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ORIGINAL ARTICLE

Reliability of plastic cups to measure breast volume

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Abstract

Breast volume measurement is valuable in clinical practice, and various methods have been used. Nonetheless, no commonly accepted standard technique exists for clinical everyday use and there is no optimal method that is quick, cheap, minimally invasive, and acceptable for the patient and for the surgeon. Previously, a study has shown that the volume measured with plastic cups differed little from that measured from mastectomy specimens. The aim of the present study was to test the reliability of breast volume measurements with plastic cups as a tool to measure breast volume in everyday clinical practice. The plastic cups were designed by the senior author (AR) and comprise 14 cups from 125 millilitres (ml) to 2000 ml. Six raters measured 12 breasts on the same day. The results show that there is a certain variation between different raters, and that a certain rater seems to consistently measure slightly lower or higher volumes than the other raters. The Intra Class Correlation (ICC) coefficient of average measures between raters is 0.89, that is, the agreement between different raters is high. According to the Bland-Altman plot, the overall assessment of the comparisons of measurements between the different raters shows that the direction of the mean differences is close to zero. The limits of agreements of the differences were within ±56 ml. The coefficient of variation (CV) between different raters was 14%. Breast volume measurement with plastic cups is an easily usable quick and cheap way to measure breast volume in everyday clinical practice. The measurements have an acceptable reliability.

Key Words: Breast volume, breast measurement, plastic cups, reliability, breast surgery

Introduction

Breast volume measurement is valuable in clinical practice. It may be useful in mammary hyperplasia, to evaluate indications for breast reduction mammoplasty, as well as in planning operative techniques in breast cancer patients, that is, indications for standard breast-conserving surgery vs oncoplastic breast surgery, and in preoperative planning and evaluation of post-operative results of asymmetry and other breast malformations.

Various methods have been used to measure breast volume; they include anthropomorphic measurements [1–4], biostereometric analysis [5,6], Archimedean methods – water displacement techniques [1], casting techniques (thermoplastic or plaster) [1–3,7–11], radiological techniques, such as measurements on mammograms [1,2,12], magnetic resonance imaging (MRI) [2,3,9], ultrasonography [13], and computer tomography (CT) [14], and 3D surface imaging [3,11,15–18], plastic cups [11,19], and the Grossman-Roudner Device [1,7,9,20], made of an adjustable geometrical conical form into which the breast is placed, and a plunger [20]. Patients themselves often discuss breast size in terms of bra size. However, cup size labelling is not standardised; different brands of bras differ in their labelling of cup size for the same breast volume. Furthermore, cup size labelling takes rib cage circumference into account [21], and bra size is thus not a feasible way to measure volume.

Nonetheless, no commonly accepted standard technique exists for clinical everyday use, and there is no optimal method that is quick, cheap, minimally invasive, and acceptable for the patient and for the surgeon [1].

Plastic cups, as a way of measuring breast volume, were first described by Strömbeck and Malm [19] in 1986 (p. 498). In their original publication they wrote: "This is a fast and dry method to measure the volume with sufficient accuracy to estimate the total volume and asymmetry", but no data on how the conclusion that the tool measures "with sufficient accuracy" were given. The only other study performed on the cups was published in 2011 by Eriksen et al. [11]. They showed that the volume measured with plastic cups differed little from that measured from mastectomy specimens.

The aim of the present study was to test the reliability of breast volume measurements with plastic cups, an easily usable quick and cheap way to measure breast volume in everyday clinical practice.

Subjects and methods

Subjects and raters

Six women (12 breasts) were recruited as subjects from the staff of the Department of Plastic and Reconstructive Surgery at Skåne University Hospital. Six persons assessed the subjects' breasts. The assessors were plastic (Raters B–D) or breast (Rater A) surgeons or nurses (Raters E–F) in our hospital. All the raters, the surgeons, as well as the nurses, received the same written instructions on how to use the cups and how to perform the measurements.

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Figure 1. The plastic cups for measurement of breast volume. The set comprises 14 cups from 125 ml to 2000 ml.

The procedures followed were in accordance with the Helsinki Declaration of 1964, as revised, and the Good Clinical Practice (GCP) guidelines. The subjects gave their informed consent to participate in the study.

