# The Use of 3D Imaging to Avoid Asymmetry and Aesthetic Problems in Cosmetic Breast Surgery

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## Introduction

> In treating breast asymmetry, the best we can hope for is a different set of differences [1]. –Dr. John Tebbetts

Developing a process for patient education for any procedure can help to manage expectations and improve patient satisfaction [2–4]. Reoperation after breast augmentation often results from failing to meet the patients' expectations in regard to size, shape, and symmetry. It is often difficult for a patient to visualize the potential post-operative result, which can make her uncomfortable with her decision to have breast surgery and can lead to an unhappy patient after surgery. If a patient is directly involved in the decision-making process, she is more likely to understand what can and cannot be achieved within the limits of her underlying anatomy and tissue characteristics with cosmetic breast surgery [5]. Reviewing the patient's photos, showing her another patient's results who has similar anatomy, drawings, or breast sizers can be used to give the patient an idea of the potential results, but not all patients can visualize their results with those modalities [6].

Three-dimensional (3D) imaging is a tool that allows the surgeon and patient to review her own anatomy in order to appreciate her asymmetry, ptosis, shape, and size prior to undergoing surgery. Because you can almost never find another patient with exactly the same anatomy for the example photos, 3D imaging allows a patient to see her possible result and understand her inherent asymmetry and tissue characteristics. Simulations can then be performed with various implants of different dimensions and shapes to give the patient a visual idea of her potential outcome from surgery. This is especially important in patients with pre-operative asymmetry. These patients need to understand the cause of their asymmetry and that no asymmetry can be completely corrected. Even with our best efforts, we can never absolutely correct volume, chest wall, or nipple position asymmetry, and in improving some elements of asymmetry, we have to be willing to accept some tradeoffs [7].

Educating patients on those tradeoffs for improving symmetry with implants of different sizes and dimensions can help them in the decision-making process and manage post-operative expectations, which can lead to better patient satisfaction after surgery. By participating in the selection of the size and shape of the implant to be used, the patient will also have some "ownership" of final result which may lessen the tendency of second guessing the size implant chosen for cosmetic breast augmentation [5].

## 3D Imaging

3D imaging was initially used in plastic surgery for evaluation of facial symmetry over time in the late 1970s. The initial systems were expensive and time-consuming to use.

Stereophotogrammetry uses two cameras in specific arrangement to allow for depth perception giving a more realistic simulation. In newer systems, the raw images are converted using software specific to creating 3D images [8]. Over the past 30 years, software developments have evolved that allow rapid evaluation and 3D reconstruction of images, allowing images to be rotated for visualization of lateral and three-quarter views, and reliable distance and volume measurements can be performed. The most current systems use passive stereophotogrammetry, which can capture images in milliseconds. Systems are available now that use handheld cameras, iPads, or equivalent, which are portable and more cost-effective. Since 2005 3D imaging for breast measurements and assessment of surgical outcomes have been used with studies validating the accuracy of results [9]. Adams

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J. Y. S. Kim (ed.), *Managing Common and Uncommon Complications of Aesthetic Breast Surgery*,
https://doi.org/10.1007/978-3-030-57121-4_10

showed a 90% correlation between 3D imaging simulation and surgical results [10]. Myckatyn et al. also showed a 91% correlation between imaging and measured post-operative volumes [11].

## Breast Asymmetry

Studies have shown that, if carefully examined, the incidence of breast asymmetry is over 95% if parameters such as volume, sternal notch to nipple distance, IMF location, N:IMF distance, width of the breast, and chest wall positioning are measured [12]. Some patients present for consultation with the specific goal of improvement of asymmetry; however, most patients are unaware of subtle differences which may be magnified in their larger post-operative breast and can be a cause of patient dissatisfaction after surgery. Developing a consultation process which allows the patient to be educated on her pre-operative anatomy with a discussion of what can and cannot be changed and what tradeoffs she may be willing to accept to achieve improved symmetry or improve the size and/or shape of her breast can help to avoid post-op dissatisfaction.

## Patient Consultation Process

Having a process in place allows consistency in the consultation process. What works for any surgeon or patient differs, but basic principles should be followed for each consult with adaptations as indicated [14].

Some surgeons use 3D imaging during the initial patient consultation; others will have the patient return for imaging at a second consultation; the utilization needs to fit the surgeon's style of consultation. Patient portals can be set up for patients to be able to review their simulations on their own computers which can be useful if a spouse or significant other was unable to attend the patient's consultation. Some surgeons charge a fee for 3D imaging, which is discounted from the surgeon's fee if the patient schedules a procedure; others do not. Some surgeons allow patients to have copies of their imaging photos and the size implants chosen; others do not for fear the patient will take the images to another surgeon who does not have 3D imaging available in their practice. These are all factors that each surgeon needs to decide for him/herself. Patients like new technology, and studies have shown that availability of 3D imaging can influence a patient's choice of the surgeon they seek for consultation [7].

Whether 3D imaging is used or not as part of the consultation process, a defined consultation process including history, physician examination, measurements, patient education, and surgical planning with a post-operative plan has been shown to lower reoperation rates and improve patient satisfaction. This will be briefly covered in the context of utilizing 3D imaging in the entire consultation process for cosmetic breast surgery.

## Medical History

One should obtain a clinical history of medical issues, medications, smoking history, allergies, personal and family history of breast disease, and bleeding or clotting disorders. Pregnancy and breast-feeding history as well as previous surgery and anesthesia history should be obtained. Mammograms pre-operatively should be performed per the recommendations of the American Cancer Society. Height, weight, and bra size should also be documented [2–4, 13].

## Patient Concerns with Her Breast and Surgical Goals

A patient's desired results and motivations for surgery should be assessed. The patient should put in writing her specific concerns about her breast pre-operatively. Is it size, shape, or sagginess? Asymmetry? What bothers her the most? Does she have goals that are realistic within the framework of her current anatomy? Is she more concerned about how she looks in clothes or out of clothes? What are her goals for cleavage and position of the breast on the chest wall? Is she concerned about being too large? Or not large enough?

## Examination

- Height, weight, BMI
- Quality of patient's tissues
- Measurements: SN:N, BW, soft tissue coverage (pinch test), N:IMF
- Breast footprint (location of the breast on the chest wall)

## 3D Imaging as Part of the Consultation

### Simulation Process

The order of the consultation process utilizing 3D imaging will vary depending on each surgeon's style and how her/his office is structured. It is not a substitute for a good physician examination and measurements to allow for dimensional planning.

