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IDEAS AND INNOVATIONS

Breast

New Validated Method for Measuring Fat Graft Retention in the Breast with MRI

Mikkel Herly, MD*
Mathias Ørholt, MD*
Felix Christoph Müller, MD†
Mathilde N. Hemmingsen, MD*
Joachim Hansen, BMSc*
Andreas Larsen, BMSc*
Bo S. Rasmussen, MD, PhD*
Jens J. Elberg, MD‡
Christian von Buchwald, MD, DMSc§
Krzysztof T. Drzewiecki, MD, DMSc*
Peter V. Vester-Glowinski, MD, PhD*

Summary: In this study, we present a new method for measuring fat graft volume retention in the breast based on magnetic resonance imaging scans and a validation study to assess its accuracy and precision. The method was validated by 4 observers using the magnetic resonance imaging scans of 14 patients undergoing breast augmentation with fat grafting. The method was translated into software and was used to measure the change in breast volume from a preoperative scan to a postoperative scan recorded within 3 hours after the surgery, which was compared with the injected fat graft volume. The new method measured the injected fat graft volumes with an average systematic overestimation of 6.3% (SD, 10.5). The median interobserver variation was <7%. We propose that this new method can be a good alternative to previous techniques for clinical research purposes. The software can be made available upon request free of charge for use on the MeVisLab platform.
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INTRODUCTION

One of the greatest challenges with fat grafting is that a variable part of the graft volume is resorbed in time after surgery. An accurate method for assessing the volume retention of fat grafts in the breast after breast augmentation[1,2] and breast reconstruction[3] is needed in the development of new strategies to improve the fat grafting procedure.[4] In previous validation studies,[5,6] we showed that the current gold standard breast volumetry technique[7] was subject to a large systematic error when it was used to measure fat grafts. We hypothesize that the systematic overestimation occurs when lax tissue is drawn into the breast after the breast augmentation. Our new method takes this into account because it includes the same amount of tissue on both scans. The problem is that fat grafts cannot be delineated in the breast; therefore, the change in fat graft volume must be calculated from a change in the total breast volume between a preoperative magnetic resonance imaging (MRI) scan and a follow-up scan. This change in breast volume can then be compared with the injected volume to calculate the fat graft volume retention rate or the percent augmentation.[8] In this study, we present a dedicated method for measuring fat graft volume retention in the breast based on MRI scans.

PATIENTS AND METHODS

The study was approved by the regional ethics committee of Copenhagen (nr. H-1501379) and the Regional Data Protection Agency. All participants provided written informed consent before inclusion.

Accuracy and Precision

The accuracy and precision of the method were assessed in 14 healthy women who underwent a breast augmentation with fat grafting between 2015 and 2018. The patients were included from the University Hospital Copenhagen, Rigshospitalet, and underwent an MRI examination preoperatively and again within 3 hours after

*From the *Department of Plastic Surgery and Burns, Rigshospitalet, Copenhagen, Denmark; †Department of Radiology, Herlev and Gentofte Hospital, Herlev, Denmark; ‡Amalieklinikkken, Copenhagen, Denmark; and §Department of ORL, Head and Neck Surgery and Audiology, Rigshospitalet, Copenhagen, Denmark.*

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the surgery. The liposuction was performed with a water-jet device, and the fat was centrifuged at 100*g* for 3 minutes. The fat grafts were injected with the structural fat grafting technique with blunt 14-G cannulas.[9,10] The postoperative MRI was performed before the fat graft resorption so that the increase in breast volume would be roughly equal to the injected volume. Thereby, we could assess the accuracy of the method by comparing the measured increase in breast volume with the injected fat graft volume. Interobserver and intraobserver variability was assessed between 4 blinded observers (M.H., M.Ø., J.H., M.N.H., and J.H.). The MRI scans were acquired on a 3 Tesla MRI unit (Siemens Magnetom Verio, Erlangen, Germany) with a 4-channel breast coil in a head-first prone position. Parts of the MRI scans have been used in a previous study.[6] The software is calibrated for in-phase and out-phase images of a 2-point Dixon sequence.

