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主論文

ORIGINAL ARTICLE

Natural mastopexy repositioning based on age-related mean breast shape

Tatsuki Kono*, Taro Kusano, Nobuhiro Sato, Shinya Yoshimoto, Seigo Nakamura

Department of Plastic and Reconstructive Surgery and Breast Surgery, Showa University School of Medicine, Shinagawa-ku, Tokyo, Japan

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KEYWORDS
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Summary *Background:* The most important element during breast reconstruction preoperative planning is determining the new position and shape of the breast. A youthful breast with no signs of ptosis may not necessarily be the ideal breast for women of all ages. However, indicators have not been established on how breasts should be positioned depending on age. We investigated and reported on the proper positioning of the breasts based on age during breast reconstruction using mean age-based data from three-dimensional (3D) modeling.

Methods: We photographed 110 breast cancer patients using a compact 3D scanner and calculated the measured means. Data were grouped according to age group. Three-dimensional simulation images from all patients were reconstructed from the data. Breasts from all age groups were divided into healthy and affected breasts. For each measured value, the means of the two groups were compared.

Results: There were no major differences in the mean values in the 30s, 40s, and 50s age groups. Major changes were noted in the 60s age group compared with the 30s, 40s, and 50s age groups. There were no statistically significant differences between healthy and affected breasts.

Conclusions: This is the first study to use a 3D method to calculate the means based on age group. This study showed that particular attention should be paid to age-related changes during breast reconstruction surgeries for women aged ≥60 years. We believe that the method used in our study on mean breast shape based on age group can be used as a reference or indicator to ensure that the reconstruction of natural breasts befits the age of the patient.

* Corresponding author. Department of Plastic and Reconstructive Surgery and Breast surgery, Showa University School of Medicine, 1-5-8, Hatanodai, Shinagawa-ku, Tokyo, 142-8666, Japan.
E-mail address: t2kinkin@gmail.com (T. Kono).

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1. Introduction

In breast reconstruction, breast reduction and mastopexy of the healthy side are often required to achieve bilateral symmetry of the breasts. The most important element during preoperative planning in such situations is determining the new position and shape of the breast. Textbooks document breast measurement data for what is considered a beautiful breast and can be referred to as an indicator during the preoperative planning of breast design. With age, the breasts become larger, the upper pole fullness is lost, and signs of ptosis appear. However, indicators have not been established on how breasts should be positioned depending on age, and, at present, surgeons are expected to make a decision on the basis of their experience. Several papers have measured breast sizes and calculated the means to provide some indicators for use as reference values,[1–3] but these numbers do not take age into consideration. We investigated the proper positioning of the breasts based on age during breast reconstruction using age-based mean data from three-dimensional (3D) modeling.

2. Patients and methods

This study was approved by the hospital institutional ethical committee, and informed consent was obtained from all patients. We photographed 110 breast cancer patients who presented to our outpatient clinic from April 2014 to April 2015. The right breast was affected in 56 patients, the left breast was affected in 48 patients, and both breasts were affected in six patients. Age ranged from 26 years to 73 years, with a mean of 47.5 years. All patients were breast cancer patients of ≤ Stage II and none had a history of preoperative chemotherapy or breast surgery, including partial excisional biopsy history. However, history of needle biopsy was not considered because it did not seem to affect the breast shape.

Before their surgery, we calculated the measured means of the following eight items that were obtained from 3D images: breast volume; width; height; projection; distance from the sternal notch to the nipple (S-N); distance from the sternum nipple level to the nipple (M-N); distance from the nipple to the inframammary fold (N-IMF); and angle formed by a line drawn from the sternal notch to the sternal notch nipple line (Angle N; Figure 1). Of these, S-N and M-N were determined from the numbers derived from the XY plane. Because IMF is in a hidden position, N-IMF 3D measurements were inaccurate, and linear measurements were conducted instead.

