

An Online Calculator for Estimating Breast Implant Volume from Imaging

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Summary: Breast implant surgery remains one of the most common surgical procedures performed in the United States. Implant exchange can be complicated by unavailability of medical records or implant identification cards. Using chest imaging of 154 breast implants, an algorithm for estimating breast implant volume was generated. Based on four simple measurements and patient body mass index, a free, online calculator was created with a mean error of volume estimate of less than 1 cm³ and a SD of 44 cm³. In instances where a surgeon does not have implant records available but has chest imaging, this online tool can be used to obtain a relatively accurate estimate of implant volume. (*Plast Reconstr Surg Glob Open* 2022;10:e4273; doi: 10.1097/GOX.0000000000004273; Published online 18 April 2022.)

INTRODUCTION

Breast implant placement remains one of the most common procedures performed by plastic surgeons in the United States.¹ Lifetime revision and implant exchange rates remain high. In the setting of breast reconstruction, implant revision rates have been found to be as high as 35.5%.^{2,3} The most common reasons for implant exchange are capsular contracture and patient requested size changes, followed by leakage, rupture, infection, and rippling.³ However, as patients change surgeons or lose their implant identification cards, accurately identifying the existing implant size or type can be challenging. Even at the same practice, medical records may only be maintained for a period of 5–10 years depending on state law.⁴ Although increasing use of electronic medical records may improve record keeping, systems are inconsistent across hospitals, and many private practices continue to rely on paper records. In cases where implant identification is not possible, surgeons must approximate the implant volume and select implants for the operating room with limited information.

Previous literature has examined whether magnetic resonance imaging (MRI) can be used to ascertain implant volumes.^{5–7} Although the FDA recommends routine breast ultrasounds or MRI scans for patients with implants,⁸ only 5% of patients ever receive a breast MRI.³ Chest computed

tomography (CT) imaging is less expensive, more readily available, and although not formally recommended by guidelines, frequently implemented for cancer staging or surveillance.^{9,10} Our study validated an algorithm created to estimate implant volume using simple measurements from a chest CT scan and introduces a free, interactive, online tool for volume estimation.

MATERIALS AND METHODS

Patients

After receiving approval from the Yale University institutional review board (HIC#2000021587), medical records of patients who underwent implant-based breast reconstruction at Yale-New Haven Hospital from 2012 to 2018 were reviewed. Patient age, body mass index (BMI), availability of a chest CT scan, and operative details (implant catalog numbers, prepectoral or subpectoral placement) were recorded. Only patients with a pre-existing chest CT and catalog number for their implant(s) available in the operative note were included. Patients with tissue expanders, anatomic implants, or with a CT scan without both axial and sagittal views were excluded. From publicly available manufacturers' catalogs or online listings, implant type (silicone versus saline), diameter, projection, and volume were recorded.^{11,12}

CT Scan Measurement

All CT scans were available digitally through our institution's electronic medical record. Four reviewers (K.L.M., A.S.L., J.Z.G., and A.H.J.) measured the axial diameter (mm) and projection (mm) and sagittal (mm) diameter and projection (mm) on each chest CT. The image in each view with the largest implant diameter was chosen

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for measurement. The axial and sagittal projections were measured on the same slice as the diameter (Fig. 1). A random sampling of 10% of chest CT scans were measured by all reviewers for standardization, and interrater variability for measurements was found to be less than 5%. For patients with bilateral implants, measurements were made independently for each implant.

Statistical Analysis and Algorithm Creation

A multivariate linear regression was utilized to create an algorithm incorporating CT measurements and BMI to predict manufacturer-specified breast implant volumes. A backward step-wise method was employed to assess variables for model inclusion (significance level = 0.15). Our statistical power was sufficient for model creation at 0.800. A Shapiro–Wilk–W test was utilized to ensure that the variables were normally distributed. The requirement of homoscedasticity was verified by running a Lagrange multiplier test and the effects of multicollinearity within each of the models was monitored by ensuring that the variance inflation factor (VIF) was below the accepted threshold of five. To assess the fit of the models, we report adjusted R^2 values and the SD of error within the algorithm. All analyses were performed in SAS Version 9.4.

