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Breast

Breast Shape Change Associated with Aging: A Study Using Prone Breast Magnetic Resonance Imaging

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Background: Objective assessments of the shapes of various parts of the body can be made using images acquired with multidetector row computed tomography or magnetic resonance imaging. These images can be useful for understanding the changes in body shape that accompany aging.
Methods: Data from our previous bilateral prone breast magnetic resonance imaging studies between March and August 2013 were analyzed. Breast size and volume were measured using these images. All the patients included in the study were divided into a younger group (54 years or younger) and an older group (55 years or older). The values were compared between the 2 groups using paired *t* tests. Regarding variables that were shown to have a significant difference between the 2 groups, the relationships between age and the values of the variables were evaluated using the Pearson correlation coefficient.
Results: A total of 90 breasts, 45 breasts in the younger group and 45 breasts in the older group, were used for analysis. There was a significant correlation between age and craniocaudal nipple deviation ($R = -0.38$; $P < 0.001$) and between age and the measured breast volume ($R = 0.26$; $P < 0.05$). There was also a significant correlation between the measured breast volume and the craniocaudal nipple deviation ($R = -0.48$; $P < 0.001$).
Conclusions: A caudal deviation of the nipple and an increase in volume were age-related changes in breast shape. These 2 variables were also correlated. *(Plast Reconstr Surg Glob Open 2015;3:e413;doi: 10.1097/GOX.0000000000000289; Published online 4 June 2015.)*

An understanding of breast morphology is needed to improve the aesthetic outcomes of various surgical procedures involving the breast. Objective assessments of the shapes of various parts of the body can be made using images acquired with multidetector row computed tomography[1] or magnetic resonance imaging (MRI). MRI examinations of the breast are highly sensitive for the detection of breast cancer[2,3] and are being used in large populations (such as patients with a high risk of breast cancer), for preoperative breast surveillance, and for problem solving. Image acquisition in the prone position is also a characteristic of breast MRI examinations.[4] Although breasts are pulled ventrally by gravity during MRI procedures, they are far less influenced by caudal transformation than they are in a daily upright position.

Understanding the changes in body shape that accompany aging is also important to help surgeons

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identify the surgical techniques that are needed in a given case. Hoenig et al[5] has clarified the relationship between aging and morphologic changes in the buttocks. An investigation of such changes in the breast is likewise important to improve breast-conserving surgery, breast reconstruction, and reshaping or rejuvenating surgical procedures.

Although several studies have investigated the relationship between aging and changes in the breast parenchymal tissue using mammography[6–10] or MRI,[11] the relationship between aging and breast shape has not been previously reported. The purpose of the present study was to clarify the changes in breast shape related to aging using MR images acquired while the subject was in a prone position.

MATERIALS AND METHODS

Patients

After obtaining institutional review board approval, data from our previous breast MRI studies, which were performed between March and August 2013, were analyzed in this study. Breast MRI scanning was performed in a total of 88 patients and a total of 175 breasts (1 women had undergone a unilateral mastectomy for breast cancer and only had a left breast). The clinical records of the patients were reviewed for information about their prior history of breast surgical procedures. Breasts that had undergone any surgical operation or other therapeutic intervention were excluded because of possible deformation effects after these procedures. Breasts with any malignant lesions or lesions of unknown significance or with benign mass lesions more than 10 mm in diameter were also excluded from this study because of the possible deformation effect on the overall breast shape. All the patients included in the study were divided into 2 age groups[1]: a younger group (54 years or younger) and an older group (55 years or older).

MRI Technique

All the contrast material–enhanced breast MR examinations were performed using a 3.0-T MRI scanner (Signa HDxt 3.0T; GE Healthcare, Hino, Japan) with a bilateral breast surface coil. Patients were placed in a prone position on the table. A transverse and sagittal 3-dimensional T1-weighted gradient-echo sequence, which had been performed during image acquisition for each patient, was adopted as the images used for the breast size measurements. T1-weighted gradient-echo images were acquired using the following parameters: repetition time/echo time, 6.6 ms/2.3 ms; flip angle, 10°; matrix, 384 × 352 pixels; field of view, 360 × 360 mm; and section thickness, 2 mm, with no intersection gap.