After physical examination, the patient can be imaged in the 3D imaging system used by the surgeon. Some surgeons do imaging in the same room the patient is examined; others have a photography room where photos and imaging are both performed; this will depend of the configuration of the office and size of exam rooms. There are many 3D imaging systems available; each surgeon and staff need to determine which system best meets their needs in terms of cost, portability, and compatibility with the surgeon's electronic medical records systems. After the imaging and photos are completed, it is best for the patient to get dressed so she can be comfortable reviewing the images with her surgeon or some practices use a trained patient consultant for the image review. The surgeon, or patient consultant depending on the specifics of the practice, should sit down with the patient and review the 3D images on the computer screen (Fig. 10.1). Systems vary, but generally the simulation shows volume measurements for each breast, base width, nipple position measurements, and chest wall anatomy. These measurements should be explained to the patient and what asymmetries may exist in volume, nipple position, width, and her chest wall. The image can be rotated to allow the patient to see her anatomy in various positions. Simulation of various sizes and shape of implants can then be visualized with the patient's participation showing her the possible outcomes when implants of different volumes, shapes, or projections are used (Fig. 10.2). This allows implant selection to be performed in a transparent fashion with the patient understanding the reasons for choosing the implant used. Some systems allow visualization of mastopexy so patients can see the shape of the breast with and without mastopexy if indicated in the patient. Some systems also allow a swimming suit top or t-shirt to be placed on the simulation so the patient can also see a simulation with clothing.

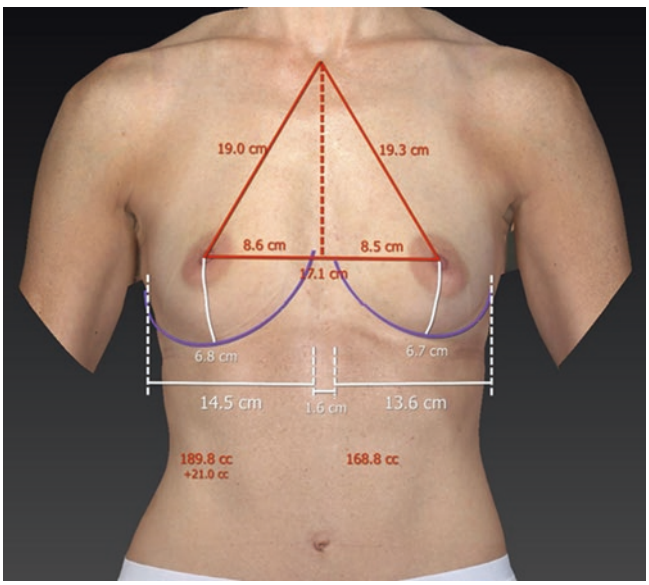


**Fig. 10.1** The assessment screen on the Vectra 3D imaging system. This is used to show the patient the measurements and point out asymmetry and can be used in surgical planning

Ultimately, the surgeon controls the simulation and must use those parameters which work with that patient's anatomy. A patient may keep asking to see the next bigger size, and although the simulation allows any size implant to be used within the simulation, the surgeon must be able to educate the patient as to why she must stay within the size range that fits the measurements obtained within the computer simulation to give her a long-lasting result [19].

## What Can the Simulation Be Used for?

### Size Selection

After reviewing the patient's anatomy, simulation can be performed with various size implants using the same or asymmetric implants with the patient's input as to her satisfaction with the size and shape of the breast. Size change accounts for a significant number of reoperations after cosmetic augmentation [17]. Patients often second guess the size of their implants and may be influenced by social media and pressure by significant others, family, and friends. With 3D imaging the patient sees her measurements on the computer screen and can better understand how the width of the implant may or may not work with her specific anatomy. Using the Vectra system, the implants that are within the measured base width of her chest are highlighted in the implant selection program on the computer screen; this allows patients to see how specific volumes may not work with her anatomy. Simulation can also be performed using implants of different sizes, shapes, or projections in each breast, so the patient can get an idea of the appearance of the breast when using asymmetric implants and understand what can and cannot be corrected in terms of asymmetry of her breasts. The patient contributes to the decision-making process, making her comfortable with the choice of implant size and less likely to second guess that choice after her surgery [5, 11, 17].

### Shape/Projection Selection

Implants of different projections and shapes can also be used and compared within the 3D simulation. A patient may come in for a consultation specifically requesting a shaped implant, but when she sees the simulation, she may determine that she wants more upper pole fill or more sloped upper pole. Various projections can be placed in the simulations and evaluated in side-by-side comparisons so the patient can choose which is more appealing to her.

