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IDEAS AND INNOVATIONS

Estimation of implant size based on mammograms in immediate breast reconstruction

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Abstract

Background Implant size selection is a critical component of preoperative planning for immediate breast reconstruction. This paper introduces a novel formula, based on preoperative mammograms, for estimating implant volume in patients undergoing immediate breast reconstruction.

Methods A retrospective analysis of 115 consecutive patients with immediate breast reconstruction following skin or nipple sparing mastectomy was performed. A calculated implant size was obtained using the formula, calculated implant size (ml) = π × height (cm) × [base width (cm) − 3]. The calculations were performed independently by two surgeons and based on the ipsilateral preoperative mammogram. The calculated implant size was compared with the actual implant size used during the surgery and results were analysed.

Results The mean calculated and actual implant sizes were 376.03 ml and 324.49 ml, respectively. There was no difference found between calculated and actual implant sizes ($t = -1.704$, $p = 0.090$), and there was a strong positive correlation between calculated and actual implant sizes ($r = 0.7748$, $p < 0.00001$). Further analysis revealed greater accuracy of the formula in patients with an estimated implant size of less than 350 ml, and a tendency to overestimate implant size in breasts with an estimated volume of more than 350 ml.

Conclusions The mammography-based formula is a simple and practical method to estimate implant size preoperatively. Ultimately, implant selection for the best possible cosmetic outcome is a multifactorial process, of which breast volume is one consideration. This formula can serve as a useful adjunct for preoperative assessment.

Level of Evidence: Level III, diagnostic study.

Keywords Implant selection · Breast implant formula · Immediate breast reconstruction · Preoperative planning · Mammography

Introduction

Implant size selection is a critical component of preoperative planning for immediate breast reconstruction. An ideal implant size selection system should be comprehensive, versatile, simple to use and teach, easily reproducible through objective measurements and structured execution, and supported by evidence based on patient outcomes [1]. Although various methods have been developed in recent years, there is minimal evidence in the literature and no universal consensus supporting a particular approach [1, 2]. There are virtual assessment systems like CRISALIX 3D® and VECTRA 3D®, which are known to be accurate in predicting implant size [3, 4]. However, these increase cost and require additional hospital visits for patients. Hence, most surgeons have individualised methods for implant selection, usually taking into consideration patient anatomy (commonly assessed by linear measurements), personal experience and availability of implants [2].

Breast volume is one facet of the complex decision-making process of implant selection. In this paper, we propose a simple and practical way of preoperatively estimating implant volume in patients undergoing immediate breast reconstruction using mammographic measurements.

Yan Yu Tan and Howard Chu contributed equally to this work

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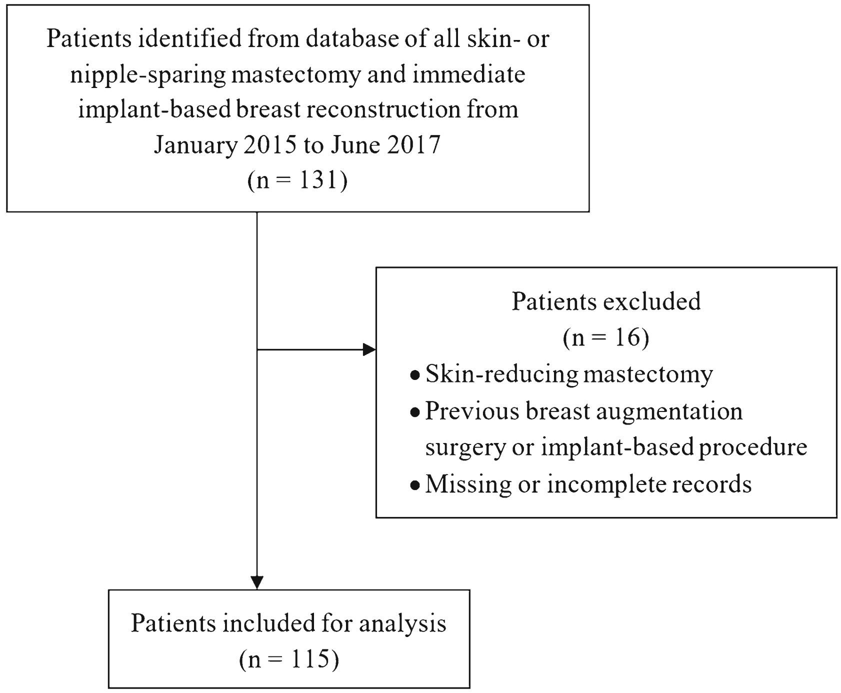

Fig. 1 Study recruitment flow diagram

Methods

Retrospective analysis of prospectively collected data of patients who underwent skin or nipple-sparing mastectomy and immediate breast reconstruction from January 2015 to June 2017 was performed. Patients who underwent skin-reducing mastectomy, previous breast augmentation or previous implant-based surgeries were excluded (Fig. 1). Demographic details, preoperative mammographic measurements and implant size selected were evaluated.