Photographs were obtained using a compact 3D scanner KINECT (Microsoft, Redmond, WA, USA), and the data were processed using capture software ARTEC Studio Pro (Artec 3D, Luxembourg, Luxembourg), which was developed for high precision 3D scanners. The image data were analyzed using Breast Rugle (Medic Engineering, Kyoto, Japan) analytical software. During the analysis, one doctor was responsible for determining which landmarks to use and preparing the virtual chest wall. All patients were photographed in a normal anatomic standing position.

Measurement data were grouped on the basis of age group, and the respective means were calculated. For each measured value, age groups were compared using the Steel–Dwass test. Breasts from all age groups were divided into healthy and affected breasts, and means of the various measurements were calculated. For each measured value, the means of two groups were compared using the Student *t* test. A *p*-value of ≤ 0.05 was considered statistically significant. All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan).

3. Results

Data were analyzed according to standard statistical methods. The overall means for all patients based on age group are shown in Table 1. The measurements for each age group were compared, excluding the 20s and 70s age groups, where $n = 1$. Mean values for the 30s, 40s, and 50s age groups revealed no clear patterns by age, and there were no statistically significant differences between the groups. However, in the 60s age group, although height, M-N, and angle N showed no statistically significant differences compared with that in the 30s, 40s, and 50s age groups, other measurements showed statistically significant differences and showed a major increase (Figure 2).

The reconstructed 3D simulation images for the mean breast shapes based on age group for all patients are shown in Figure 3. Measured data did not reveal any major differences among the 30s, 40s, and 50s age groups. However, as age increases, associated aging changes are more likely to appear in the breasts. Measurement results were separated into affected and healthy breasts, and there were no statistically significant differences between them (Table 2).

4. Discussion

During breast reconstruction, breast reduction and mastopexy of the healthy breast may often become necessary to maintain bilateral symmetry of the breasts. One of the most important elements during preoperative planning is determining the new position and shape of the breast. There are several surgical techniques for breast reduction and mastopexy, such as periareolar, vertical, and inverted T incisions; some studies have reported on how to establish the nipple position, which provides an indicator for the preoperative design. A line is drawn from the clavicle or sternal notch to the nipple, a specific distance is designated along that line,[4–6] and the position is determined on the basis of the IMF position or midpoint of the humerus.[7–12] There are several other methods,[13] but, in the majority of these, designs are solely based on esthetically perfect breasts, and none of them take natural aging into account.

In general, as breasts age, they become larger, the upper pole fullness is lost, and ptosis is observed. Regnault's breast ptosis classification is typically used to evaluate these changes.[14] Aging effects are thought to be caused by the weakening of the fascial ligamentous support system of the breast and not merely by sagging skin.[15] We believe that these aging phenomena are not necessarily unattractive and represent *naturalness befitting the age*. Allow us to consider what *naturalness befitting the age* should look like.

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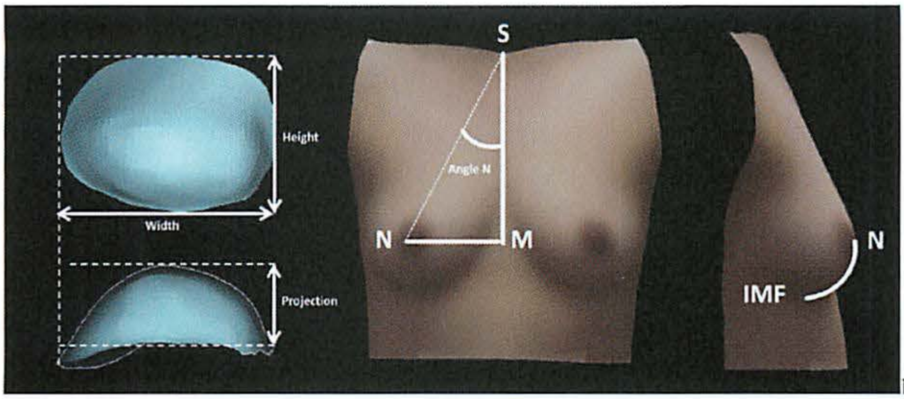

Figure 1 Items measured. Volume (mL), width (cm), height (cm), projection (cm), S-N (cm), M-N (cm), N-IMF (cm), and angle N (°) were the eight items measured. Angle N = angle formed by a perpendicular line from the sternal notch and the sternal notch to the nipple line; IMF = inframammary fold; M = sternum of nipple level; N = nipple; S = sternal notch.

