume to breast volume presented in Fig. 4B indicates that for 83.1% of the breasts, the tumor volume was relatively small (<5% of total breast volume). Next, we assessed whether the presence of the tumor had any effect on breast volume compared to the contralateral healthy breast. For T_U = 60, unilateral breast tumors for which contralateral breast volume was available (Fig. 5), tumor presence did not lead to a larger or smaller breast volume compared to the contralateral healthy breast (one-sample t-test, $P = 0.146$). Similarly, no significant differences were noted when looking at 75% of tumors that were 3 cm or less in diameter ($P = 0.486$), or the remaining 25% that were >3 cm ($P = 0.06$).

DISCUSSION

We present distributions showing the number of patients exhibiting SN-N and volume asymmetry in a population of breast cancer patients before breast reconstruction surgery, and their association with clinical and demographic factors: age, BMI, race, and cancer status. Both these measures have been previously utilized for surgical planning and outcome assessment. Reddy et al.[29] reported the use of the SN-N ratio for cosmetic outcome assessment in breast conservation therapy. The SN-N ratio was found to be correlated to patient-reported cosmesis, whereas other vertical and horizontal distance measures were correlated to physician-reported cosmesis. Using a difference greater than 5 mm as the threshold for SN-N measurement,

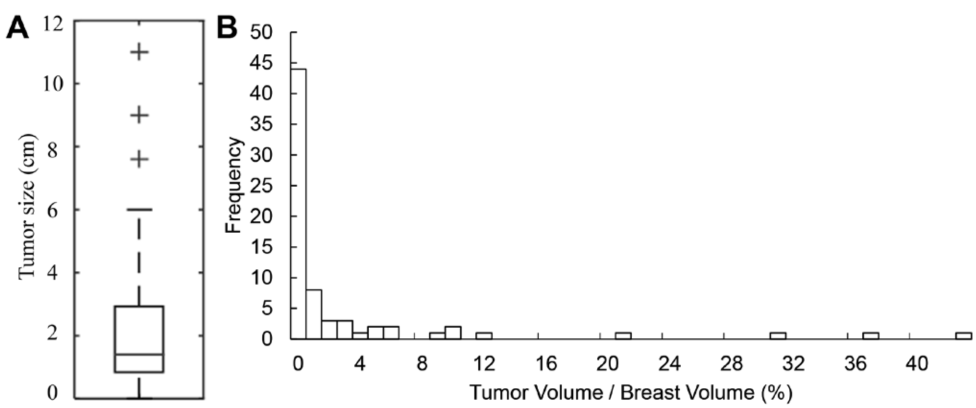

Fig. 4. Tumor size and volume. A, Box plot of the tumor sizes (T = 77). Three tumors were greater than 6 cm in diameter and are seen as outliers. B, Histogram of the tumor volume to breast volume ratio (bin size, 1%; T = 71). The majority of breasts (83.1%) had a small tumor to breast volume ratio (<5%).

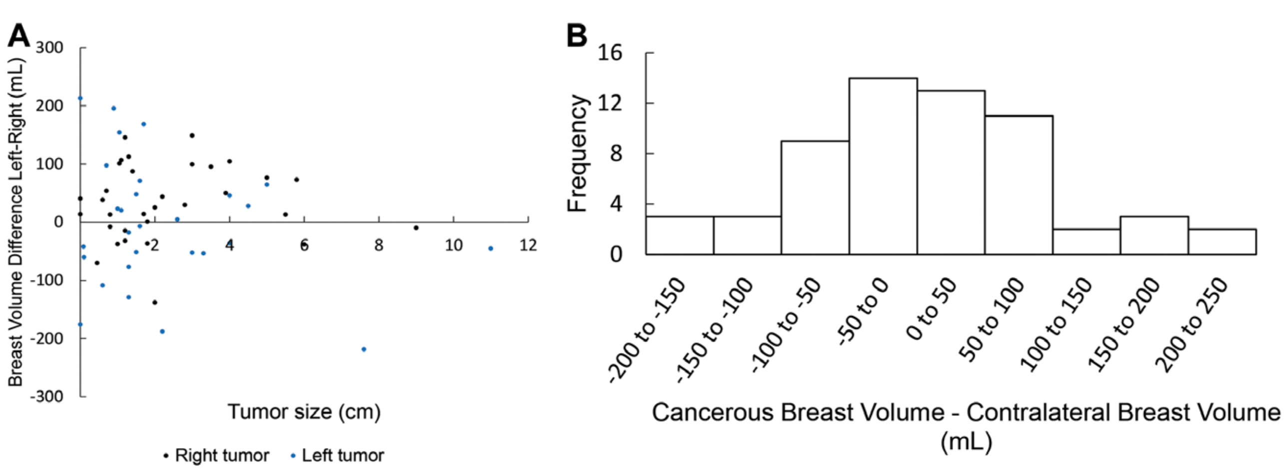

Fig. 5. Effect of tumor size on breast volume. A, Scatterplot of the breast volume difference (mL) versus tumor size (cm). The breast volume difference is measured by subtracting the right breast volume from the left breast volume. Patients with bilateral breast cancer were excluded from the plot. The black dots represent 32 patients with a tumor in the right breast, whereas the blue dots represent 28 patients with a tumor in the left breast. The dots above zero indicate that the left breast is larger than the right breast, and dots below zero indicate the right breast is larger than the left breast. B, The bar graph shows the breast volume difference with the contralateral breast volume subtracted from the cancerous breast (N = 60). If the cancerous breast is larger than the contralateral breast, the difference is positive.