RESULTS

The records of 947 patients who underwent implant-based reconstruction following mastectomy were reviewed, of which 95 (10.0%) had an existing chest CT scan and implant catalog number recorded. Two patients with anatomic implants and three patients with only axial view CT scans were excluded. Of the 90 patients included in the final analysis, 26 (28.9%) had unilateral implants, whereas 64 (71.1%) had bilateral implants. In all, 154 breast implants were included in the analysis. Mean BMI was 26.52 kg/m², and mean implant volume was 531.07 cm³ with an SD of 164.31 cm³. All three US manufacturers were represented, with primarily Mentor (87.0%) implants followed by Allergan (11.0%) and Sientra (2.0%) (Table 1).

Five variables—axial diameter (mm), axial projection (mm), sagittal diameter (mm), sagittal projection (mm),

Takeaways

Question: Breast implant exchange can be complicated by unknown current implant volume. We aimed to develop an easy to use tool for volume estimation based on chest CT scans.

Findings: Using CT imaging of 154 implants, we created an online calculator tool that provides an estimate of volume based on four simple measurements and BMI with a mean error of less than 1 cm³ and SD of error of 44 cm³.

Meaning: When current implant volume is unknown, this tool can aid in preoperative planning for implant exchange using existing chest CT scans.

and BMI (kg/m²)—were included in the model for estimating breast implant volume. The equation

$$\text{Volume (cm}^3\text{)} = -873.3 + (3.9 \times \text{Axial diameter}) + (4.0 \times \text{Axial projection}) + (3.0 \times \text{Sagittal diameter}) + (2.3 \times \text{Sagittal projection}) + (4.8 \times \text{BMI})$$

related CT diameters/projections and BMI to estimated implant volumes (cm³). The model was calibrated to accurately predict breast implant volume. The algorithm-derived breast implant volumes fell within a normal distribution with a mean error of 0.6 cm³ and median error of 8.0 cm³. The SD of error was 43.6 cm³ and correlated well with manufacturer-specified volumes (adjusted $r^2 = 0.9214$). A breast implant size estimator using this algorithm was created on the website domain <https://breastimplantcalculator.com/> as an interactive free tool (Fig. 2).

DISCUSSION

We present an accessible online calculator for estimating breast implant size from chest imaging. With four linear measurements from a chest CT scan, an estimated volume with an error distribution can be calculated. Breast implant revision surgery is complicated by unavailable implant identification cards or operative records requiring surgeons to approximate implant size from physical examination. Improved preoperative estimates of

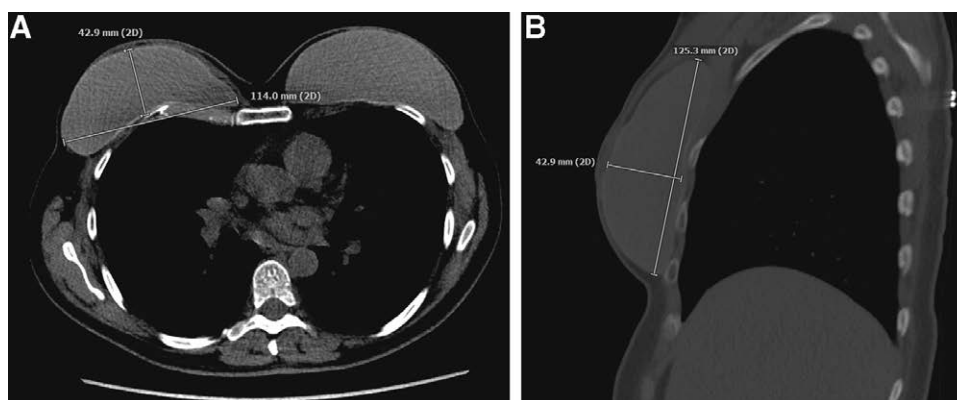


Fig. 1. Measurement of implant diameter and project on CT scan. A, Axial view. B, Sagittal view. Measurements are taken from the axial (A) and sagittal (B) view of the CT scan in the slice with the greatest implant diameter. Diameter and projection are measured in the same slice.