Plastic cups

The plastic cups were designed by the senior author (AR) and manufactured by Emballageform AB, (Limhamn, Sweden). The original cups were described by Strömbeck and Malm [19] in 1986. Their method was based on 12 standard plastic cups for household use manufactured by Hammarplast AB (Tingsryd, Sweden). Those cups have since been discontinued. The cups used in this study were redesigned with shapes that are better suited for the female breast. For instance, they were made wider than the original cups. The set comprises 14 cups with better-adjusted intervals from 125 millilitres (ml) to 2000 ml (Figure 1).

Measurements

All measurements were performed by all raters on the same day. The patient is placed in an upright relaxed position with her arms hanging down. The breast is lifted with one hand and the rim of the cup is put in the submammary fold so that the breast "falls" into the cup. The cup is firmly pushed against the thoracic wall with the rim circumferentially in contact with the skin. When the cup is in place the volume of any remaining air distally in the cup is evaluated (Figure 2). If plenty of air remains, a smaller cup is used; if plenty of breast contour remains outside the rim, a larger cup is chosen. For plastic cup sizes 125–650 ml the volume should be measured in 25 ml intervals, for plastic cups sizes 650–1000 ml in 25–50 ml intervals, and for cup sizes >1000 ml in 50–100 ml intervals.

Statistics

Statistical tests were performed using the IBM SPSS 21 for Mac (SPSS Inc Chicago, IL) and Microsoft Excel for Mac 2011 14.0 (Microsoft Corporation, Redmond, WA). To assess agreement between different raters, Intra Class Correlation (ICC) coefficients [22] were calculated. The ICC does not take the order of the observations into account and can be used when there are more than two observations per subject. ICC can range from 0–1, with the maximum of 1 corresponding to complete reliability, that is, no measurement error. The coefficient of variation (CV) between raters was calculated as (1 SD/mean) × 100. The overall CV was calculated as $\sqrt{((CV1^2 + CV2^2 + CV3^2 \ldots CV12^2)/12)}$.

Bland-Altman plots [23] were drawn between the measurements of the two nurses (raters E and F) to visualise any systematic variation over the range of measurements. These two raters were chosen as they were taught about the usage of the plastic cup by the same surgeon, at the same time, and had been using the cups equally long and equally frequently.

Results

The diagram of measurements (Figure 3) shows that there is a certain variation between different raters and that a certain rater seems to consistently measure slightly lower or higher volumes than the other raters. The Intra Class Correlation (ICC) coefficient of average measures between raters A–F is 0.89, and the 95% confidence interval is 0.71–0.97. An ICC implies that 89% of the variation in breast volume is between patients rather than within patients, which is a sign of low intra-rater variance, that

Figure 2. Measurement of breast with plastic cup.

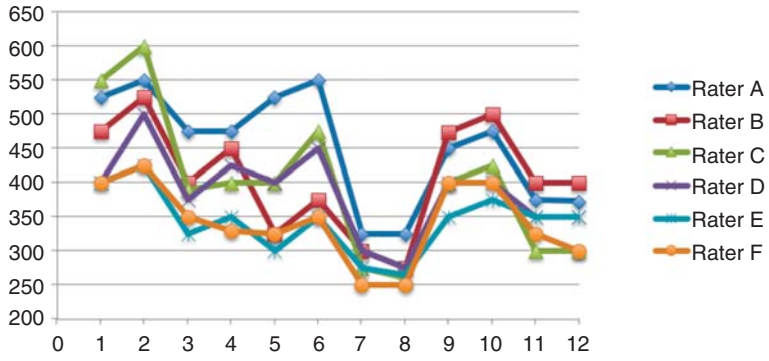

Figure 3. Different raters' measurements of the volume of the 12 breasts with plastic cups.

is, the agreement between different raters is high. The median absolute difference in volume between biggest and smallest measured volume for each breast was 125 ml (mean 133 ml, min 75 ml, and max 225 ml). The coefficient of variation between different raters was 14%.

According to the Bland-Altman plot (Figure 4), the overall assessment of the comparisons of measurements between the different raters shows that the direction of the mean differences is fairly close to zero. The limits of agreements of the differences were within ±56 ml.