A simple formula based on the mammographic measurements in craniocaudal view was designed and used. The ipsilateral preoperative mammogram was used to calculate the estimated implant size using the following formula:

$$\text{Predicted implant size (ml)} = \pi \times \text{Height(cm)} \times [\text{Base Width (cm)}-3]$$

An illustration demonstrating mammographic measurements is shown in Fig. 2. Three centimetres were subtracted from the base width with consideration for 1.5 cm of skin flap thickness on each side. Two independent breast surgeons with experience of reading mammograms performed the implant size estimation, whilst blinded to the actual implant size used. The average size from the two readings was used as the calculated implant size.

Intraoperative implant size was estimated by an implant size calculator chart using the patient's breast base width and height, and then confirmed intraoperatively with an adequate sizer placed in the subpectoral or prepectoral pocket created for implant placement. Breast specimen weight was also measured intraoperatively; however, this data was not analysed as there is known disparity between breast specimen weight and implant volume [5, 6]. As this was a retrospective analysis of previously operated patients, the calculated implant sizes were not available at the time of operation. A comparison was made between the calculated implant size and the actual implant size used for reconstruction by a third surgeon not involved in implant size calculation. Patients with actual implant size within 10 ml (± 10 ml) of the calculated implant size were considered to have an accurate estimation.

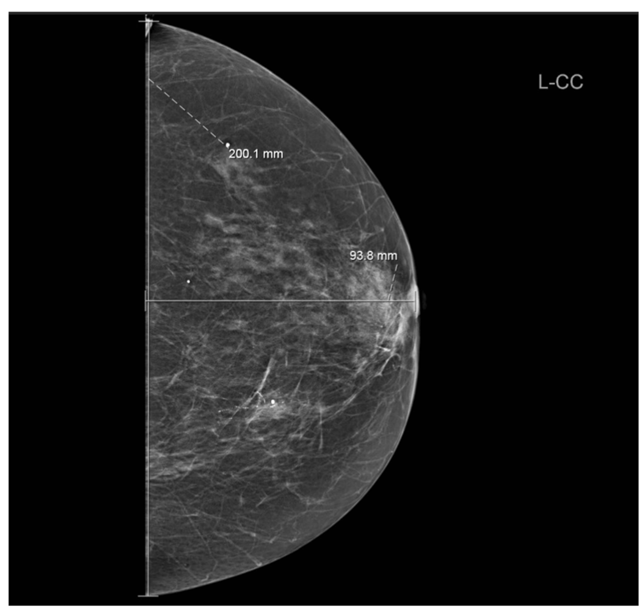

Fig. 2 Preoperative mammogram demonstrating measurements. Base width is measured by the maximum diameter of the breast base. Height is measured by the perpendicular distance from the nipple to breast base

Table 1 Comparison of calculated implant sizes and actual implant sizes

	Calculated implant size (ml)	Actual implant size used (ml)
Number of patients ($n = 115$)		
< 350 ml	61 (53.04%)	71 (61.74%)
> 350 ml	54 (46.96%)	44 (38.26%)
Mean	376 ml	324.48 ml
Range	112–906 ml	105–560 ml

Statistical analysis was performed using the two-tailed paired t test to assess for statistically significant difference between calculated implant size and actual implant size, and the Pearson's test to evaluate correlation. Based on the mean calculated implant size (376 ml), we used the value of 350 ml to separate patients into two groups for further analysis.

Results

One-hundred and thirty-one patients underwent a skin or nipple-sparing mastectomy with immediate implant-based breast reconstruction in the given study period. Sixteen patients did not meet the inclusion criteria. Thus, 115 patients were included in the final analysis (Fig. 1).

The median age of the cohort was 50 years with a mean body mass index of 26.09 kg/m^2. Sixty-one patients had a calculated implant size of less than 350 ml and 54 patients had a calculated implant size of greater than 350 ml. Sixty-one patients (53.0%) had subpectoral implants and 54 patients (47.0%) had prepectoral implants. All implants were anatomically shaped.