Breast Size and Volume Measurements

Breast size was measured using the following definitions (Fig. 1):

Height (H): distance between the cranial and caudal termination of the bulging of the breast measured using a sagittal imaging slice in which the center of the nipple was observed.

Upper height (UH): upper part of the width between the cranial termination of the bulging of the breast and a line drawn perpendicular to the chest wall and across the center of the nipple.

Lower height (LH): lower part of the width between the caudal termination of the bulging of the breast and a line drawn perpendicular to the chest wall and across the center of the nipple.

Width (W): distance between the medial and lateral termination of the bulging of the breast measured using a transverse imaging slice in which the center of the nipple was observed.

Inner width (IW): inner part of the width between the medial termination of the bulging of the breast and a line drawn perpendicular to the chest wall and across the center of the nipple.

Outer width (OW): outer part of the width between the lateral termination of the bulging of the breast and a line drawn perpendicular to the chest wall and across the center of the nipple.

The mediolateral and craniocaudal nipple deviation rate from the midpoint were respectively calculated using the following formulas:

$$\text{Mediolateral nipple deviation} = (IW - OW)/2/W$$

$$\text{Craniocaudal nipple deviation} = (LH - UH)/2/H.$$

Cranial or lateral deviation was regarded as positive values for these 2 deviation variables, respectively.

All the measuring methods were suggested and instructed by 1 radiologist (Y.M.), who had 7 years of experience performing breast imaging. Another radiologist (M.N.), who had 6 years of experience with diagnostic radiology and was not engaged in breast imaging in daily practice, received instruction and measured all the variances in the absence of any supervision by Y.M.

The breast volume was also measured using transverse images on a workstation (Virtual Place Lexus64, 64edition; AZE, Japan). The volume measurements were performed by 1 radiologist (Y.M.).

Statistical Analysis

Among the values that were measured or calculated, the height-to-width ratio, the craniocaudal

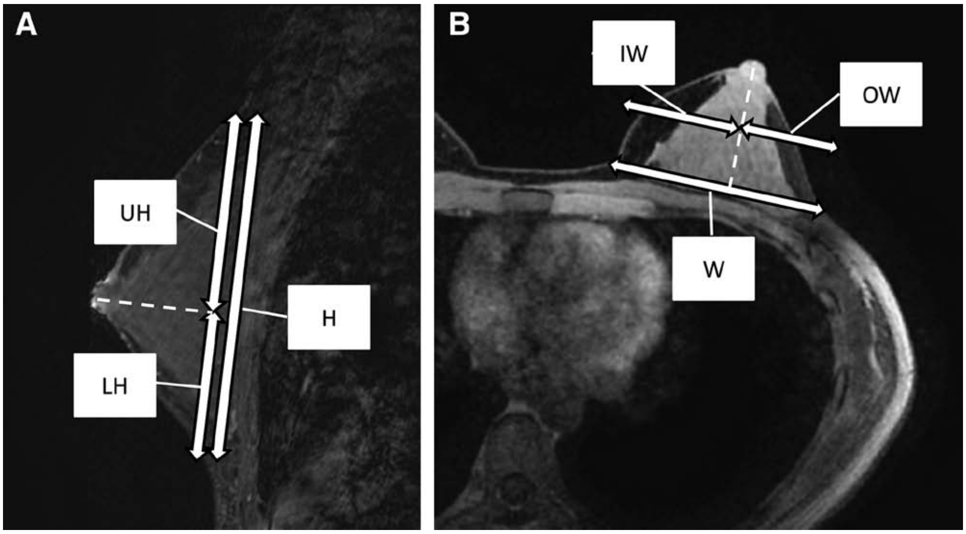

Fig. 1. Examples of breast shape measurements. Sagittal (A) and axial (B) images of T1-weighted gradient-echo MRI. Height (H), upper height (UH), and lower height (LH) were measured on the sagittal image, whereas width (W), inner width (IW), and outer width (OW) were measured on the axial image.

and mediolateral nipple deviation, and the volume were compared between the 2 groups using paired *t* tests. Regarding variables that were shown to have a significant difference between the 2 groups, the relationships between age and the values of the variables were evaluated using the Pearson correlation coefficient. A *P* value <0.05 was considered to indicate a statistically significant difference. All the statistical analyses were conducted using software (Microsoft Excel 2013, Microsoft Corporation, Redmond, Wash.).