Table 1 Mean data based on age group for all women.

Age, [y (*n*)]	All ages (*n* = 110)		20–29 (*n* = 1)		30–39 (*n* = 15)		40–49 (*n* = 53)		50–59 (*n* = 30)		60–69 (*n* = 10)		70–79 (*n* = 1)	
Side	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Volume (mL)	232.92	251.15	315.40	261.00	218.53	235.14	232.29	215.54	232.01	260.09	328.34	325.06	393.50	441.00
Width (cm)	14.47	14.64	14.50	14.60	14.62	14.69	14.32	14.12	14.49	14.70	15.70	15.84	16.90	18.10
Height (cm)	14.44	14.56	15.50	15.20	14.04	14.11	14.38	14.31	14.43	14.68	15.59	15.55	15.60	16.00
Projection (cm)	3.99	4.12	5.20	4.70	3.67	3.85	4.10	3.84	3.67	4.06	4.70	4.54	4.60	5.10
S-N (cm)	18.95	19.32	18.32	17.81	18.97	19.11	18.99	19.15	18.74	19.38	20.97	20.88	21.49	22.61
M-N (cm)	9.06	9.45	9.77	9.72	8.98	9.59	9.30	9.01	9.00	9.51	9.85	9.53	8.78	9.72
N-IMF (cm)	6.41	6.41	7.00	7.50	6.43	6.60	6.21	6.23	6.20	6.29	7.56	7.50	8.50	8.00
Angle N (°)	28.41	29.35	32.20	33.10	28.2	30.0	29.29	28.52	28.74	29.47	28.26	27.18	24.1	25.4

Angle N = angle formed by a perpendicular line from the sternal notch and the sternal notch to the nipple line; M-N = distance from the sternum of the nipple level to the nipple; N-IMF = distance from the nipple to the IMF; S-N = distance from the sternal notch to the nipple.

Based on the breast measurements of 100 topless models, Mallucci and Branford[16] stated that an ideal breast should aim for the following: the ratio of the upper to lower pole is 45:55, the angulation of the nipple is upward with a mean angle of 20° from the nipple meridian, the upper pole slope is linear or slightly concave, and the lower pole is convex. It is true that cosmetic surgery patients who are looking for mammoplasty such as augmentation prefer a youthful breast.[17,18] However, significant differences in breast shape preferences have been demonstrated between cosmetic breast surgery patients and reconstructive breast surgery patients.[19] Reconstructive breast surgery patients are less concerned about superomedial fullness to create cleavage than cosmetic surgery patients, and they are more concerned about asymmetry.[19] They tend to ask for a more naturally shaped breast. In addition, plastic surgeons and patients may have drastically different images of breast shape.[20] Furthermore, country of residence, age, and practice type significantly impact breast shape preferences of plastic surgeons.[21] In particular, Japanese women tend to be modest and do not wish to stand out from others, and thus, would prefer a natural breast shape rather than esthetically perfect breasts. Thus, a youthful breast with no signs of ptosis may not necessarily be the ideal breast for women of all ages. Obviously, it would be unnatural if a woman in her 60s had breasts shaped like a 20-year-old. Therefore, the goal is not necessarily to create esthetically perfect breasts but to create normal, age-appropriate breasts. Normally, we refer to the mean values for each age group. If the same method as that in our study is taken into consideration during the preoperative planning of breast reconstructions, it may be possible to create a more natural-looking breast.

Breasts have been measured in the past, and some researchers also calculated various mean measurements, as determined in our study.[1–3] Breast measurements by Penn[1] have had a major impact on subsequent designs by surgeons, although they only chose esthetically perfect female models as their participants. Smith et al[2] chose *normal* female volunteers without any esthetic judgment using a population similar to that of our study. However, their participants were aged 18–31 years, resulting in a skewed age range. Compared with the results from our investigation, there was a difference in breast volume, and this was believed to be because of racial differences between Japanese and American/European females.