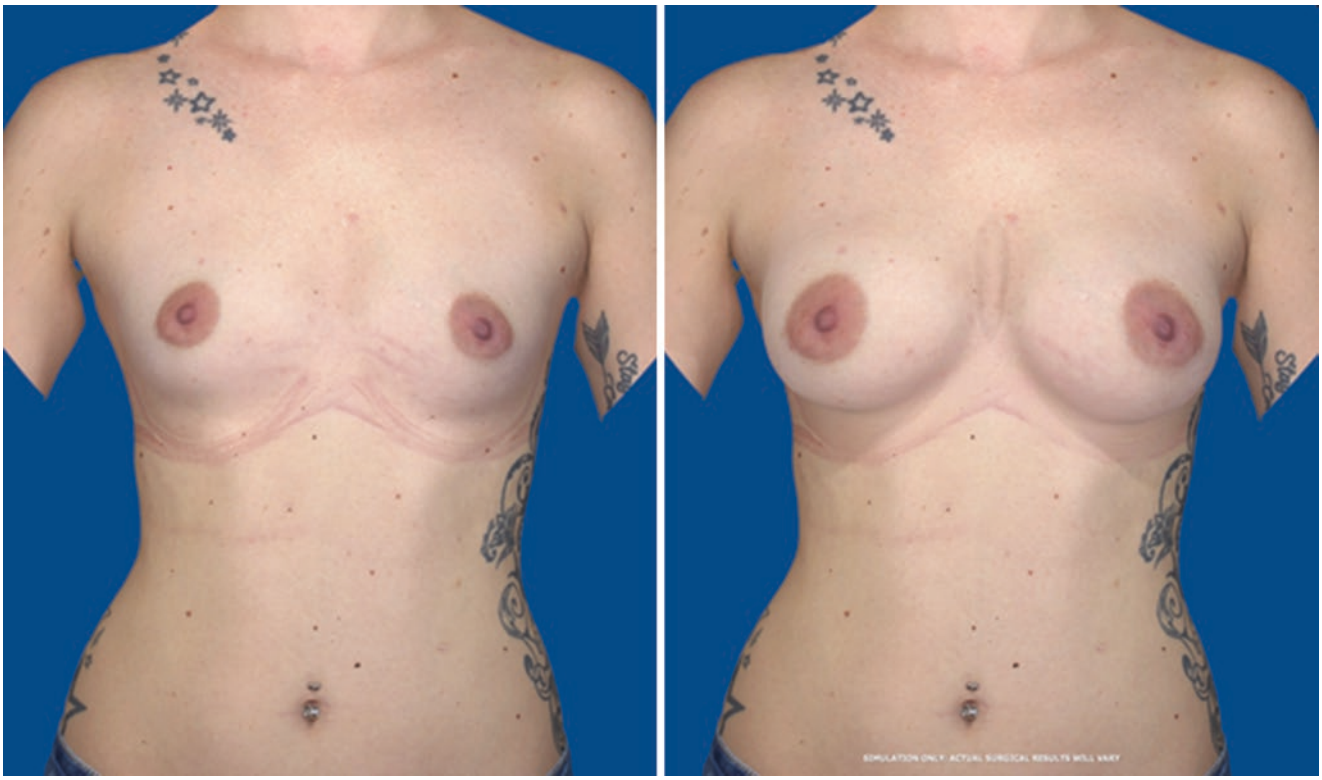

**Fig. 10.2** Various implants can be used to simulate the potential result with the patient and visualized in the simulation

## Asymmetry

All women's breasts have asymmetry; it is important to make a patient aware of any asymmetry PRIOR to her surgical procedure. Evaluation for structural asymmetry of the chest wall and spine such as scoliosis, pectus excavatum or carinatum, and thoracic hypoplasia is important as part of the pre-operative education process. 3D imaging gives the patient an estimate of the volume asymmetry between breasts, although these measurements should not override surgical judgment as studies have shown that the accuracy of volume measurements varies between systems and with patient anatomy. During simulation, asymmetric implants can be used to camouflage the patient's volume asymmetry. IMF asymmetry can be assessed, and implants adjusted in the simulation to show what can and cannot be done to adjust the asymmetry parameters [3, 4, 11].

Adams recommends using a written acknowledgment of each element of the patient's breasts that are not symmetric and having the patient sign off on those differences before surgery. It is better to be sure that a patient is aware of her asymmetries prior to surgery rather than to point them out after surgery when a patient expresses dissatisfaction [2, 14].

## Specific Asymmetry Evaluation Using 3D Imaging

### IMF Asymmetry

Maxwell showed 95% IMF asymmetry in patients presenting for breast surgery when evaluated in the Vectra system [18]. Many patients are unaware of mild asymmetries, which may be magnified with a larger breast. 3D imaging allows the patient to see the degree of IMF asymmetry in position and also depth of the fold (i.e., well-developed fold on one side versus the other). Asymmetric folds are often associated with chest wall asymmetry, which may not be correctable. It is better to point this out to patients prior to surgery with measurements of N:IMF distance, photographs, and imaging than to have an unhappy patient after surgery because she did not understand her pre-operative asymmetry.

### Volume Asymmetry

Mild asymmetry of breast volume is common and would seem to be an easy fix by placing implants of different volumes. Implants with different volumes have different dimensions, so

volume asymmetry could become a shape asymmetry; placing a larger implant in a tighter pocket can cause changes in the shape of the breast as a tradeoff for volume symmetry, and the patient has to be able to visualize those tradeoffs to see if it is worthwhile for her. How do you determine the volume differences? 3D imaging can be used for volume estimates and to determine breast volumes. Simulations can give the patient an idea of the tradeoffs involved in using implants of different dimensions, although volume measurements have been shown to be the least consistent in 3D measurements. After imaging within the 3D system, the patient should sign off on the size and shape implants chosen using the system. The measurements obtained with imaging can help the surgeon and patient determine the amount of volume asymmetry and visualize the potential results of using different sized and/or shaped implants with the simulation. 3D imaging has been shown to be 90% accurate in post-operative simulations, although recent publications have shown that volume assessment is not always accurate [5, 10, 19], so the use of intraoperative sizers is recommended for patients with significant asymmetry in breast volume. Having an idea of the asymmetry, and therefore the ability to develop a surgical plan, can shorten operative times, requiring fewer implants to be ordered with lower costs of shipping.

### Nipple Position Asymmetry

Almost all women have some degree of nipple position asymmetry, which can be caused by asymmetric ptosis, chest wall asymmetry, and asymmetry of the footprint of the breast on the chest wall. Patients are often unaware of mild nipple position asymmetry prior to surgery, and again, it is best to point this out to the patient prior to surgery. For ptosis, 3D imaging can be used to simulate mastopexy so the patient can appreciate the tradeoff of scars for nipple position asymmetry [4, 14].

### Chest Wall Asymmetry

Pre-operative evaluation of chest wall asymmetry allows the patient to see what she may be completely unaware of and lower the risk of post-operative dissatisfaction with the results of her surgery. Chest wall asymmetry can be difficult for the patient to appreciate. The asymmetry can be illustrated using different positions in the 3D imaging that cannot be appreciated using only her photographs. Using different heights and projections of implants can help to camouflage some chest wall asymmetry but can be more difficult to correct than other forms of asymmetry. Visualizing with 3D imaging can help with surgical planning and manage the patient's expectations.

### Mastopexy

Patients with ptosis that cannot be corrected by filling the envelope with an implant alone may not be willing to accept scar from a mastopexy as a tradeoff. Those patients may say that they prefer to have implants and accept the loose skin, only to change their mind after surgery, when their lower pole is not adequately filled by an implant. For those patients, 3D imaging can be invaluable as part of the pre-operative educational process. Mastopexy simulation can be done on one or both sides for asymmetry and as a periareolar, vertical, or Wise pattern mastopexy in some systems. Simulations are not as accurate in patients with any degree of ptosis, and the breast volume cannot be decreased, so the use is limited. 3D imaging can give the patient an idea of the possible size/shape of the breast with and without mastopexy and could also be valuable for a patient to determine not to have surgery if her desires cannot be met or she is willing to accept the tradeoffs, such as scars or a volume that is larger or smaller than she may desire [15].

