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ORIGINAL ARTICLE / *Breast imaging*

Breast tomosynthesis: Dosimetry and image quality assessment on phantom

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Mammography;
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Abstract
Purpose: To evaluate using phantom study the average glandular dose (AGD) and image quality in breast tomosynthesis.
Materials and methods: The study was performed with a full-field digital mammography system (Mammomat Inspiration®, Siemens, Erlangen, Germany) combined with tomosynthesis equipment (3D). For AGD evaluation, polymethyl methacrylate (PMMA) plates and a dosimeter were used to directly measure the absorbed doses in 2D and in 3D. The doses were then compared to the doses displayed on the equipment using the Mann—Whitney test. Three phantoms, accredited for 2D digital mammography (MTM 100, ACR RMI 156, BR3D), were imaged three times in 2D then in 3D. For each acquisition, the AGD was recorded. For image quality assessment, scores, defined by the rate of visible inserts, obtained for each acquisition both in 2D and in 3D, and for each phantom, were compared (Kruskall—Wallis and post-hoc Dunn tests).
Results: There was no significant difference between the measured and displayed AGD, both in 2D and in 3D imaging ($P > 0.05$). With identical acquisition parameters, AGD were significantly greater in 3D than in 2D $P < 0.01$). For phantoms MTM 100 and ACR RMI 156, there was no significant difference between the rate of visible inserts in 2D and in 3D ($P = 0.06$ and $P = 0.36$, respectively). However for phantom BR3D, the rate was significantly higher in 3D than in 2D ($P < 0.0001$).
Conclusion: Doses are significantly greater in 3D than in 2D. With tomosynthesis, out of the three phantoms tested, only phantom BR3D showed a higher rate of visible inserts.

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By comparison with screen-film radiography, digital mammography improves breast cancer screening [1—3], reduces average glandular dose [2—5] by about 22% [4] and makes it possible to add tomosynthesis in routine use [6]. The combination of tomosynthesis with digital mammography increases diagnostic accuracy [6—15] and reduces recall rates by 30 to 40% [8,9]. In the United States, tomosynthesis was approved by the Food and Drug Administration in 2011 [16]. However, recent articles have reported that the AGD per view is higher in tomosynthesis mode than with mammography alone [13,15,17]. Therefore, reducing the dose is essential to validate a possible use of tomosynthesis in screening programs. In addition, the absorbed dose in tomosynthesis should be assessed simultaneously with image quality, like is currently done for 2D mammography breast cancer screening programs. In France, regulatory quality control testing of digital mammography screening is done with phantoms in order to obtain reproducible testing, and thereby a long-term follow-up of mammography systems. In France, only phantom MTM 100 (Meditest, France) is used in mammography screening programs, but tomosynthesis is not covered [18]. To the best of our knowledge, there is not one specific phantom for tomosynthesis acquisitions, unlike for 2D mammography. However, several phantoms are on the market and could be adapted to assess breast tomosynthesis reconstructions.

The goal of this study was to evaluate the average glandular dose (AGD) and the quality of the images obtained by tomosynthesis using the phantoms currently available.

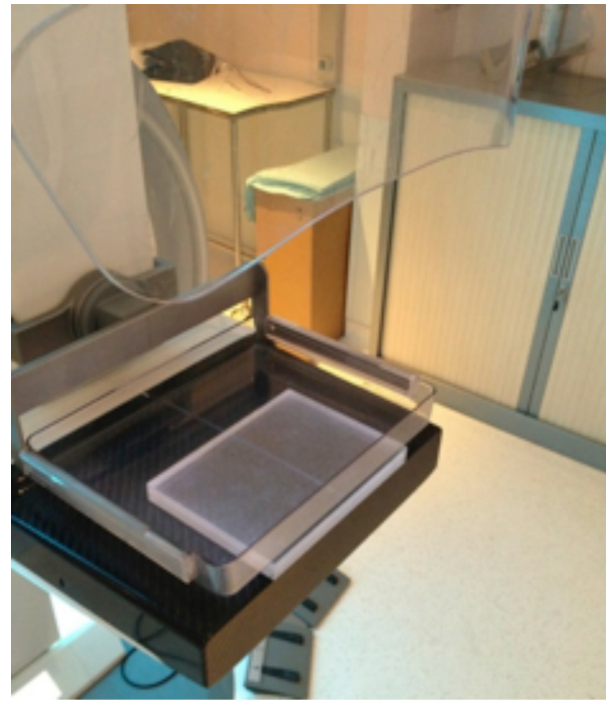

Figure 1. Polymethyl methacrylate (PMMA) plate.

Materials and methods

Tomosynthesis

All the images were acquired with the Mammomat Inspiration® mammograph (Siemens, Erlangen, Germany).

The 3D tomosynthesis acquisition parameters were the following: an overall angle of 50°, with the X-ray tube rotating 25° in both directions from the target by 2-degree increments to obtain 26 projection views. A reconstruction algorithm (Equalizing Filtered Back Projection) was applied to obtain 1-mm slices.

Evaluation of AGD in 2D and 3D imaging on polymethyl metacrylate (PMMA) plates

The AGD was evaluated in 2D and 3D imaging, on PMMA plates of varying thickness. Five images were acquired in 2D then in 3D with PMMA placed on the detector plate while the thickness varied from 20 to 60 mm, by 10-mm increments (Fig. 1). The values of kV, mAs and AGD displayed by the mammography system were recorded.

Using a Piranha dosimeter (RTI electronics AB, Sweden), the AGD was measured for 2D (noted AGD) and for 3D (noted AGD_T). The AGD was calculated based on the entrance surface air kerma (ESAK). Acquisitions were obtained in manual mode, with parameters selected so as to be as close as possible to those used in clinical practice. The detector was placed on the compression paddle so as not to affect the AGD delivered during exposure (Fig. 2).

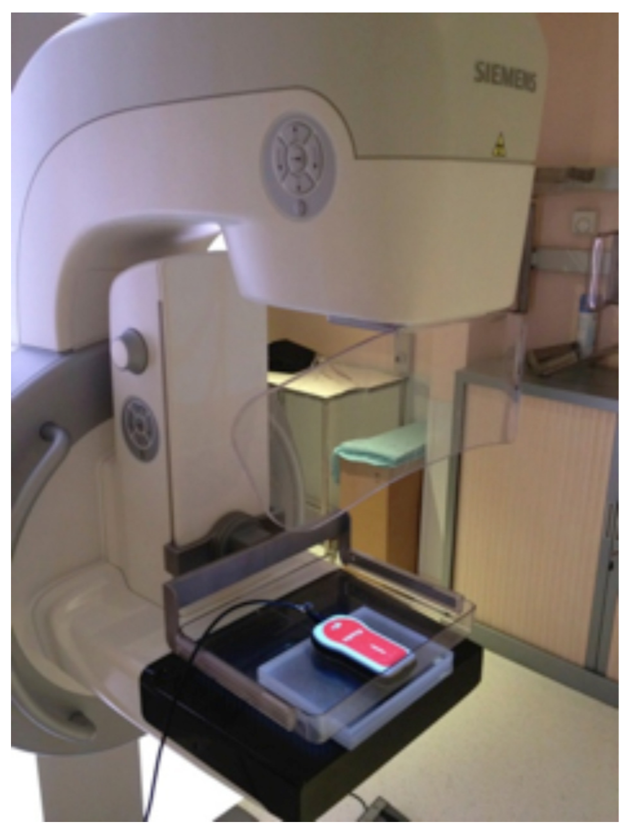

Figure 2. Piranha (RTI electronics AB Sweden) dosimeter positioned on a PMMA plate fixed by the compressor.