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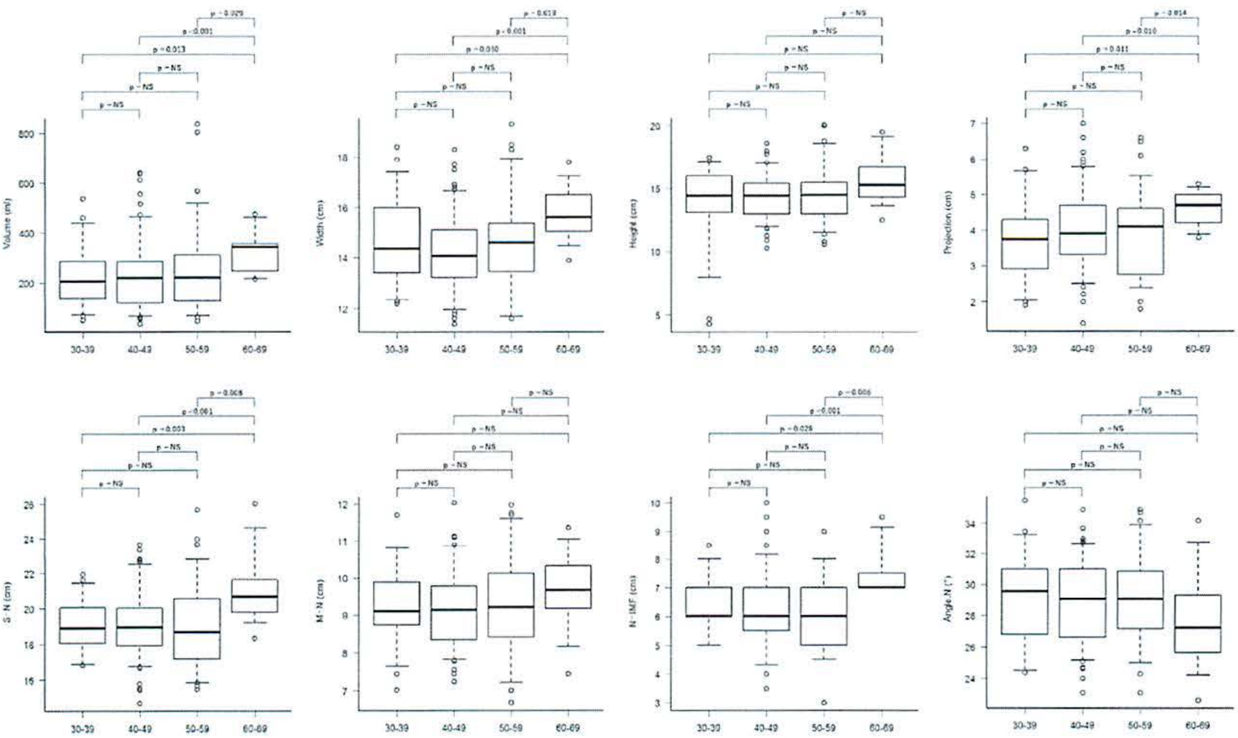

Figure 2 Box plots of each measured value between age groups. The solid line in the middle of the box represents the median value, the upper *and* lower extremes of the box represent 25th and 75th percentiles, and the bars represent the 5th and 95th percentile. Difference between each age group is indicated using *p* values (Steel–Dwass test; NS = not significant; $p < 0.05$). Volume, width, projection, S-N, and N-IMF for women in the 60s age group were statistically significant compared with those in the 30s, 40s, and 50s age groups. N-IMF = distance from the nipple to the IMF; S-N = distance from the sternal notch to the nipple.