## Potential Benefits from Using 3D Imaging

### Reoperation Rate Reduction/Patient Satisfaction [16]

There are many reasons for reoperation after breast augmentation surgery. Some factors are related to surgical decisions, and others are related to patient factors such as age, weight gain or loss, pregnancy, and patient wish for a different sized or shaped implant. Oversized implants can lead to soft tissue stretch, atrophy of the breast tissue, and malposition [2]. Including the patient in the decision-making process and using her anatomy as the template to determine the implant most appropriate for her may reduce the incidence of reoperation. Although there are no studies that confirm a higher patient satisfaction rate or lower reoperation rate, there are studies that show that the majority of patients who underwent simulation felt that the simulations accurately reflected their result [3, 10, 11].

### Conversion Rates

Heden et al. showed an increase in conversion rates in patients who had 3D imaging as part of their consultation

[5]. For any cosmetic procedure, issues that may keep a patient from scheduling surgery include safety, cost, and concern about the resulting appearance. Giving the patient an idea of the possible results by using her anatomy can help a patient feel more comfortable about moving forward with the process and scheduling her surgery.

Studies have shown that patients use the availability of 3D imaging to influence their choice of surgeon for breast augmentation [5, 11]. Although surgeons who use 3D imaging anecdotally feel they have higher conversion rates and lower dissatisfaction post-operatively, there have been no definitive studies thus far that have shown if reoperation rates decline or if patient satisfaction is higher in patients who have undergone pre-operative imaging. What may be as important to increasing conversion rates for cosmetic consultations is to discourage patients who have unrealistic expectations from undergoing a cosmetic procedure for which their goals may not be met. The patient who needs a mastopexy, but does not want scars, may think that a larger breast will meet her needs, but when faced with the result of an augmentation without mastopexy with 3D imaging, she may rethink whether she is willing to accept mastopexy scars, or if she is better off not having a procedure at all.

## Alternatives to 3D Imaging for Patient Consultation with Asymmetry

Fewer than 15% of plastic surgeons in the United States use 3D imaging as part of their consultation process, so there are other options available for patient education [3]. Reviewing the patient's 2D photos with her, pointing out any asymmetries, and having her sign off on the asymmetries help the patient to understand the size and shape of her pre-operative breasts, but it does not give the patient an idea of her potential results. Another common technique used in consultation is to show patients before and after photos of other patients with similar anatomy to show the limitations of what can be done. Stand in front of a mirror with the patients to point out her anatomic variations. Use a checklist and have the patient sign off on the noted asymmetries. Drawings and annotations on the patient's own photographs can also be used as part of the educational process. Bra sizers are often used in conjunction with 3D imaging to give the patient another perception of her result, such as how she will look in clothes [6, 17].

## Tips for Using 3D Imaging

### Limitations

Patients with a loose skin envelope or any degree of ptosis will not give as accurate a result in the simulation. Often the nipple position and cleavage may seem more lateral than they will be in person. Having a before/after book with patients' simulations and their actual results can be useful, especially for patients who have any ptosis or who have a wide pre-operative cleavage [15, 20].

## Using the 3D Images in Clinical Practice

### Patient Consultation

3D imaging is not a substitute for a physical examination; it is a tool that allows communication with the patient about her anatomy and how that anatomy can or cannot be surgically altered to meet her surgical goals. Using the imaging, reviewing the patient's photos, and having an honest discussion make the patient a part of the surgical decision-making process and help her to understand the potential outcome and limitations of her surgical result. This can manage expectations and lead to better satisfaction with the results and potentially lower the risk of reoperation. Imaging with the patient's own anatomy potentially shortens consultation time, since the patient can see her own anatomy; this eliminates time spent explaining the differences in results from photos of other patients who did not have the exact anatomy of the patient, which can lead to long explanations of the differences between her and another patient with similar, but not duplicate, anatomy. Also, the use of bra sizes can be time-consuming and not always accurate, because what can fit in a bra cannot always fit in the body [21].

### Using 3D Imaging in Surgical Planning

Although 3D imaging systems are made to be easy to use and are straightforward in most cases, there are tricks for getting the most out of the individual images. Although the algorithms in the systems are mathematical, there is a degree of "art" in getting the most useful images. Most systems use landmarks for the imaging simulation; these usually include the sternal notch, nipple position, IMF position, medial and lateral border, or the breast. Some systems "auto landmark" the patient's breasts. These marks are generally adequate for patients with relatively normal breasts, without significant asymmetry. However, for a patient with a constricted breast, it is best to lower the landmark in the IMF; otherwise, the implant will image in an abnormally high position using the patient's high, tight fold, when surgically that fold will be lowered, by necessity, in correcting that patient's deformity. Implants can also be repositioned on the screen to adjust to the patient's breast footprint. For surgeons just beginning to use a system, practicing on the built-in simulations in the system can be useful to allow the surgeon to feel comfortable when doing consultations early in the implementation process.

The systems contain example cases, and before utilizing systems with patients, surgeons and patient consultants should perform practice simulations to be comfortable with the system, including placing asymmetry implants, repositioning implants within the simulations, and adjustment of the landmarks.

## Case Examples

### Case 1 (Fig. 10.3a, b)

This 22-year-old woman has congenital asymmetry. She has volume, nipple position asymmetry, N:IMF asymmetry, and base width asymmetry. The 3D imaging shows a volume asymmetry of almost 200 cc, which was more volume asymmetry than expected by her physical exam. In the simulation, a 335-cc implant was chosen for the smaller right breast and 160 cc for the larger left breast. In surgery, sizers were used, and it was determined that the sizes chosen during the simulation gave the best asymmetry. Using pre-operative images, the appropriate implants were ordered and available in the operating room. The post-operative photos are 5 years post-op.

### Case 2 (Fig. 10.4a, b)

This patient has asymmetry in the footprint of her breast on the chest wall. The left breast sits lower on the chest wall, and she has a longer N:IMF distance on the left than the right, which the patient was unaware of prior to seeing the 3D imaging, Reviewing this with the patient on a screen allows her to see her own anatomy and understand the limitations on achieving absolute symmetry. She also has some volume asymmetry. The patient participates in the process of implant selection, which can improve patient satisfaction post-operatively. Different volume and projection implants were used to improve symmetry. Photos are 2 years post-op.