Discussion

Breast volume measurements are important in clinical practice for both breast surgeons and plastic surgeons. Nonetheless, no commonly accepted gold standard technique exists for clinical everyday use. In the present study the reliability of breast volume measurements is tested. Previously, a study has shown that the volume measured with plastic cups differed little from that measured from mastectomy specimens [11]. The present study shows the reliability and feasibility of the breast volume measurements with plastic cups, an easily usable, quick, and cheap way to measure breast volume in everyday clinical practice.

Our study showed that the differences in measured volume between different raters were within acceptable clinical ranges (±56 ml) (Figure 4). Nonetheless, there was a slight variation between different raters (Figure 3), even though each rater tended to be consistent in their measurements, as to if their estimations were slightly smaller or slightly greater than those of the other raters. The variance could be explained by that, even though the raters have had the same written instructions for the usage of the cups, they might use slightly different techniques and have different experiences with the cups.

Indeed, it is known that anatomical definition of the breast is a factor that complicates breast volume measurement [5]. When the cups are used, care must be taken to include only the actual breast in the cup, and not part of the chest wall or the abdomen, which will lead to an overestimation of the breast volume. Similarly, care must be taken to not use a too small cup, so that the entire breast can be included within the cup and the volume, thus, not underestimated. The measurement must, as was the case in this study, be performed in an upright position to not complicate the definition of the borders of the breast further, in relation to for example the axillary fat (*processus axillaris*). Even though measurement with the cups includes a subjective component, that is the definition of the borders of the breast, the tool only comprises one measurement to generate the volume, whereas for example anthropomorphic methods include several individually measured, subjectively defined, variables [3]. Furthermore, in contrast to the anthropomorphic methods, a mathematical formula is not needed when

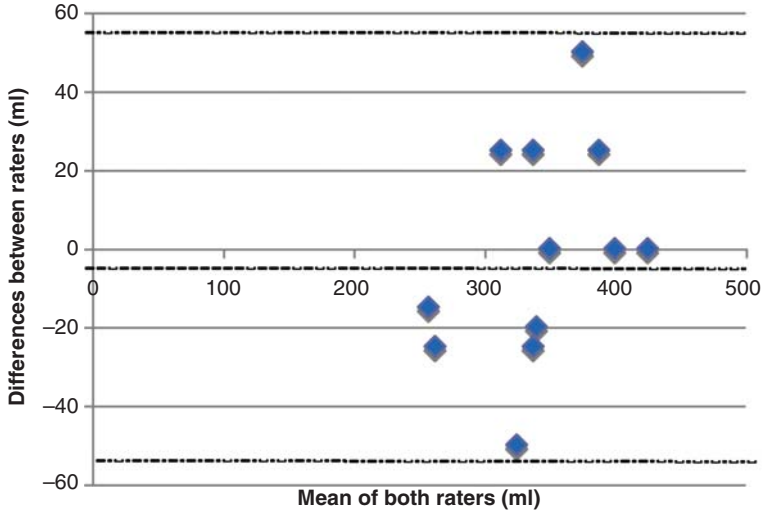

Figure 4. Bland-Altman plot of breast volume measurements made by rater E and rater F. The middle dashed line indicates the mean difference. The upper and lower dashed lines shows "limits of agreement" (mean ± 2 standard deviations (SD)).

measurement with the plastic cups is performed. The usage of a mathematical formula is another potential source of error and in many cases there is an uncertainty over which mathematical formula should be used [2]. Hence, in comparison with anthropomorphic measurements, measurement with plastic cups should vary less.

The principles of the Grossman-Roudner devise are similar to those of the cup, as the disc is aligned with the upper and lower breast contour, converting it into a cone that should be filled completely by the breast. Therefore, the subjective determination required and the deviation of measured volumes of the plastic cups and the Grossman-Roudner device should be similar. However, the Grossman-Roudner device cannot be used to measure breasts with volumes greater than 425 ml [1,7], and is, therefore, in contrast to the plastic cups, not useful in the context of breast hypertrophy.