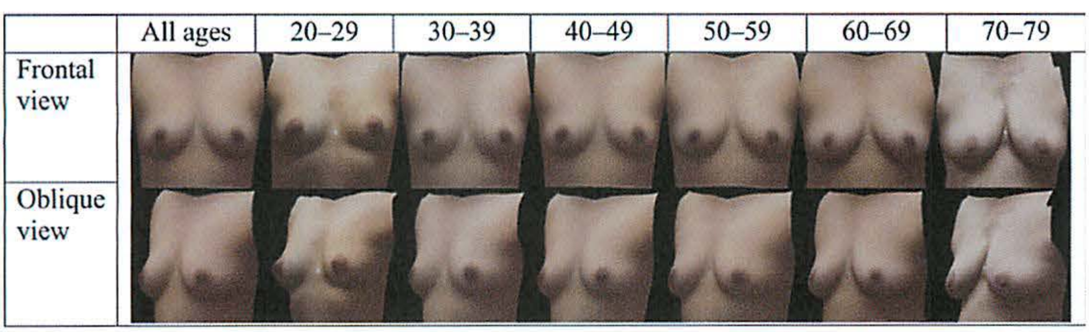

Figure 3 Three-dimensional simulation images of mean breast shapes for each age group. The reconstructed three-dimensional simulation images for the mean breast shapes based on age group for all patients. As age increases, associated aging changes are more likely to appear in the breasts.

There has been a recent increase in the number of published reports on breast measurements using 3D modeling.[22–28] However, ours is the first study that has used 3D methods to calculate the means by age group. Xi et al[29] reviewed 74 articles that measured breast size and then classified and compared various breast measurement methods to see if there were any differences between 3D methods and linear measurements. Shape measurements showed that linear measurements provided data that were comparable with data derived by 3D methods and that 3D modeling is the most reliable tool for volume measurement.[29]

There are many advantages of using 3D methods. The patient and surgeon find it easier to imagine the reconstructed breast by looking at a reconstructed 3D image. Compared with actual measured data, the 3D method also enables accurate volume measurements.[29] Based on these measurements, excision volumes can be estimated preoperatively, allowing the reconstruction of a more symmetrical breast.[28] It is also easy to compare breasts visually

Table 2 Mean comparisons of healthy and affected breasts.

Side	Healthy	Affected	*p*
Volume (mL)	247.65	237.00	0.56
Width (cm)	14.62	14.50	0.59
Height (cm)	14.55	14.45	0.70
Projection (cm)	4.08	3.91	0.24
S-N (cm)	18.91	18.81	0.69
M-N (cm)	9.31	9.21	0.50
N-IMF (cm)	6.45	6.35	0.58
Angle N (°)	28.91	28.85	0.85

Angle N = angle formed by a perpendicular line from the sternal notch and the sternal notch to the nipple line; M-N = distance from the sternum of the nipple level to the nipple; N-IMF = distance from the nipple to the IMF; S-N = distance from the sternal notch to the nipple.

before and *after* reconstruction, making this an excellent assessment method.

Although 3D cameras may be more expensive and capturing images may be difficult, the 3D KINECT scanner (Microsoft) that we used in our study was compact, easy to handle, and inexpensive compared with traditional 3D cameras. However, the creation of a virtual chest wall is still necessary, and there are practical limitations such as problems with reproducibility caused by error and variability among surgeons in judging margins and landmarks.[30] Moreover, in breasts with severe ptosis, landmarks tend to become inaccurate and imaging certain less-illuminated areas such as the underside of the breast may necessitate challenging techniques.[24,25,27,28]

During our measurements, the distance from the nipple to IMF alone was inaccurate; therefore, we used actual linear measurements. This is one of the problems with 3D measurements, but we believe that technological and technical advances will resolve such problems.

Surprisingly, there were no major differences in the mean values in the 30s, 40s, and 50s age groups. Major changes were noted in the 60s age group compared with the 30s, 40s, and 50s age groups, and, based on these data, it appears that changes associated with aging rapidly occur in women in their 60s. In particular, age-related changes observed in this group include increases in breast volume, a bigger breast shape in terms of width and projection, and signs of ptosis. If this assumption is correct, we may need to be particularly careful about age-related changes during breast reconstruction surgeries for women aged ≥60 years. That is, it is necessary to increase the volume of the breast and set the position to be slightly lower compared with the other ages in breast reconstruction surgeries for women aged ≥60 years. Similarly, when breast reduction and mastopexy of the healthy breast are required, excessive superior reposition and volume reduction should be avoided.