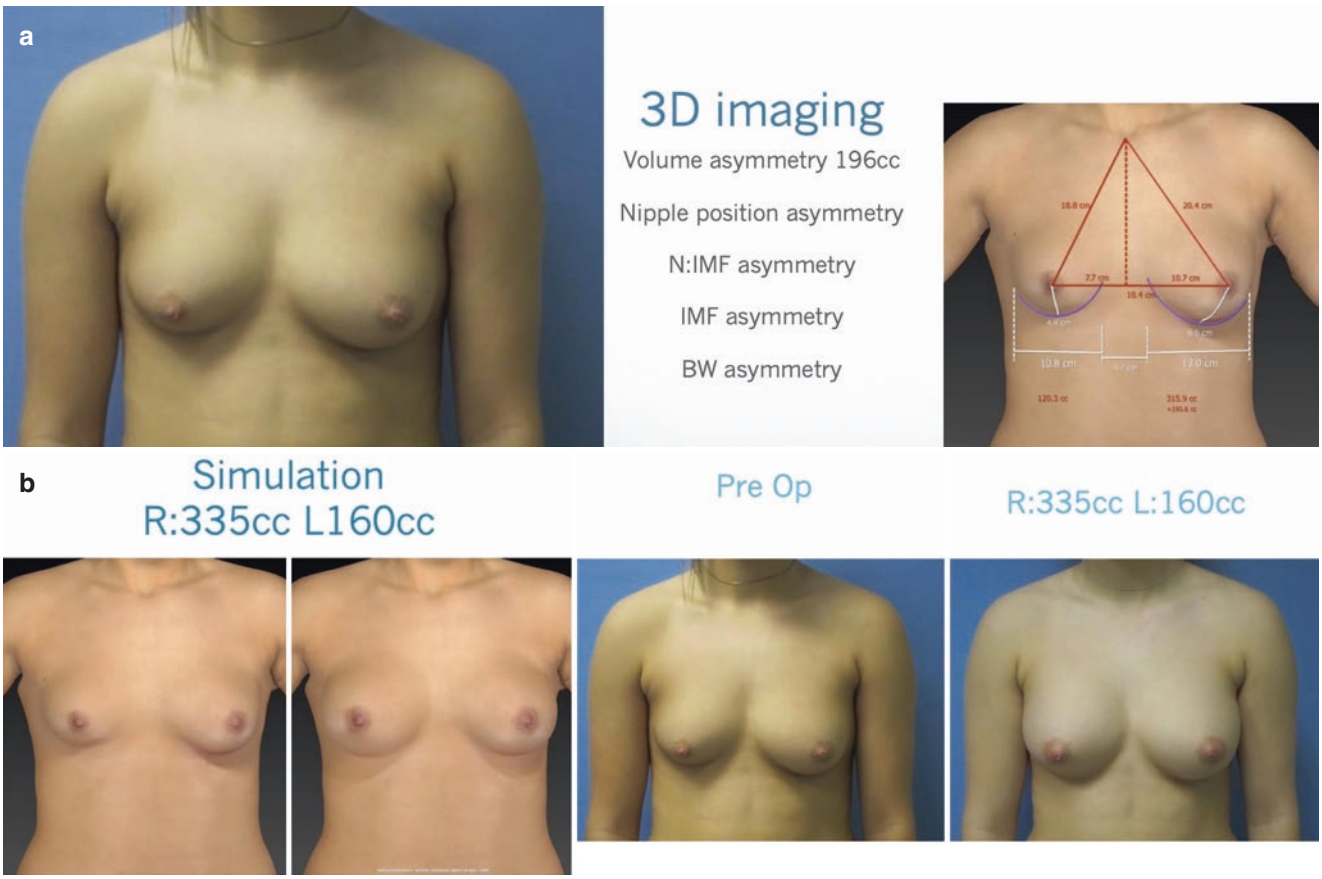


**Fig. 10.3** (**a**) Pre-operative and 3D assessment with measurements. (**b**) 3D simulation of asymmetric implants and 5-year post-operative images of a 22-year-old woman who has congenital asymmetry