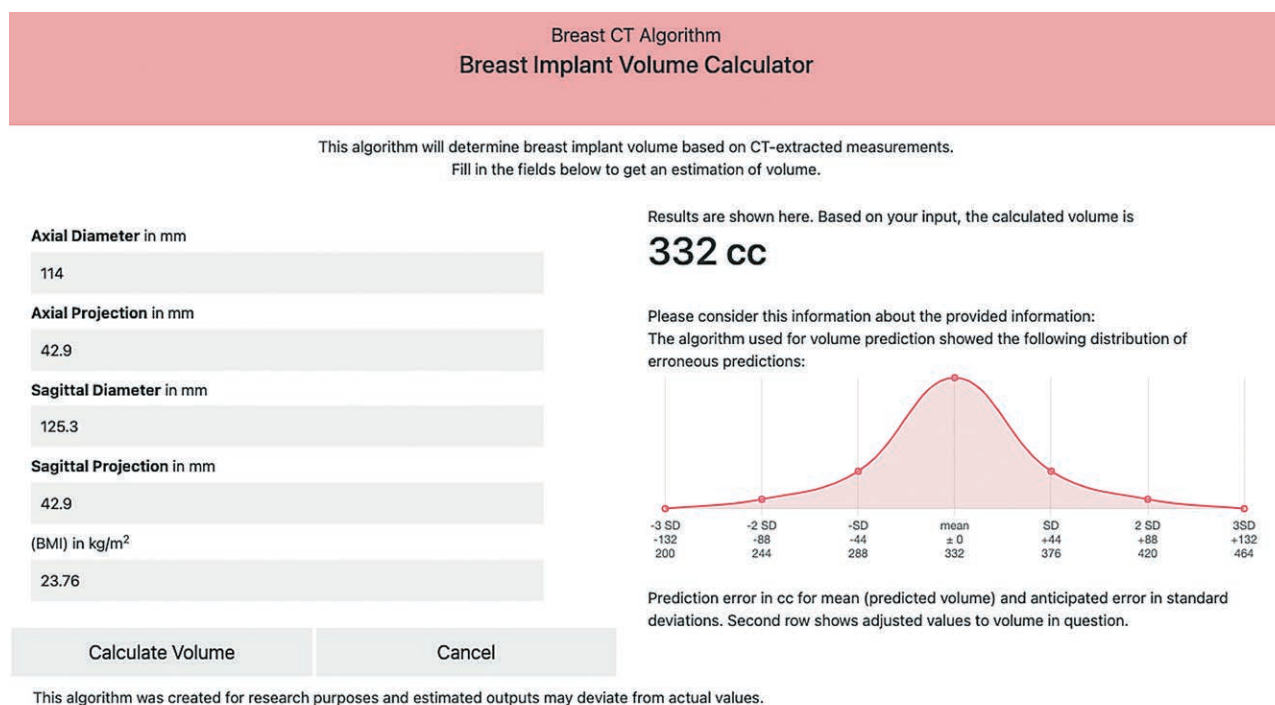


Fig. 2. Online breast implant volume calculator. Measurements from a CT scan and patient BMI are input into the calculator to receive an estimate of implant volume with anticipated error. In this case, the manufacturer-specified implant volume is 325 cm³ (Mentor 350-3254BC implant).

implant size can streamline implant ordering and provide improved surgical preparation.

A recent study by Levine and Kassira described highly accurate volume estimation using MRI imaging through the use of downloadable software,⁵ and in cases where exact volume estimation and detailed anatomical survey is needed, an MRI scan may be necessary. In contrast, our website <https://breastimplantcalculator.com/> offers measurements that can be extrapolated from electronic

medical records directly without the need for additional software and through the utilization of CT scans. The algorithm allows for accuracy with a mean error of less than 1 cm³ and 68% of estimates falling within 44 cm³ of the true volume. Further research will explore whether an algorithm can be validated for use with chest x-ray.

Given the risk of radiation, this calculator is most useful for patients with existing prior chest CT scans and unavailable implant records.¹³ Limitations of our study include that the primary indication for these implants was breast reconstruction, rather than breast augmentation, and that the majority of implants were from one manufacturer. Finally, although our study included a range of implant sizes, it may not be applicable to anatomic teardrop-shaped implants.

CONCLUSION

For patients whose breast implant size is unknown and who have a chest CT scan available, we offer an accessible online calculator (<https://breastimplantcalculator.com/>) to estimate implant volume with high accuracy.

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Table 1. Characteristics of Included Patients and Implants

Variables	No. (%)
Patient Variables	
Total	90 (100)
BMI	
<20	12 (13)
20–24.9	29 (32)
25–29.9	27 (30)
30–34.9	10 (11)
35–39.9	10 (11)
>40	2 (2)
Implant laterality	
Unilateral	26 (28.9)
Bilateral	64 (71.1)
Implant Variables	
Total	154 (100)
Implant brand	
Mentor	134 (87.0)
Allergan	17 (11.0)
Sientra	3 (2.0)
Implant volume (cm³)	
≤300	15 (9.7)
301–400	24 (15.6)
401–500	40 (26.0)
501–600	26 (16.9)
601–700	24 (15.6)
>700	25 (16.2)

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