Although there were no major changes in the measured data in the 30s, 40s, and 50s age groups, this was inconsistent with the simulated images that showed signs of breast aging with increasing age. Age-related changes such as a decrease in upper pole fullness may be the cause of this. The method for accurately reflecting minor age-related changes in breast reconstruction surgery that cannot be calculated on the basis of the items measured in this study may be a future area for research. Selecting the appropriate measurement to monitor age-related changes is thought to be a vital topic.

Because the women in our study were breast cancer patients, they were predominantly in their 40s and 50s, and the data became skewed because very few of them were in their 20s, 30s, or 60s. In other words, our findings of major changes in the data for patients aged ≥60 years may be lacking in precision. If we can measure more women in their 20s and 60s, it should be possible to calculate age-related differences more accurately. Other study limitations include the fact that breast volume, height, body mass index (BMI), torso width, breastfeeding history, brassiere use history, and other factors that can potentially affect the shape of the breast had not been taken into consideration. Further investigations are required to address these issues; specifically, height and BMI will affect S-N and N-IMF and torso width has a major impact on M-N.[19,31] Thus, grouping women on the basis of their height, BMI, and torso width and determining the respective means may provide another indicator.

Another finding was that there were no significant differences in the measured values between affected and healthy breasts. However, tumor size can potentially affect the shape of the breast, which had not been taken into consideration. If this aspect was considered, we would have obtained more appropriate results. Nevertheless, we believe that our results reinforce the findings from preceding studies conducted in healthy volunteers. Although we only studied Japanese women, the same method could be employed in other ethnic groups, and it should be possible to calculate mean breast shapes by age regardless of race.

There is a tendency for the nipple to deviate after surgery, and the final nipple position is less controllable.[32] There are also various technical restrictions involved in the actual surgical procedure, and it is impossible to reproduce the data completely in actual practice. These data are only for reference. In the future, we hope to apply these results during breast reconstruction.

Although limited by a variable number of participants in each age group and possible issues in the selection of measurement parameters, we think that the method used in our study on mean breast shapes based on age group can be used as a reference or indicator to ensure the reconstruction of natural breasts that befits each patient's age.

Conflicts of interest

The authors declare that they have no conflict of interest.

References

1. Penn J. Breast reduction. *Br J Plast Surg*. 1955;7:357–371.
2. Smith Jr DJ, Palin Jr WE, Katch VL, Bennett JE. Breast volume and anthropomorphic measurements: normal values. *Plast Reconstr Surg*. 1986;78:331–335.
3. Westreich M. Anthropomorphic breast measurement: protocol and results in 50 women with aesthetically perfect breasts and clinical application. *Plast Reconstr Surg*. 1997;100:468–479.