RESULTS

Patient Populations

Out of the 175 breasts in 88 women who underwent breast MRI scanning during the period, 85 breasts in 82 women were excluded from further analysis for the following reasons: 2 breasts in 2 women with a previous lumpectomy; 4 breasts in 3 women with previous radiofrequency ablation for breast cancer; 66 breasts in 64 women with diagnosed breast cancer (ductal carcinoma in situ, $n = 9$; invasive carcinoma with or without intraductal carcinoma, $n = 57$; bilateral cancers in 2 women); 9 breasts in 9 women with lesions of unknown significance; and 4 breasts in 4 women with diagnosed benign lesions more than 10 mm in diameter (phyllodes tumor, $n = 2$; intraductal papilloma, $n = 1$; radial sclerosing lesion, $n = 1$). The remaining 90 breasts in 77 women were used for further analysis. This population included 45 breasts in the younger group (Fig. 2) and 45 breasts in the older group (Fig. 3).

Comparison of Parameters between the 2 Groups

The height-to-width ratio was not significantly different between the younger group (1.88 ± 0.40) and the older group (2.05 ± 0.71). As for the craniocaudal nipple deviation, caudal nipple deviation was observed in both of the groups and was significantly greater in the older group (-0.22 ± 0.10) than in the younger group (-0.15 ± 0.10) ($P < 0.001$). As for the mediolateral nipple deviation, the nipples tended to deviate laterally in the younger group (0.003 ± 0.13), whereas they tended to deviate medially in the older group (-0.06 ± 0.15) ($P = 0.046$). The measured breast volume was significantly larger in the older group (471.5 ± 267.6 mL) than in the younger group (315.4 ± 223.6 mL) ($P = 0.003$).

Correlation between Age and Variables

There was a significant correlation between the craniocaudal nipple deviation ($R = -0.38$; $P < 0.001$) and the measured breast volume ($R = 0.26$; $P < 0.05$). No significant correlation was observed for the mediolateral deviation of the nipple ($R = -0.08$) (Fig. 4). We then further evaluated the correlations between the 2 variables that were confirmed to be significantly correlated with age.

Correlation between Measured Volume and Craniocaudal Nipple Deviation

There was a significant correlation between the measured breast volume and the craniocaudal nipple deviation ($R = -0.48$; $P < 0.001$) (Fig. 5).

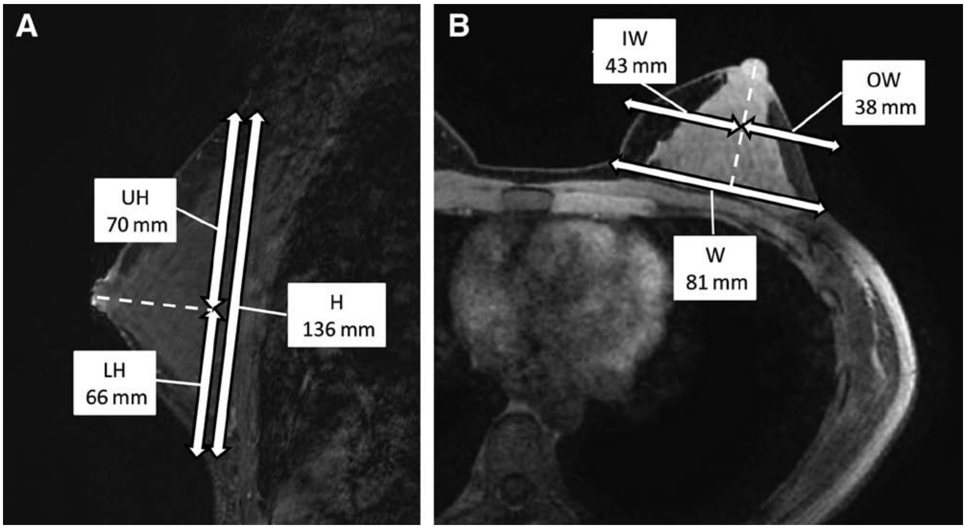

Fig. 2. Left breast of a 31-year-old woman. Sagittal (A) and axial (B) images of T1-weighted gradient-echo MRI. The measured volume, height-to-width radio, mediolateral nipple deviation, and craniocaudal nipple deviation of this breast were 204 mL, 1.68, 0.03, and –0.015, respectively. (The same person is shown in Fig. 1.)