Variability in volume measurements due to variations in definition of the borders of the breast have also been seen for 3D surface imaging [16,17], biostereometric analysis [6], the casting techniques [4], and for radiological methods [12]. The definition is especially difficult in obese patients [6] and in women with clearly ptotic breasts [17], in which manual definition of the borders of the breast always is required. Indeed, an improvement in variability has been seen for 3D surface imaging if a surgeon palpates and defines the borders of the breast before the measurement is performed [18]. When the plastic cups are used, a surgeon or specially trained nurse always manually defines the breast and bases his/her measurement on these definitions. This may vouch for the fact that, even though the definitions are subjectively performed, they are performed in the best possible way and the volume measurement becomes as accurate as possible. The only two raters that had been taught by the same person, at the same time, and subsequently used the cups equally frequently, were the two nurses and the limits of agreements of their measurements were considered to show acceptable accordance (Figure 4).

In addition to the difficulty in defining the borders of the breasts, the female breast is an organ with varying volume, width, height, projection, tissue density, composition, shape, and position on the chest wall [24], which further complicates the standardised measurement of breast volume. For instance, Grossman and Roudner [25] themselves have commented that the Grossman-Roudner device is unsuitable to use in face of firm capsular contracture (Baker III and IV) as the breast then does not mound to the cone. This is also true for the breast cups, as the breast with capsular contracture does not mound to the cup, and hence cannot be used in such cases [25]. Furthermore, the Grossman-Roudner has the shape of a cone, a shape that deviates from the normal shape of the female breast, and hence part of the device cannot be filled completely with breast tissue and an estimation always has to be made. This estimation should be more inaccurate when the entire device cannot be filled with breast. This has also been noticed by Westreich [24], who wrote that the tip of the cone is not always filled with breast. The problems with unfilled parts of the device are smaller with the plastic cups used in this study as they have been especially designed to conform to the shape of the female breast.

There are other factors besides volume measurement accuracy that need to be considered when the method to measure breast volume is chosen in everyday clinical practice. Such factors include economy, time consumption, acceptability for patient and surgeon, and risks for the patients. Previous research has revealed that the most economic methods are the plastic cups [11] and the Grossman-Roudner device [9]. The two methods, as well as casting methods, Archimedean methods, and anthropometric measurements, are also rapid and acceptable for both the patient and the surgeon [2]. However, casting methods can involve several suboperations and are, thus, more time-consuming in everyday clinical practice [1], and some patients might have difficulty in performing the Archimedean methods. 3D surface imaging and radiological methods require costly equipment, expertise in using the equipment, interpreting the result, and using mathematical algorithms. In addition, many radiological techniques expose the patient to radiation [9]. Considering this, as regards economy, usability, and acceptability, the plastic cups or the Grossman-Roudner device seem to be the best methods for breast volume measurements in clinical practice.

In addition to the difficulty in determining the borders of the breast, limitations of the study include a small sample size and the lack of subjects with very large breasts. However, there is no reason to believe that measurements should be more inaccurate in larger breasts, and the breast cups are available in sizes up to 2000 ml. We have experienced no difficulties in measuring larger breasts in everyday clinical practice. Strengths of the present study are that they measure the usage of the plastic cup in everyday clinical practice. The accuracy of the cups as compared to mastectomy samples has already been established previously [10]. In addition, as compared with other studies, our study has included several raters and can, thus, really compare the difference in measurements between different doctors and nurses. A coefficient of variation of 14% might sound like a bad performance of the method. However, the coefficient of variation has to be judged in light of the mean value. The coefficient of variation may be high for very small volumes and low for big volumes, in analogy with coefficient of variations of lab tests. For example, a bilirubin test with an SD of 0.1 mg/dL at a mean value of 0.5 mg/dL has a coefficient of variation of 20%, whereas an SD of 1.0 mg/dL at a concentration of 20 mg/dL corresponds to a coefficient of variation of 5.0%. The small volumes of the 12 breasts measured in this study might have contributed to the relatively high coefficient of variation.

In conclusion, breast volume measurement with plastic cups is an easily usable quick and cheap way to measure breast volume in everyday clinical practice. The measurements have an acceptable reliability.

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Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

[1] Kayar R, Civelek S, Cobanoglu M, et al. Five methods of breast volume measurements: a comparative study of measurements of specimen volume in 30 mastectomy cases. Breast Cancer 2001; 5:43–52.