4. Strombeck JO. Mammaplasty: report of a new technique based on the two-pedicle procedure. *Br J Plast Surg*. 1960;13:79–90.
5. Dufourmentel C, Mouly R. Mammaplasty by the oblique method. *Ann Chir Plast*. 1961;6:45–58 [In French].
6. Keskin M. Seventeen years of experience with reduction mammaplasty avoiding a vertical scar. *Aesthetic Plast Surg*. 2008;32:653–659.
7. Pitanguy I. Surgical treatment of breast hypertrophy. *Br J Plast Surg*. 1967;20:78–85.
8. Vogt PM, Mühlberger T, Torres A, Peter FW, Steinau HU. Method for intraoperative positioning of the nipple–areola complex in vertical scar reduction mammaplasty. *Plast Reconstr Surg*. 2000;105:2096–2099.
9. De Benito J, Sánchez K. Key points in mastopexy. *Aesthetic Plast Surg*. 2010;34:711–715.
10. Maliniac JW. *Sculpture in the Living*. New York: Grune and Stratton; 1934:112.
11. Maliniac JW. *Breast Deformities and their Repair*. New York: Grune and Stratton; 1950:68–72.
12. Lassus C. Update on vertical mammaplasty. *Plast Reconstr Surg*. 1999;104:2289–2298. discussion 2299–2304.
13. Gulyás G. Marking the position of the nipple-areola complex for mastopexy and breast reduction surgery. *Plast Reconstr Surg*. 2004;113:2085–2090.
14. Regnault P. Breast ptosis. Definition and treatment. *Clin Plast Surg*. 1976;3:193–203.
15. Grotting JC, Chen SM. Control and precision in mastopexy. In: Nahai F, ed. *The Art of Aesthetic Surgery: Principles and Techniques*. St Louis: Quality Medical; 2005:1907–1950.
16. Mallucci P, Branford OA. Concepts in aesthetic breast dimensions: analysis of the ideal breast. *J Plast Reconstr Aesthet Surg*. 2012;65:8–16.
17. Swanson E. Five-year prospective outcome study in 325 cosmetic breast surgery patients. *Plast Reconstr Surg*. 2008; 122:112–113.
18. Mallucci P, Branford OA. Population analysis of the perfect breast: a morphometric analysis. *Plast Reconstr Surg*. 2014; 134:436–447.
19. Liu YJ, Thomson JG. Ideal anthropomorphic values of the female breast: correlation of pluralistic aesthetic evaluations with objective measurements. *Ann Plast Surg*. 2011;67:7–11.
20. Hsia HC, Thomson JG. Differences in breast shape preferences between plastic surgeons and patients seeking breast augmentation. *Plast Reconstr Surg*. 2003;112:312–320. discussion 321–322.
21. Broer PN, Juran S, Walker ME, et al. Aesthetic breast shape preferences among plastic surgeons. *Ann Plast Surg*. 2015;74: 639–644.
22. Galdino GM, Nahabedian M, Chiaramonte M, Geng JZ, Klatsky S, Manson P. Clinical applications of three-dimensional photography in breast surgery. *Plast Reconstr Surg*. 2002;110:58–70.
23. Tanabe YN, Honda T, Nakajima Y, Sakurai H, Nozaki M. Intraoperative application of three-dimensional imaging for breast surgery. *Scand J Plast Reconstr Surg Hand Surg*. 2005;39: 349–352.
24. Kovacs L, Yassouridis A, Zimmermann A, et al. Optimization of 3-dimensional imaging of the breast region with 3-dimensional laser scanners. *Ann Plast Surg*. 2006;56:229–336.
25. Losken A, Seify H, Denson DD, Paredes Jr AA, Carlson GW. Validating three-dimensional imaging of the breast. *Ann Plast Surg*. 2005;54:471–476. discussion 477–478.
26. Tepper OM, Small K, Rudolph L, Choi M, Karp N. Virtual 3-dimensional modeling as a valuable adjunct to aesthetic and reconstructive breast surgery. *Am J Surg*. 2006;192:548–551.
27. Nahabedian MY, Galdino G. Symmetrical breast reconstruction: is there a role for three-dimensional digital photography? *Plast Reconstr Surg*. 2003;112:1582–1590.
28. Nahabedian MY. Invited discussion: Validating three-dimensional imaging of the breast. *Ann Plast Surg*. 2005;54: 477–478.
29. Xi W, Perdanasari AT, Ong Y, et al. Objective breast volume, shape and surface area assessment: a systematic review of breast measurement methods. *Aesthetic Plast Surg*. 2014;38:1116–1130.
30. Swanson E. A measurement system for evaluation of shape changes and proportions after cosmetic breast surgery. *Plast Reconstr Surg*. 2012;129:982–992.
31. Vandeput JJ, Nelissen M. Considerations on anthropometric measurements of the female breast. *Aesthetic Plast Surg*. 2002;26:348–355.
32. Spear SL, Albino FP, Al-Attar A. Classification and management of the postoperative, high-riding nipple. *Plast Reconstr Surg*. 2013;131:1413–1421.

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