Software Workflow

Using our method requires 2 MRI scans to measure fat graft volume retention in the breast: a preoperative scan and a follow-up scan acquired when the fat graft has reached volumetric steady state.[11] First, the software is used to align the 2 scans on top of each other using fixed osseous pointers in the thorax. Then, the user outlines a region of interest on the follow-up scan (containing the residual fat graft), which is automatically mirrored on the preoperative scan. This ensures that the regions of interest will delineate the same block of tissue on the 2 scans. The software will then delineate the skin and calculate the increase in breast volume automatically, which can then be used to calculate the fat graft retention rate by dividing it with the initially injected volume. Figure 1 and **Video 1** show a demonstration of the software. (**See Video [online],** which displays how the software can be used to measure fat graft volume retention in a patient 4 months after a fat grafting procedure.)

Statistical Analysis

The accuracy and precision of the method were calculated with descriptive statistics, and data were visualized with a scatter plot and a Bland–Altman plot. All analyses were performed in R, version 3.6.1 (www.r-project.org; R Foundation-for-Statistical-Computing, Vienna, Austria).

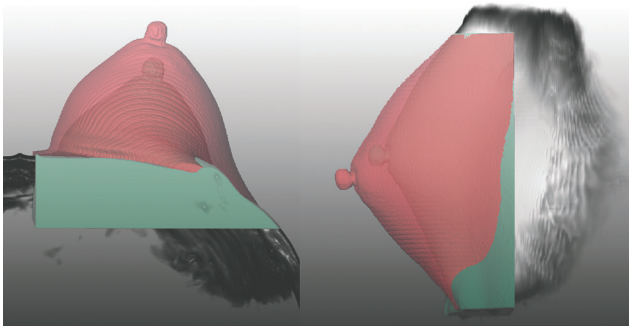

Fig. 1. Image showing 3-dimensional reconstruction from Lipovol. The follow-up scan (red color) is aligned and superimposed on the preoperative scan (green color).

Table 1. Breast Augmentation with Fat Grafting

Individual breasts, No.	28
Individual measurements, No.	112
Median fat graft volume, mL	300
Range, mL	250–350
Mean measured fat graft volume, mL	322
SD, mL	31.5
Range, mL	242–403
Mean systematic error, pct	6.28
SD, pct	10.5
Median interobserver variation, pct	4.8
IQR, pct	2.7–9.8
Median intraobserver variation, pct	4.2
IQR, pct	2.0–8.7

IQR, interquartile range; No., number; pct, percentage.

RESULTS

The measurement error of the method was 6.28% overestimation of the fat graft and an SD of 10.5%. The median interobserver variation was 4.8% (interquartile range, 2.7–9.8), and the intraobserver variation was 4.2% (interquartile range, 2.0–8.7). A summary of the validation results is provided in Table 1. A linear regression with a 95% prediction interval is shown in Figure 2 and indicates a high correlation between the measured volumes and the true volumes with $r^2 = 0.97$. The measurement errors are shown in a Bland–Altman plot in Figure 3.

DISCUSSION

In this study, we present a new method for measuring fat graft volume retention in the breast. The validation