[2] Bulstrode N, Bellamy E, Shrotria S. Breast volume assessment: comparing five different techniques. Breast 2001;10:117–23.

[3] Kovacs L, Eder M, Hollweck R, et al. Comparison between breast volume measurement using 3D surface imaging and classical techniques. Breast 2007;16:137–45.

[4] Wilmore JH, Atwater AE, Maxwell BD, et al. Alterations in breast morphology consequent to a 21-day bust developer program. Med Sci Sports Exerc 1985;17:106–12.

[5] Loughry CW, Sheffer DB, Price TE, et al. Breast volume measurement of 598 women using biostereometric analysis. Ann Plast Surg 1989;22:380–5.

[6] Galdino GM, Nahabedian M, Chiaramonte M, et al. Clinical applications of three-dimensional photography in breast surgery. Plast Reconstr Surg 2002;110:58–70.

[7] Palin WE Jr, von Fraunhofer JA, Smith DJ Jr. Measurement of breast volume: comparison of techniques. Plast Reconstr Surg 1986;77:253–5.

[8] Campaigne BN, Katch VL, Freedson P, et al. Measurement of breast volume in females: description of a reliable method. Ann Hum Biol 1979;6:363–7.

[9] Caruso MK, Guillot TS, Nguyen T, Greenway FL. The cost effectiveness of three different measures of breast volume. Aesthetic Plast Surg 2006;30:16–20.

[10] Edsander-Nord A, Wickman M, Jurell G. Measurement of breast volume with thermoplastic casts. Scand J Plast Reconstr Surg Hand Surg 1996;30:129–32.

[11] Eriksen C, Lindgren EN, Olivecrona H, et al. Evaluation of volume and shape of breasts: comparison between traditional and three-dimensional techniques. J Plast Surg Hand Surg 2011; 45:14–22.

[12] Kalbhen CL, McGill JJ, Fendley PM, et al. Mammographic determination of breast volume: comparing different methods. AJR Am J Roentgenol 1999;173:1643–9.

[13] Malini S, Smith EO, Goldzieher JW. Measurement of breast volume by ultrasound during normal menstrual cycles and with oral contraceptive use. Obstet Gynecol 1985;66:538–41.

[14] Neal AJ, Torr M, Helyer S, Yarnold JR. Correlation of breast dose heterogeneity with breast size using 3D CT planning and dose-volume histograms. Radiother Oncol 1995;34:210–18.

[15] Isogai N, Sai K, Kamiishi H, et al. Quantitative analysis of the reconstructed breast using a 3-dimensional laser light scanner. Ann Plast Surg 2006;56:237–42.

[16] Yip JM, Mouratova N, Jeffery RM, et al. Accurate assessment of breast volume: a study comparing the volumetric gold standard (direct water displacement measurement of mastectomy specimen) with a 3D laser scanning technique. Ann Plast Surg 2012;68:135–41.

[17] Koch MC, Adamietz B, Jud SM, et al. Breast volumetry using a three-dimensional surface assessment technique. Aesthetic Plast Surg 2011;35:847–55.

[18] Veitch DE, Burford K, Dench P, et al. Measurement of breast volume using body scan technology (computer aided anthropometry). WORK 2012;41:4038–45.

[19] Strombeck JO, Malm M. Priority grouping in a waiting list of patients for reduction mammaplasty. Ann Plast Surg 1986;17: 498–502.

[20] Grossman AJ, Roudner LA. A simple means for accurate breast volume determination. Plast Reconstr Surg 1980;66:851–2.

[21] Ringberg A, Bageman E, Rose C, et al. Of cup and bra size: reply to a prospective study of breast size and premenopausal breast cancer incidence. Int J Cancer 2006;119:2242–3.

[22] Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. Psychol Bull 1979;86:420–8.

[23] Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;1:307–10.

[24] Westreich M. Anthropomorphic breast measurement: protocol and results in 50 women with aesthetically perfect breasts and clinical application. Plast Reconstr Surg 1997;100:468–79.

[25] Grossman AJ, Roudner LA. Discussion of “Measurement of breast volume: Comparison of techniques” by Palin WE, Jr, et al. Plast Reconstr Surg 1986;77:255.