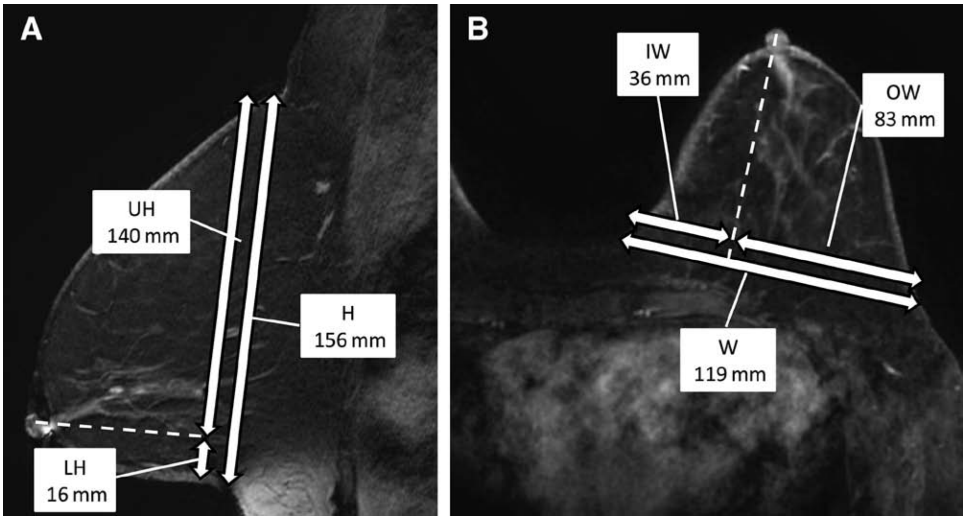

Fig. 3. Left breast of a 76-year-old woman. Sagittal (A) and axial (B) images of T1-weighted gradient-echo MRI. The measured volume, height-to-width radio, mediolateral nipple deviation, and craniocaudal nipple deviation of this breast were 730 mL, 1.31, –0.20, and –0.40, respectively.

DISCUSSION

We have found that caudal nipple deviation was significantly greater in the older group than in the younger group and that the craniocaudal nipple deviation was significantly correlated with age. As all the measurements were performed using the breasts of women in a prone position, the shapes of the breasts were thought to be far less influenced by caudal transformation than they are in a daily upright position. Therefore, these results indicate that the shape of the breast itself changes with aging in a manner such that the nipple deviates caudally. This change in shape probably occurs mainly because of the elongation of the skin of the breast mainly cranial to the nipple and the elongation of the other supporting connectives.

Several characteristics are used when breast shape is measured clinically. These include breast width, intermammary distance, suprasternal notch to nipple (SSN) distance, breast height, upper pole, lower pole, nipple to inframammary fold distance, and projection of the breast.[12] Out of these factors, caudal nipple deviation, which was found to be an age-related change in this study, corresponds to the change in the ratio of the upper pole to the lower pole in clinical examinations of breast shape. In addition, caudal nipple deviation