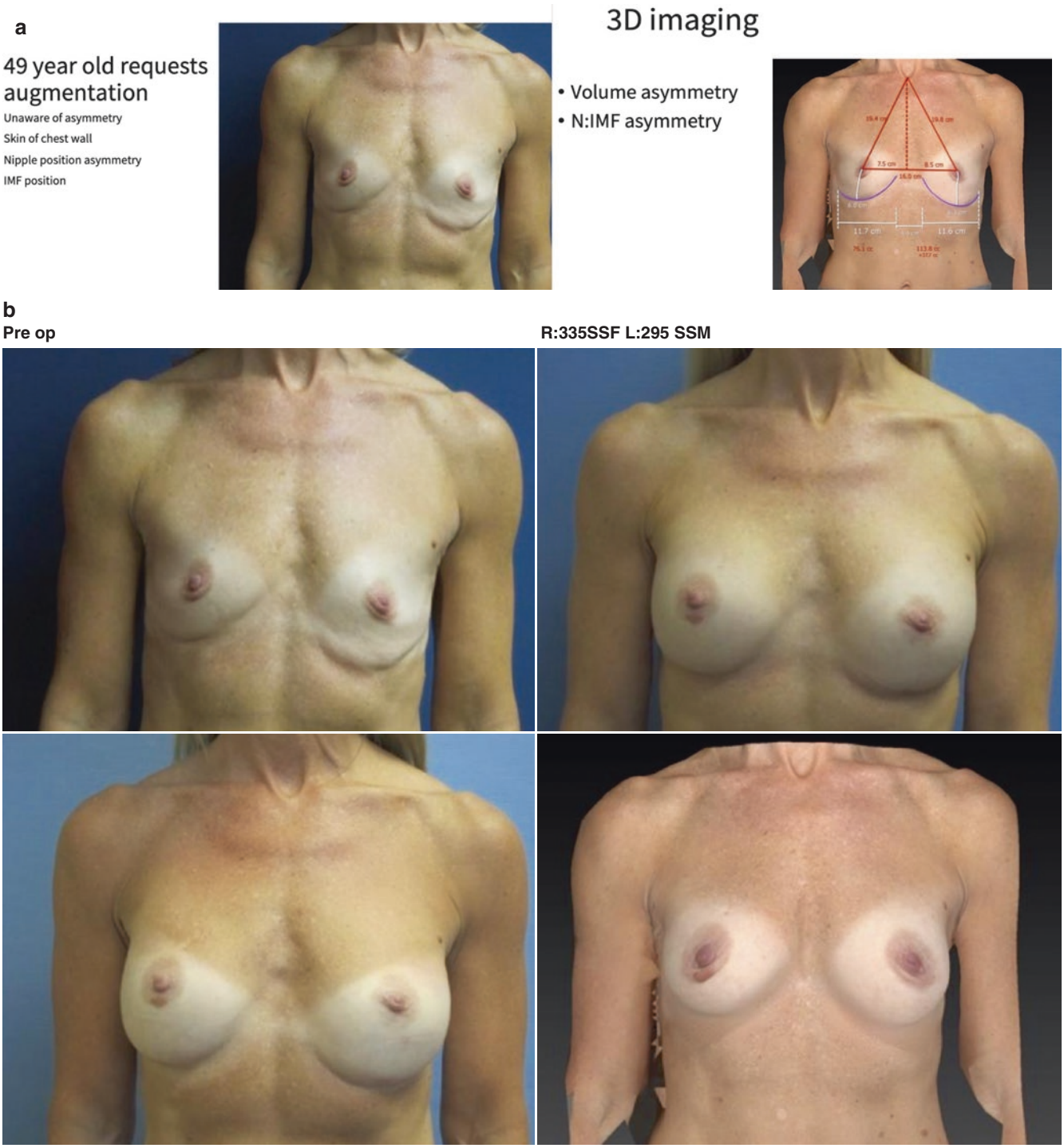


**Fig. 10.4** (**a**) Pre-operative and (**b**) post-operative images of a patient who has asymmetry in the footprint of her breast on the chest wall and 3D assessment with measurements. (**b**) Pre- and post-op photos and simulation

## Case 3 (Fig. 10.5a, b)

This patient was unaware of her chest wall asymmetry, which caused a 2-cm difference in the position of her IMF. Simulation was performed; the patient could see the pre-operative asymmetry and understands that she will not have absolute symmetry. The patient is educated prior to surgery on the expected result, which is key to patient satisfaction.

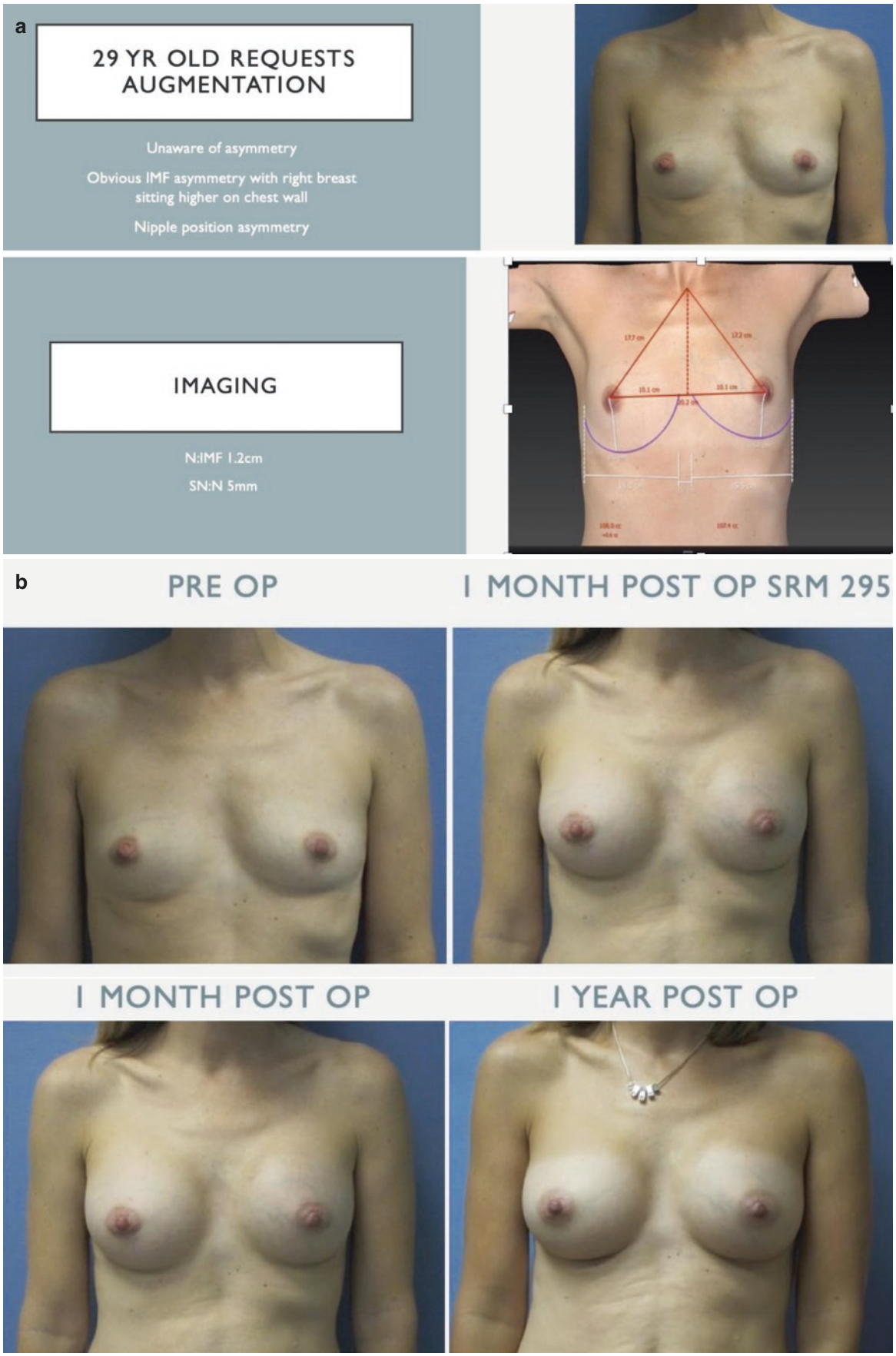


**Fig. 10.5** (**a**, **b**) Patient with chest wall asymmetry, pre-operative photo, and 3D assessment. Notice the asymmetry of the costal margin (**b**) pre-op, 1 month, and 1 year post-op

