A human observer study of multi-lesion detection in digital breast tomosynthesis

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Rationale

Multifocal and multicentric breast cancer (MFMC) is defined as two or more tumor foci within a single breast. A diagnosis of MFMC significantly impacts treatment planning. The long-term objective of our research is to optimize digital breast tomosynthesis (DBT) for detection of MFMC. Our vision is that DBT has the potential to improve the detection of multiple breast lesions and may offer advantages such as fewer false-positive findings, lower cost, and better accessibility. Prior efforts to identify DBT system geometries that optimize image quality only considered unifocal breast cancer scenarios, and DBT system geometries that yield images that are informative for the task of detecting unifocal breast cancer may not necessarily be informative for the task of detecting MFMC. This study focuses specifically on the impact of different DBT system geometries on radiologists' detection performance for MFMC.

Methods

Five radiologists specializing in breast imaging and/or having experience with DBT interpretation were recruited. 3D anthropomorphic computational phantoms with a random number of embedded synthetic breast lesions were scanned by a simulated DBT system to simulate MFMC cases. Four regions of interest (ROIs) are extracted at each possible lesion location to represent the reconstructed slice. The task of the radiologists was to read the DBT images for detecting multiple lesions, and to report the presence or absence of a lesion using an ordinal scale. We evaluated four DBT system geometries to investigate two key factors of image acquisition: narrow-arc geometry vs. wide-arc geometry, and large vs. small projection angular increment. We estimated the area under ROC curve (AUC_{ROC}) and under alternative response ROC curve (AUC_{AFROC}) as the figures of merit for the observer performance in making image-level and location-specific detection decisions, respectively.

Results

For the narrow-arc geometries, the observers achieved higher AUC_{ROC} and AUC_{AFROC} for the MF cases than for the MC cases. However, for the wide-arc geometries, the observers achieved higher AUC_{ROC} and AUC_{AFROC} for the MC cases than for the MF cases. This conflict suggests that the narrow-arc geometry may be more effective for detecting MF lesions while the wide-arc geometry may be more effective for MC lesions. Moreover, for both MF and MC cases, the rank ordering of the DBT geometries by AUC_{ROC} was not the same as that by AUC_{AFROC}. This suggests that the optimal designs of DBT would change if the clinical task of interest changes.

Conclusions

We present a human observer study that investigates DBT system geometries for detecting MFMC lesions. We have shown that the DBT geometries may not be equally efficient for MF cases and MC cases. We have also shown that the optimal geometry of DBT may vary when the task of clinical interest changes.