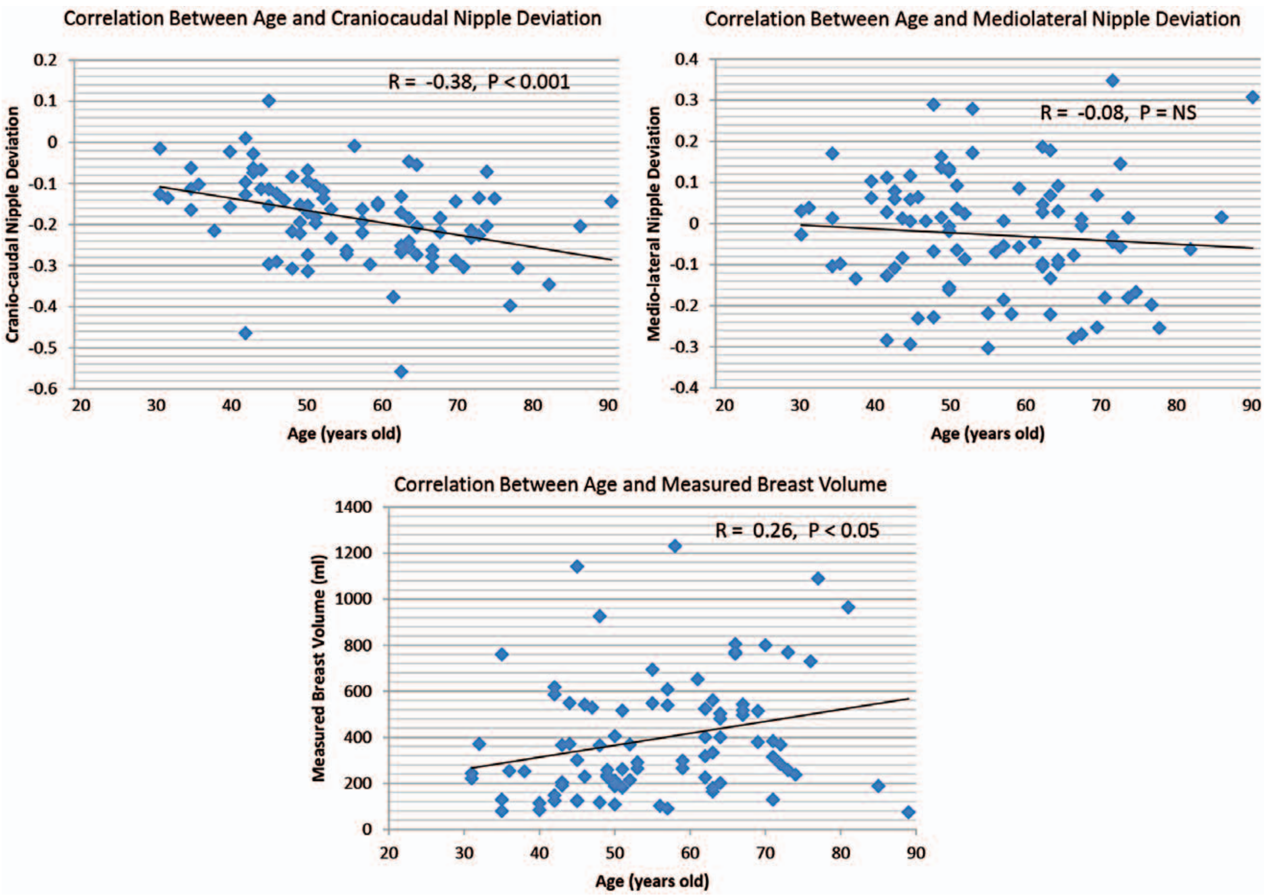

Fig. 4. Correlations between age and variables. NS indicates not significant.