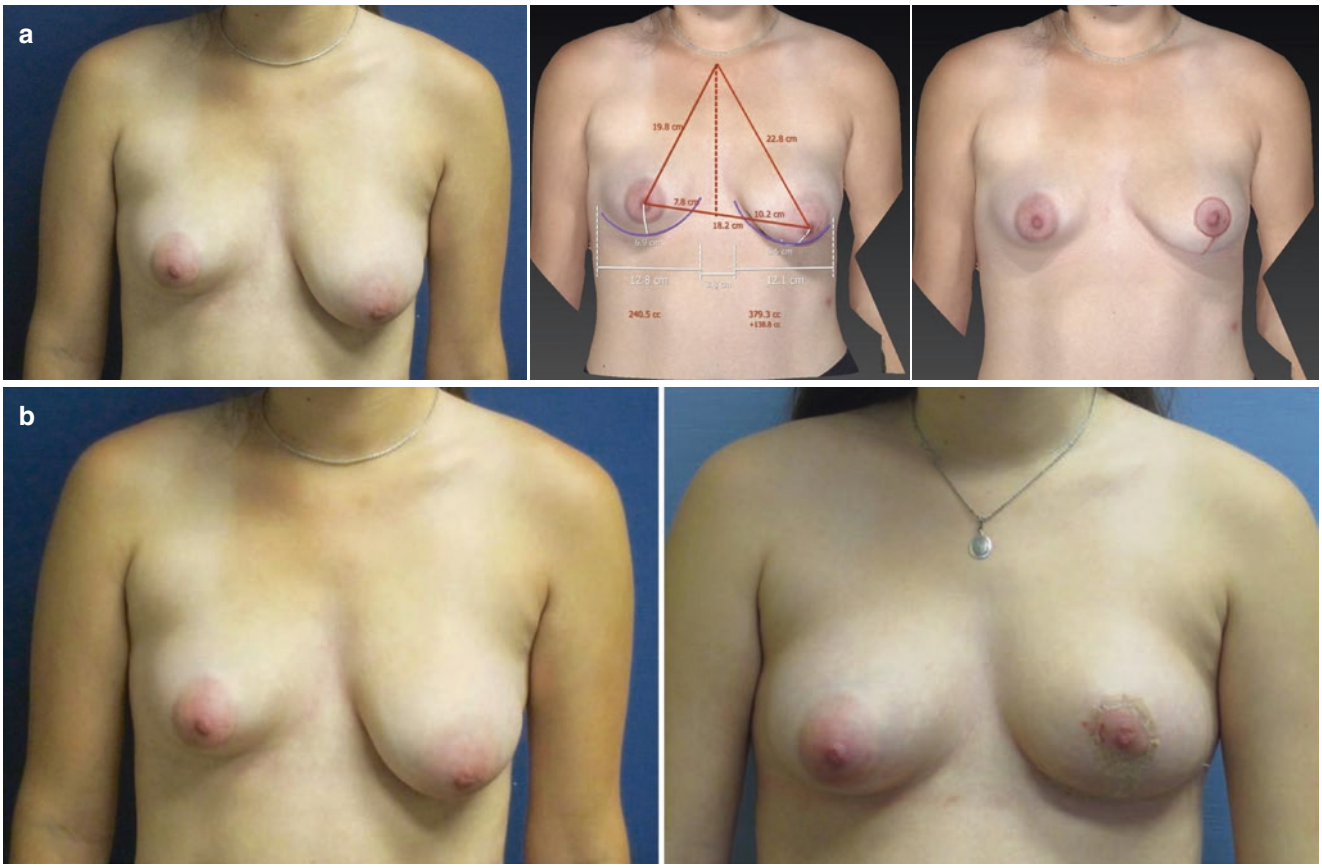


**Fig. 10.6** (**a**, **b**) Pre-operative; simulation, with a mastopexy; and post-operative images of a 17-year-old patient who has significant breast asymmetry with differences in volume, nipple position, and tissue envelope

### Case 4 (Fig. 10.6a, b)

This 17-year-old patient has significant breast asymmetry with differences in volume, nipple position, and tissue envelope. Simulation showed volume, nipple position, N:IMF, and chest wall asymmetry. The volume asymmetry was 130 cc, and there was a 3-cm nipple position asymmetry. Simulation was performed with a unilateral mastopexy. The measured volume asymmetry can be useful in surgical planning. The patient elected to have mastopexy only without an implant. The post-operative photo is 1 year post-op.

### Case 5 (Fig. 10.7a–c)

This 32-year-old woman is evaluated for cosmetic augmentation. She has volume asymmetry that she is unaware of. The assessment showed a 30-cc volume difference. Simulation can be performed with implants of the same or different volume in a patient with mild volume asymmetry, and the patient can visualize the different options and participate in implant selection. The patient elected to have implants with a 30-cc volume difference. The post-operative photos are 3 years post-op.

## Conclusion

3D imaging is a useful tool in evaluation of a patient with asymmetry for surgical planning and patient education. It does not replace a good physical examination and communication with the patient using other tools such as 2D photos, reviewing photos of patients with similar anatomy, or using breast implant sizers in a bra. For those patients who learn and understand using visual means, it can be an invaluable tool for surgeons in surgical planning and patient education and in managing patients' expectations. It can be done in a cost-effective and time-efficient manner to enhance the patient consultation process.

