Computational Simulation of Effects of the Morphology of Fibroglandular Tissues on Projected Breast Density Changes after Breast Compression Based on 3D MRI

T-C. Shih1,2, J-H. Chen1,3, M. Lin1, D. Chang1, K. Nie1, O. Nalcioglu1,4, and M-Y. Su1

1Department of Biomedical Imaging and Radiological Science, China Medical University, Taichung, 40402, Taiwan, 2Department of Radiology, China Medical University Hospital, Taichung, 40402, Taiwan, 3Tu & Yuen Center for Functional Onco-Imaging and Department of Radiological Sciences, University of California, Irvine, Irvine, CA 92697, United States, 4Department of Cogno-Mechatronics Engineering, Pusan National University, Busan 609-735, Korea, Republic of

Background and Purpose: To date, no means to prevent breast cancer has been discovered. Early detection of breast cancer by X-ray mammography can increase survival rate for patients. Mammographic density (i.e., breast density) is a quantitative estimate of the ratio of fibroglandular tissue to the total breast tissue. Breast compression is essential in mammography to flatten the breast and then reduce the breast thickness, which not only can improve the image quality but also reduce the radiation dose to the patient[1-2]. However, the breast density depends on the projection angles, compression levels, the patient positions, and radiologist technician techniques[3-4]. Different projection angles can result in different breast densities even for the same patient and radiologist technician. Usually, a breast tumor is harder than any tissue around it and the shape of benign masses is round or oval. By contrast, a malignant tumor is irregular in shape and has the invasive characteristics. Little is known about the influence of the morphology of fibroglandular tissues on breast density. Fibroglandular tissues would affect breast density. Breast compression changes breast density that indirectly influences the assessment of breast cancer risk. Thus, the purpose of this study is to investigate the effect of the morphology of fibroglandular tissue on the projected breast density after the breast compression based on a non-linear deformation using patient-specific magnetic resonance images.

Materials and Methods: In this study, one hundred sixty MR slices were used to cover the whole breast. All 3T MR images were obtained with the patient in the prone position. Two different morphological types of fibroglandular tissues were used, as shown in Fig.1. The field of view (FOV) at acquisition was 330 mm. Image data were reconstructed within a 512×512 matrix at a slice thickness of 1 mm. These MR images had a voxel dimension of 1.3×1.3×1.3 mm³. A flow chart for breast simulation was displayed in Fig. 2. As acquired the patient-specific prone MR images, we further need to segment into the breast and fibroglandular tissues and then individually assign tissue properties for simulation[3]. Since the fibroglandular tissue is a high individually variability with irregular shapes, here we need to semi-automatically segment the fibroglandular tissue from the whole breast tissue. The segmentation images of the breast were reconstructed from breast 3T MR. The 3D surface mesh of the breast and fibroglandular tissues were created by the Amira software package. The finite volume mesh of the breast was generated by the MSC.Marc software package. In addition, we qualified the projected breast density change (i.e., projected area ratio of fibroglandular to breast) after breast compression.

Results and discussions: While the compression paddles were moving along the compression direction, the posterior breast (i.e., the chest wall on ribcage) was fixed in the y-axis direction (i.e., the boundary condition) thus, the breast deformation was restricted within the space between the compression paddles and extended largely in the other directions; that is, the breast tissue was pushed away from the chest wall. The projected area changes at different compression ratios for fibroglandular tissues and fatty tissues, as shown in Figs. 2 (f) and (g), respectively. With crano-caudal(CC) and mediolateral-oblique(MLO) view compressions, the projected breast density(i.e., projected area ratio) changes at compression ratio ranging from 0 to 60% were listed in Table 1. Higher compression ratio has a larger projected area. For the centralized type, the change of projected breast density is small for CC or MLO compressions. Moreover, the projected breast density has a larger difference between CC(i.e. 44.7%) and MLO(i.e. 48.9%) view compressions for the irregular type of fibroglandular tissue. For centralized type, at the same compression ratio of 60%, the projected area ratios were 42.1% and 41.2% for CC and MLO view compressions, respectively.

Conclusions: It is becoming clear that different compression levels obtain different projected breast densities. For centralized type, the projected breast density may slightly be changed at different compression ratios. Here, we may not only provide a novel computer simulation approach of breast compression but also obtain the projected breast density of different fibroglandular tissue morphologies from MR images for different compression levels, CC and MLO view compressions.


Acknowledgments: This work was supported in part by the National Scienctific Council under Grants NSC 99-2221-E-039-011(Taiwan).