41.4% of our sample population exhibited SN-N asymmetry. Previous studies have examined a number of factors, including older age, higher BMI, breastfeeding, no previous childbirth,[30] menopause, menstruation,[10] and cancer predisposition,[9] as affecting breast asymmetry. According to Losken et al.,[15] age did not directly impact breast symmetry based on comparisons of the SN-N distance and the root mean squared value between the left and right breast surfaces, but a larger BMI was associated with increasing asymmetry. According to the multiple linear regression model in our study, age, BMI, race, and cancer diagnosis were not significantly associated with the SN-N ratio. Our results conform with Losken et al.,[15] in that age was not associated with SN-N asymmetry, but we did not note any association of BMI with SN-N asymmetry. However, although not studied previously by others, we found that a higher BMI increased the probability of ptosis disagreement.

Breast volume has also been used for outcome assessment[13,14,20] and as a measure of asymmetry using 20, 25, and 50 mL volume difference thresholds across the two breasts.[11,22] We note that volumetric symmetry can be difficult to meaningfully quantify using only volume differences as a measure. For example, a 50 mL difference would be noticeable when comparing small breasts but too subtle to perceive when comparing large breasts. Kayar and Çilengiroğlu[11] measured the volume difference and the volume ratio (volume difference divided by the breast volume of the small side) between the left and right breasts and suggested that the breast volume ratio was a more relevant measure of volume symmetry. We used both the volume difference and the relative volume ratio measure to quantify asymmetry. Using differences of greater than 50 mL in volume and less than 95% in ratio as thresholds, we found that 50.6% and 63.3%, respectively, of our sample population exhibited volume asymmetry. These results suggest that volume asymmetry occurs in over half of our patient population. According to the multiple linear regression model in our study, age, BMI, and cancer status were not significantly associated with the volume ratios. Contrary results have been reported by Scutt et al.[9] who found that the breast volume difference was significantly greater in the cancer group than in the control group. Kayar and Çilengiroğlu[11] assessed the association of the magnitude of asymmetry with cancer and found that asymmetry was not statistically associated with cancer when their calculated volume ratios were greater than 5% and 10%, but higher levels of asymmetry with volume ratios that were greater than 15% and 20% showed a statistically significant association with cancer. Our sample size limited such stratification making it difficult to assess the magnitude of asymmetry with respect to cancer. Race (Caucasian versus non-Caucasian), which was not examined in previous studies, was found to have a significant association with the volume ratio.

In the published literature, there is no consensus on whether the left or right breast is most often larger in women with regards to SN-N and volume differences (Table 1).[3,7,11,13,15,17] Although one study reported statistically significant differences in SN-N distance and volume across the two breasts,[3] others mostly reported that the difference was not statistically significant, or they did not perform statistical tests. Our study showed that the average left SN-N distance was shorter than the average right SN-N distance, and the average left breast volume was larger than the average right breast volume, but statistically, neither finding was significant.

We acknowledge that there is some subjectivity to the SN-N and volume measurements, as fiducial points on the torso were manually selected. For women with high BMI or large breasts, it is often difficult to annotate features, such as the SN and the lateral points. Moreover, subjectivity is difficult to eliminate completely, as patients stand in various postures, which can introduce asymmetry. In addition, the patients in our study who did not have cancer may not be truly representative of a healthy population, as they are at high risk of developing breast cancer, so our results showing that cancer is not associated with asymmetry may be limited in scope. Although being Caucasian was found to be significantly associated with better volume symmetry, further analyses are warranted given the disproportionate racial distribution of our study, wherein Caucasians made up 72.2% (N = 65) of the sample population and were compared with all other races combined, which consisted of a group of only 14 patients.

CONCLUSIONS

This study provides anthropometric symmetry measures of a population of breast cancer patients seeking reconstruction and supports the conclusion that asymmetry is a normal occurrence. Cosmetic and reconstructive breast surgeons aim to enhance breast aesthetics in accordance to patient preferences (given medical feasibility is established), where breast symmetry is the most desired outcome for patients. But for many women who undergo breast surgery, a majority are generally unaware of inherent asymmetry, and most have an expectation of having perfectly symmetrical breasts after surgery. Our data provide a better understanding of factors related to breast asymmetry and could help surgeons with surgical planning and managing patients' expectations. Age, BMI, and cancer were not significantly associated with SN-N asymmetry or breast volume asymmetry. Race was found to be significantly associated with breast volume symmetry but not with SN-N asymmetry. A higher BMI increased the likelihood of ptosis disagreement between the left and right breasts. Furthermore, tumor size was not significantly related to increased or reduced breast volume when compared to the contralateral breast.

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ACKNOWLEDGMENTS

The data used in this study were generously provided by the Department of Plastic Surgery at The University of Texas MD Anderson Cancer Center. The authors recognize the support and contributions of former and current surgeons, David Adelman, *Donald P. Baumann, Elisabeth Beahm, Charles Butler, Edward Chang, David W. Chang, Mark Clemens, Melissa A. Crosby, Patrick B. Garvey, Matthew M. Hanasono, Steven J. Kronowitz, Alexander T. Nguyen, Gregory Reece, Geoffrey Robb, Jesse Selber, Roman Skoracki, and Mark Villa. We gratefully acknowledge Dawn Chalaire, Associate Editor of Dept. Scientific Publications at MD Anderson Cancer Center for her assistance with technical writing.*

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