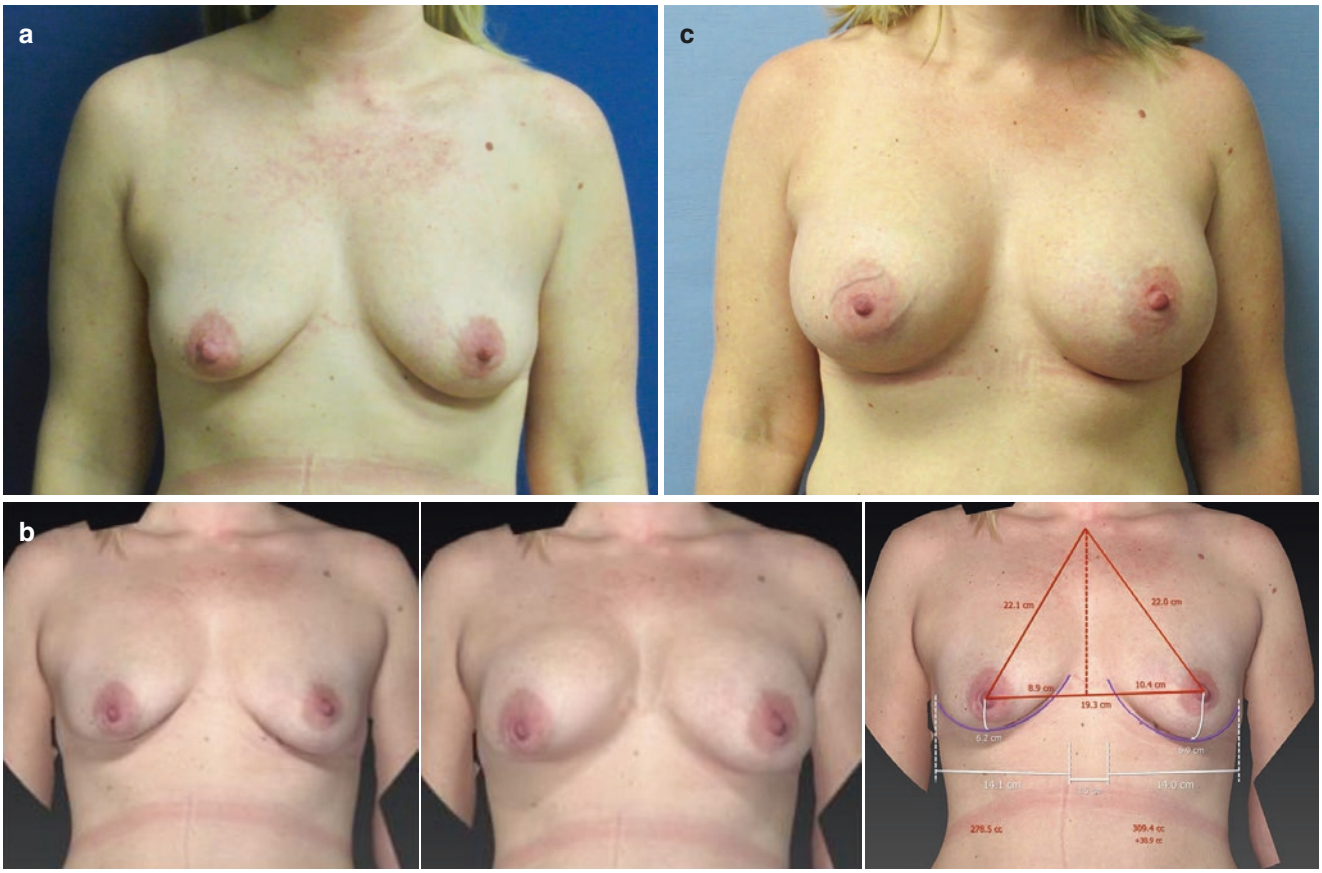


**Fig. 10.7** (**a**–**c**) Pre-operative, simulation, and post-operative images of a 32-year-old woman with volume asymmetry evaluated for cosmetic augmentation

## References


1. Tebbetts JB. Correction of breast asymmetry does not exist, and the role of 3-dimensional imaging remains a question. Plast Reconstr Surg. 2011;128(2):595–6; author reply 596.
2. Tebbetts JB, Adams WP. Five critical decisions in breast augmentation using five measurements in 5 minutes: the high five decision support process. Plast Reconstr Surg. 2005;116(7):2005–16.
3. Wan D, Rohrich RJ. Modern primary breast augmentation. Plast Reconstr Surg. 2018;142(6):933e–46e.
4. Adams WP Jr, Mallucci P. Breast augmentation. Plast Reconstr Surg. 2012;130(4):597e–611e.
5. Donfrancesco A, Montemurro P, Hedén P. Three-dimensional simulations in breast augmentation: an investigation of patient's satisfaction and the correlation between prediction and actual outcome. Plast Reconstr Surg. 2013;132(4):810–22.
6. Adams WP Jr, Mckee D. Matching the implant to the breast: systematic review of implant size selection systems for breast augmentation. Plast Reconstr Surg. 2016;138:987–94.
7. Liu C, Luan J, Ji K. The role of three-dimensional scanning technique in evaluation of breast augmentation: a 100-case study. Plast Reconstr Surg. 2010;126(6):2126–32.
8. Weissler JM, Stern CS, Schreiber JE, Amirlak B, Tepper OM. Evolution of photography and three-dimensional imaging in plastic surgery. Plast Reconstr Surg. 2017;139(3):761–9.
9. Chang JB, Small KH, Choi M, Karp NS. Three-dimensional imaging surface imaging in plastic surgery: foundation, practical applications and beyond. Plast Reconstr Surg. 2015;135(5):1295–304.
10. Roostaeian J, Adams WP Jr. Three-dimensional imaging for breast augmentation: is this technology providing accurate simulations? Aesthet Surg J. 2014;34(6):857–75.
11. Overschmidt B, Qureshi AA, Parikh RP, Yan Y, Tenenbaum MM, Myckatyn TM. A prospective evaluation of three-dimensional image simulation: patient reported outcomes and mammometrics in primary breast augmentation. Plast Reconstr Surg. 2018;142(2):133e–44e.
12. Rohrich RJ, Hartley W, Brown S. Incidence of breast and chest wall asymmetry in breast augmentation: a retrospective analysis of 100 patients. Plast Reconstr Surg. 2006;118(7 Suppl):7S–13S; discussion 14S, 15S–17S.
13. Schwartz MR. Evidence-based medicine: breast augmentation. Plast Reconstr Surg. 2017;140(1):109e–19e.
14. Adams WP Jr. The process of breast augmentation: four sequential steps for optimizing outcomes for patients. Plast Reconstr Surg. 2008;122(6):1892–900.
15. Hammond DC. Discussion: three dimensional simulated images in breast augmentation surgery: an investigation of the patient's satisfaction and the correlation between prediction and actual outcome. Plast Reconstr Surg. 2013;132(4):823–5.
16. Choudry U, Kim N. Preoperative assessment preferences and reported reoperation for size change in primary breast augmentation: a survey of ASPS members. Plast Reconstr Surg. 2012;130(6):1352–9.

17. Brown T. Patient expectations after breast augmentation. Aesth Plast Surg. 2013;37(6):114–39.
18. Yeslev M, Braun SA, Maxwell GP. Asymmetry of inframammary folds in patients undergoing augmentation mammoplasty. Aesthet Surg J. 2016;36(2):156–66.
19. Wesselius TS, Verhulst AC, Vreeken RD, Xi T, Maal TJJ, Ulrich DJO. Accuracy of three software applications for breast volume calculations from three dimensional images. Plast Reconstr Surg. 2018;142(4):858–65.
20. Hidalgo DA. Discussion: a prospective evaluation of three-dimensional image simulation: patient reported outcomes and mammometrics in primary breast augmentation. Plast Reconstr Surg. 2018;142(2):145e–7e.
21. Costa CR, Small KH, Adams WP Jr. Bra sizing and the plastic surgery herd effect: are breast augmentation patients getting accurate information? Aesthet Surg J. 2017;37(4):421–7.