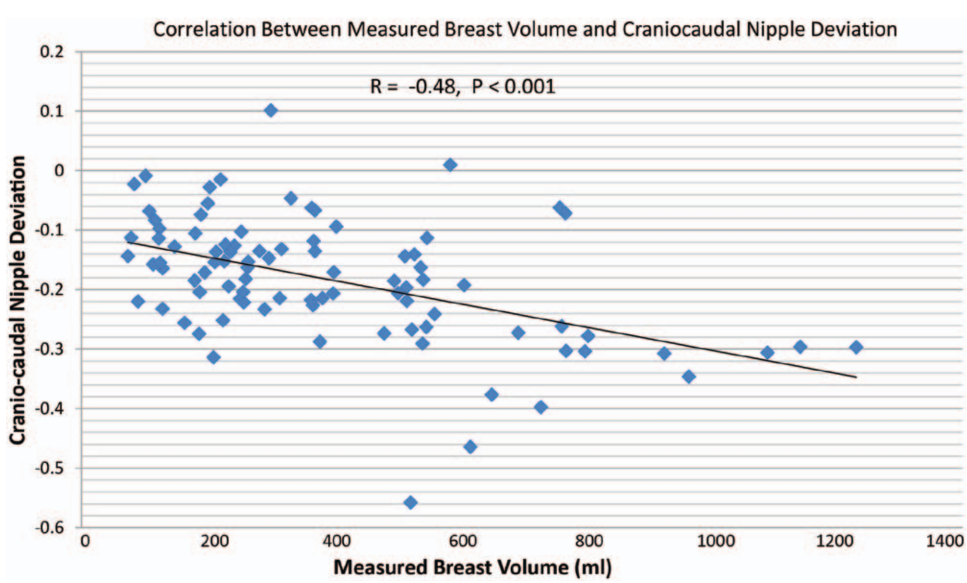

Fig. 5. Correlation between measured volume and craniocaudal nipple deviation.

observed in this study may be indirectly but positively correlated with an elongation of the SSN in clinical measurements. Therefore, this radiology-based study suggests that shortening of the upper pole of the breast or SSN may lead to a rejuvenation of the breast's shape. Although a mastopexy is known to achieve breast rejuvenation, restoring a youthful contour in women with ptotic breasts,[13] the validity of this surgical procedure should be verified metrologically using the results of the current study.

The volume of the breast was also shown to be significantly larger in the older group and was correlated with age in this study. Furthermore, we found a significant correlation between caudal nipple deviation and breast volume. This correlation is probably related to the influence of gravity. As the volume of the breast increases, it is pulled downward by gravity more strongly when the subject is in an upright position. The skin or connective tissue of the breast may be stretched and lengthened by this continuous force pulling them downward, resulting in caudal nipple deviation as aging changes of the breast shape, especially in larger breasts. As is the case with facial aging, in which the gravitational effect is known to play a principal role,[14,15] the change in breast shape is also likely to be strongly influenced by gravity. Because the breast parenchyma reportedly decreases with age or after menopause,[6–11] this increase in breast volume with aging is probably caused by an increase in adipose tissue. Given that the increase in breast volume with aging is mainly caused by adipose tissue, the additional accumulation of adipose tissue probably accelerates the caudal nipple deviation, resulting in the aging-related changes in breast shape. On the other hand, that prevention of additional adipose accumulation could minimize aging-related changes in the breast, although further investigation is required to evaluate how such prevention could be achieved.

Ptosis and atrophy have been described as age-related changes of the buttocks,[16] especially in women.[5] Although ptosis is a common age-related feature of both the breast and the buttocks, the atrophy seen in aging buttocks is in contrast to the increase in breast volume observed in this study. This difference is probably derived from the difference in composition, that is, while age-related atrophy of the gluteal muscles contributes to the atrophy of the buttocks, the breast, which lacks a muscular structure, increases in volume because of the age-related accumulation of adipose tissue.

This study has several limitations. First, breasts with benign findings of less than 10 mm, such as small cysts, were included in the analyzed population, and the influence of these small benign lesions on breast shape or aging-related changes in breast shape was not investigated in the current study. We set the exclusion criteria for the current study tentatively. The potential relationship between breast lesions and breast shape or aging-related changes in breast shape needs to be evaluated in the future. Second, although we measured the breast shape parameters using axial and sagittal sectional images, more complicated measuring methods, such as measurements using oblique reformatted images or volume rendering, may provide more information on breast shape and aging-related changes in breast shape. Third, because this study examined a relatively small number of subjects, women with various breast shapes and sizes were analyzed together. A longitudinal study in which age-related changes in breast shape and size of individual women are analyzed or a study with a larger population in which women with similar breast shapes or sizes are analyzed separately is needed to assess age-related changes in breast shape and size in greater detail.

CONCLUSIONS

By assessing the breasts of women in a prone position, we found that a caudal deviation of the nipple and an increase in volume were age-related changes in breast shape. These 2 variables were also correlated. Given that an increase in breast volume with aging is mainly due to adipose tissue, these findings indicate that the additional accumulation of adipose tissue can accelerate caudal nipple deviation and, accordingly, aging-related changes in breast shape.

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