The corresponding numbers for actual implant size used was 71 patients in less than 350 ml group and 44 patients with implant size of more than 350 ml. The mean calculated implant size was 376.03 ml (range 112 to 906 ml) and the mean actual implant size was 324.49 ml (range 105 to 560 ml) (Table 1).

There was no significant difference found between mean calculated and actual implant sizes ($t = 5.047$, $p < 0.0001$). There was a strong positive correlation between calculated and actual implant sizes (Fig. 3). The correlation coefficient was 0.753 and p value was < 0.0001.

In the group of patients with a calculated implant size of less than 350 ml ($n = 61$), the actual implant size was within the range of ± 10 ml of the calculated implant size in 7 patients (11.48%), within ± 30 ml in 31 (50.81%) patients and within ± 50 ml in 44 (72.13%) patients. Of the patients with a calculated implant size of more than 350 ml ($n = 54$), the actual implant size used for reconstruction was ± 10 ml of calculated implant size in 2 patients (3.70%), ± 30 ml in 10 (18.54%) patients and within ± 50 ml in 18 (33.33%) patients.

After excluding patients in each group with accurate implant size estimation (± 10 ml), patients were further evaluated to assess whether there was a preferential underestimation or overestimation of the implant size using this formula. In the less than 350 ml group, similar numbers of patients had underestimation or overestimation of their implant size. In comparison, in patients with a calculated implant size of more than 350 ml, there was a preferential overestimation of implant size, as demonstrated in 45 of 52 (86.5%) patients with the actual implant size smaller than the calculated size (Table 2).

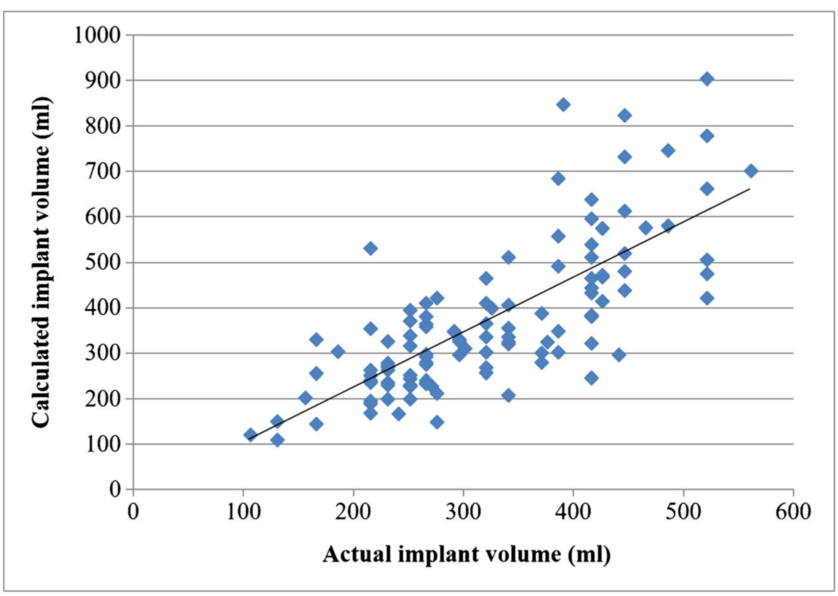

Fig. 3 Graph representing correlation between actual and calculated implant sizes

Table 2 Accuracy of calculated implant sizes

	Calculated implant size < 350 ml	Calculated implant size > 350 ml
Accurate estimation of implant size (actual implant size ± 10 ml)	7 (11.48%)	2 (3.70%)
Actual implant size ± 30 ml	31 (50.81%)	10 (18.54%)
Actual implant size ± 50 ml	44 (72.13%)	18 (33.33%)
Underestimation of implant size (> 10 ml less than actual)	28 (45.90%)	7 (12.96%)
Overestimation of implant size (> 10 ml more than actual)	26 (42.62%)	45 (86.53%)

Discussion

Breast volume is one of many variables, along with footprint, projection and soft tissue elasticity, that guides implant selection. Currently, there are a variety of methods for breast volumetric assessment and implant selection, but no particular method has been universally adopted in terms of preoperative assessment. We have devised a new simple formula to guide implant size estimation based on mammograms, which has not been previously described in the literature.

