Letter to the Editor

Comment on **"**Large area CMOS active pixel sensor x-ray imager for digital breast tomosynthesis: Analysis, modeling, and characterization" [Med. Phys. **42**, 6294-6308 (2015)]

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To the Editor,

In the paper by Zhao et al[1], the authors cited our article by Lu et al[2] on the image quality of microcalcification in digital breast tomosynthesis (DBT). They compared the contrast-to-noise ratio (CNR) of microcalcifications calculated by their simulation model of a Dexela 2923 MAM detector using metal-oxide-semiconductor active pixel sensor (CMOS APS) technology with our experimentally measured CNR values using a GE GEN2 prototype DBT system with an amorphous silicon cesium-iodide active matrix flat panel (denoted as a-Si:H TFT PPS in Zhao et al) detector. Zhao et al selected several CNR values from our paper and compared the CNRs in Fig. 11 to demonstrate that the CMOS-APS detector could produce higher CNR (about 10 in CNR value) at lower mean glandular dose (MGD) than our system over a range of microcalcification sizes. We would like to point out some errors and key differences that make the comparison unreliable and misleading.

(1) Zhao et al described that the CNR values they cited from our paper[2] were acquired with an MGD of 2.5 mGy. However, they overlooked the fact that although we acquired the original DBT scan of the American College of Radiology (ACR) phantom at 60^o tomosynthesis angle and 21 projection views (PVs) having an MGD of 2.5 mGy, we used only 11 PVs of the 21 PVs for reconstruction when we simulated the other 6 different PV distributions of DBT systems in our study. Therefore, six of the seven conditions shown in Fig. 4 of Lu et al would have an MGD of about 1.31 mGy (estimated as 11/21=52.4% of 2.5); only the CNRs labeled as full set (FS) had an MGD of 2.5 mGy. As seen in Fig. 11 of Zhao et al, they selected our CNR values obtained from the DBT reconstructions with 11 PVs but described our MGD as 2.5 mGy. They emphasized in their paper that the CMOS-APS detector could provide higher CNR values at a lower MGD of 2 mGy than the a-Si:H PPS detector at an MGD of 2.5 mGy, which is incorrect because the MGD they should compare to was 1.31 mGy. Another minor error is that the phantom images in the Lu et al study were acquired at 29 kVp but they cited it as 29-33 kVp.

(2) Zhao et al calculated the contrast of microcalcification under an idealized condition, namely, a single projection image of a microcalcification embedded in a thin (1 mm) slice of breast tissue material (Section 2.D and Eq. (20) in Zhao et al[1]) without reconstruction. They did not take into account the scattered radiation from a thick breast phantom that would degrade the image contrast. They further ignored the fact that the electronic noise of the detector would contribute

to every projection of a DBT scan. By assuming that a DBT scan was acquired by a single x-ray exposure, they could underestimate the total electronic noise in a DBT scan from the detector significantly. Furthermore, due to the oblique incidence angle of DBT projections to the detector and to a reconstructed slice of finite thickness (1 mm in this case), there is additional blurring in the reconstructed microcalcifications caused by detector blur and the voxel size used in the reconstruction. The imperfect accuracy in the geometric parameters of a real DBT system (uncertainties in the projection angle and geometric distances), the finite focal spot size, and the limited-angle reconstruction further contribute to blurring in the reconstructed image. Zhao et al ignored all these factors that can degrade the CNR of a small object such as microcalcification in DBT and directly compared their idealized, calculated CNR values with experimental data obtained from real reconstructed DBT images by Lu et al.[2] and Park et al.[3] The study by Park et al. used a DBT system with a Dexela 2923 MAM CMOS APS detector (the same model as that simulated by Zhao et al.) and reported that the measured CNR values from the reconstructed DBT images of a 0.4 mm speck ranged approximately from 28 to 40 at a fixed MGD of 2 mGy, depending on the angular distribution of the PVs and the dose distribution among the PVs. Despite the idealized model used in their CNR calculation (described above), Zhao et al. showed some experimental CNR values by Park et al. that were close to their calculated CNR values. They further compared these CNR values to those by Lu et al. and stated that "in comparison to the GE GEN2 a-Si:H based PPS x-ray imager, the CNR values achieved by the Dexela 2923 MAM CMOS APS x-ray imager are higher (by around 10) due to its low electronic noise." They attributed the difference in the CNR values simply to the detector performance, disregarding the differences in the imaging conditions, the DBT acquisition parameters (tomosynthesis angle, angular distributions of PVs, and dose distribution among the PVs), and the reconstruction methods between the studies by Lu et al. and Park et al. The conclusion is misleading.

(3) In Fig. 11, Zhao et al. reproduced an image of a simulated microcalcification cluster (nominal speck size 240 μm) from Fig. 3 of the Lu et al. paper and commented that "165 μm microcalcifications are still detectable using the Dexela 2923 MAM CMOS APS x-ray imager at MGD of 2.0 mGy, while 240 μm microcalcifications are almost invisible using the GE GEN2 PPS x-ray imager at an even higher MGD of 2.5 mGy. Therefore, smaller microcalcifications can be detected using studied CMOS APS x-ray imager at lower dose. From Fig. 11, we can speculate that it would be very difficult for microcalcifications less than 200 μm to be detected

using the conventional a-Si:H based PPS x-ray imager." We would like to point out that it is not reliable to judge the visibility of small signals from a picture in a published journal article, especially for signals such as subtle microcalcifications. We had published the results of an observer study[4] that evaluated the detectability of microcalcifications in reconstructed DBT of breast phantoms. In that study, breast phantoms 5 cm in thickness containing microcalcification clusters were imaged at seven acquisition geometries using our GE GEN2 prototype DBT system with an a-Si:H TFT PPS detector. The exposure condition was kept constant at Rh anode/Rh filter 29 kVp and 50 mAs with an estimated MGD of 1.1 mGy for each DBT scan. Six experienced radiologists participated as observers to search for the microcalcification clusters in the reconstructed DBT volumes. We found that their average sensitivities of detecting subtle microcalcification clusters (nominal speck size 150-180 μm) ranged from 80.4±6.7% at 60^o tomosynthesis angle to 95.7±6.6% at 16^o tomosynthesis angle. The speculation by Zhao et al is therefore incorrect.

Acknowledgments

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References

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