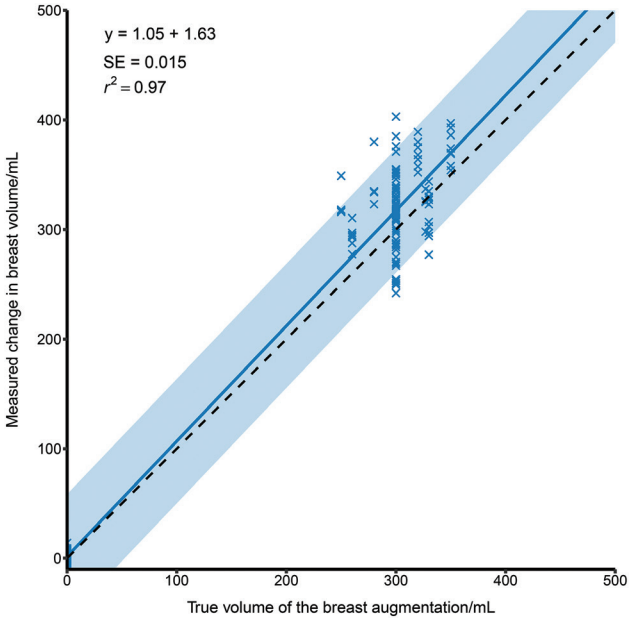

Fig. 2. Plot showing linear regression with a 95% prediction interval of the measured changes in breast volume compared with the true volumes of the breast augmentations.

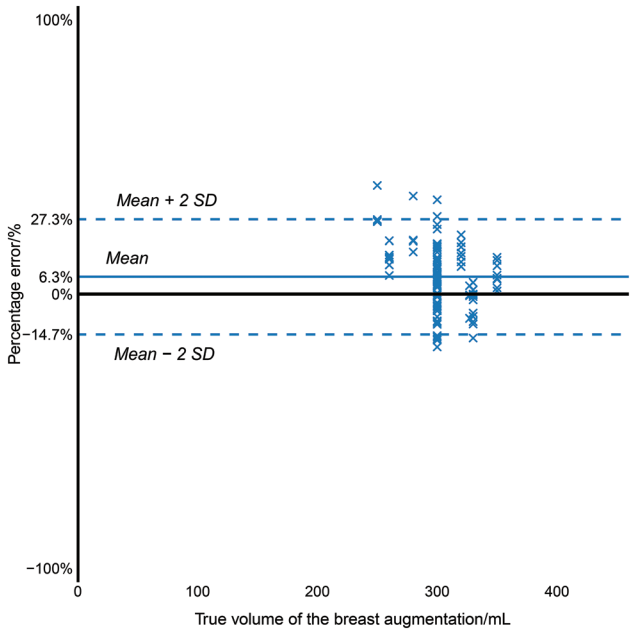

Fig. 3. Bland–Altman plot of the percentage measurement errors compared with the true volumes of the breast augmentations.

showed that the method's measurement error was only 6.28% with an SD of 10.5%. The method is based on MRI (which is highly accurate) without radiation, and clinically it provides the ability to detect complications such as oil cysts or malignant changes. The accuracy of MRI is supported by the fact that previous 3D imaging techniques are validated by comparing with manual MRI measurements.[12] However, MRI is more expensive than 3D photography devices and not available in most private clinics. Therefore, this technique may be best suited for research at centers where MRI machines are available.

The assessment of accuracy was performed on fat grafts that had just been injected in the breast. If we had used later measurements of fat graft retention, we would not know the "true" volume retention; therefore, we would be unable to assess the method's accuracy. However, some postoperative edema is expected at the time of the second scan (<3 hours after surgery), which may account for some of the 6.28% overestimation. Centrifugation of the fat was performed to minimize the water content in the fat graft; therefore, we believe that this had limited impact on the measurements. Another limitation was that the range of the injected fat graft volumes was relatively narrow in the patient population (range, 250–350 mL), but to our knowledge, this reflects the normal volumes used for primary breast augmentation.

CONCLUSIONS

Further studies are needed to investigate the accuracy of the software in measuring smaller or larger fat graft volumes than those used in this validation study. We propose this new method for unbiased and accurate scientific measurements of fat graft volume retention in the breast.

Mikkel Herly, MD
Department of Plastic Surgery and Burns Treatment
Copenhagen University Hospital
Rigshospitalet
Blegdamsvej 9
Copenhagen DK-2100, Denmark
E-mail: mikkel.herly@regionh.dk

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