Earlier methods included making a plaster cast of the chest and measuring the amount of sand required to fill it [7]; a portable mammometer constructed in the form of a very large syringe [8] was also used. The Grossman-Rounder device [9] was a variable cone that unfortunately produced inconsistent results especially when a firm or very small breast was measured as the tip of the cone could not be fully filled [10]. Bouman's water displacement method [11] was deemed useful and still utilised in some studies [12], but tended to underestimate volume as it does not measure tissue lateral to the pectoral folds and the tendency for the breast to float makes it impossible to guarantee total immersion [8, 10]. All these methods are not suitable for clinical use as special instruments are required and application can be cumbersome [10].

More recently, increasingly sophisticated methods for breast volumetry have been developed. Magnetic resonance imaging has been shown to provide reliable volumetric information for planning breast reconstruction [12]. Three-dimensional topographic imaging [2, 13–17] and simulation software [18–20] have also been used effectively for preoperative analysis, planning and patient communication. Going a step further, Chavoin and colleagues have described computer-assisted custom-made implants [21]. All these methods however are expensive and require additional resources. Our formula, on the other hand, utilises mammograms which is standard preoperative imaging for all breast cancer patients and does not require additional imaging or equipment. This therefore minimises cost and radiation exposure to the patient.

An algorithm using mastectomy weight to predict implant size was suggested [22]; however, this limits preoperative planning since mastectomy weight can only be determined intraoperatively for immediate breast reconstructions. Westreich's formula for the 'ideal' breast volume [23], as follows, is rather complicated, thus limiting its practical use [volume = (M-Ni) 1.103 × (N-Ni) 0.811 or log (volume) = 1.103 × log (M-Ni) + 0.811 × log (N-Ni), as M-Ni is the manubrium to nipple and N-Ni is the nipple-to-nipple distance].

It was reported that mammographic estimates of breast volume using the Volpara software did not correlate to actual breast volume [24]. El-Oteify et al. generated formulae for breast volumetry derived from average linear and volume measurements taken from a cohort of Egyptian nursing students [20]. Their formulae rely on measurements of breast circumference, which are subjective and consequently may have discrepancies leading to variation in volumetric estimation. The advantage of our proposed formula is the use of more objective measurements from mammographic images.

Our formula adds to the plethora of available methods for breast volumetry and implant size selection. This method of calculation is objective and there was very minimal inter-observer variation in our study. It is also simple to use and carries no additional costs or investigations. However, its simple and objective nature also means that natural variations in breast shape, which is difficult to measure, may not be well represented. For instance, our formula tended to overestimate implant sizes in larger breasts (estimated volume more than 350 ml). This perhaps is a reflection of larger volume breasts being more ptotic and less spherical in shape and the central periareolar skin loss during skin sparing mastectomy unaccounted for in terms of volume. The accuracy of our formula was much better in breasts estimated to be less than 350 ml in volume. About half of these patients (50.81%) had calculated implant sizes within 30 ml of the actual implant sizes and majority (72.13%) was within 50-ml range. This observation has practical implications on the application of our formula, suggesting that it might be more reliable for smaller breasts.

In addition, it can be argued that skin flap thickness may vary between individual patients depending on body habitus, tumour location and other factors. In the preoperative setting, this is impossible to accurately predict; therefore, the figure of 1.5 cm was selected based on reported skin flap thickness in existing literature [25, 26] and also takes into account the effect of compression during mammography [27]. Considering the small sample size of the study, it may be necessary to test this on a larger cohort of patients.

Ultimately, implant selection for the best possible cosmetic outcome is a complex process requiring consideration of several other factors such as footprint and conus [28]. The simple and objective nature of our formula means that only volume is considered; however, individual variations in breast shape and dimensions would also guide implant choice. The purpose of our formula is therefore to serve mainly as an adjunct to preoperative evaluation based on clinical examination, linear measurements of breast and other available methods of breast volume estimation.

Conclusion

The mammography-based formula is a simple and practical method to calculate implant size preoperatively. The formula can be used as an adjunct to available tools for preoperative breast volume estimation and implant size calculation. It is more accurate in patients with an estimated implant size of less than 350 ml. These findings should be confirmed in a larger cohort of patients.

Compliance with ethical standards

Conflict of interest Yan Yu Tan, Howard Chu, Mihir Chandarana, Sadaf Jafferbhoy, Sankaran Narayanan, Sekhar Marla and Soni Soumian declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Formal patient consent is not required for this retrospective analysis.

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