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REVIEW / *Breast imaging*

Overview of digital breast tomosynthesis: Clinical cases, benefits and disadvantages

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Abstract In France, the national breast cancer-screening program is based on mammography combined with clinical breast examination, and sometimes breast ultrasound for patients with high breast density. Digital breast tomosynthesis is a currently assessed 3D imaging technique in which angular projections of the stationary compressed breast are acquired automatically. When combined with mammography, clinicians can review both conventional (2D) as well as three-dimensional (3D) data. The purpose of this article is to review recent reports on this new breast imaging technique and complements this information with our personal experience. The main advantages of tomosynthesis are that it facilitates the detection and characterization of breast lesions, as well as the diagnosis of occult lesions in dense breasts. However, to do this, patients are exposed to higher levels of radiation than with 2D mammography. In France, the indications for tomosynthesis and its use in breast cancer-screening (individual and organized) are yet to be defined, as is its role in the diagnosis and staging of breast cancer (multiple lesions). Further studies assessing in particular the combined reconstruction of the 2D view using 3D tomosynthesis data acquired during a single breast compression event, and therefore reducing patient exposure to radiation, are expected to provide valuable insight.

Abbreviations: 2D, Two-dimensional; 3D, Three-dimensional; FDA, Food and Drug Administration (USA); MRI, Magnetic resonance imaging; ACR, American College of Radiology; BI-RADS, Breast Imaging-Reporting And Data System; CAD, Computer-aided detection; IRSN, Institut de Radioprotection et de Sûreté Nucléaire (French Radioprotection and Nuclear Safety Institute); HRT, Hormone replacement treatment; mGy, milliGrays; FS, Fat-saturation; IDC, Invasive ductal carcinoma; ILC, Invasive lobular carcinoma; CESM, Contrast-enhanced spectral mammography.

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Introduction

With the introduction of large-scale organized screening programs as well as individual procedures, together with improved treatment strategies, the morbidity and mortality of breast cancer have decreased [1—3]. Screening is based on mammography, more and more often digitized, and clinical breast examination. In patients with high breast density (ACR3 or ACR4), breast ultrasound is also sometimes performed. Technical progress has been made recently in breast imaging with the use of new imaging techniques [4—6], notably three-dimensional mammography, also called tomosynthesis. Tomosynthesis has been approved for screening and diagnosis of breast cancer in the USA since February 2011 and is currently used in 48 States in the USA and more than 50 countries worldwide [7].

Unlike 2D digital mammography that produces a single X-ray image, tomosynthesis is an automated technique that yields multiple low-dose angular projections of the breast during a single breast compression event, hence enabling 3D breast reconstruction.

In the review, after reviewing the technology and the existing literature on tomosynthesis, we discuss the various uses and advantages of tomosynthesis in clinical practice, as well as its limitations and future prospects.

Overview of the technology of breast tomosynthesis

Examination protocol

Tomosynthesis is an automated digital breast imaging technique that produces multiple angular projections during a single breast compression, and provides both conventional 2D- as well as 3D-information [8—12]. The examination protocol is the same as for conventional mammography: the patient is first positioned and her breast compressed, then the X-ray tube moves over the breast in a semicircular motion (Fig. 1). Low-dose images are acquired every degree over an angle of 10—20 degrees. Imaging lasts about 5 s in all. Depending on the width of the compressed breast, a series of 10 to 20 images is thus obtained and used to reconstruct breast tissue in one-millimetre thick slices for detailed analysis of the breast [13]. The projections obtained using tomosynthesis are typically craniocaudal (CC) or mediolateral oblique (MLO), although any projection can be used. Complementary spot compression imaging can also be performed using tomosynthesis. The images presented herein were obtained using the Selenia Dimensions® breast tomosynthesis system (Hologic, Bedford, Massachusetts, USA).

Review of existing literature

Examination technique

The performances of tomosynthesis (one or more series of images in different projections) combined with 2D mammography are equivalent or superior to those obtained with 2D mammography alone [14—21]. Indeed, it has been demonstrated that using a single series of tomosynthesis images in the MLO view is equivalent to both 2D mammographic views (CC and MLO) [14—17]. Thus, when combined with 2D mammography, tomosynthesis improves the quality of imaging. Performances can be further improved by combining the two tomosynthesis views and the two 2D mammographic views [16,18—21].

As regards to complementary spot compression imaging, the combination tomosynthesis/2D mammography has not been shown to be statistically superior to 2D mammography with spot compression [22]. Tomosynthesis and 2D spot compression mammography give equivalent results when characterizing and grading masses using BI-RADS categories [23], but exposure to radiation is lower with tomosynthesis [24].

Finally, the mean dose of radiation to the breast for the multiple projections of a single tomosynthesis procedure is equivalent to that received during 2D mammography [25].

Screening mammograms

Several studies showed that the combination of tomosynthesis and 2D mammography improves the sensitivity of detection of suspicious lesions [19,26] and reduces the patient recall rate for benign lesions [19,21,28] when used as part of a screening program [19,21] or for follow-up after second reading [26—28].

Skaane et al. in a prospective clinical study including 12,631 patients concluded that more breast cancers could be detected using 2D mammography in combination with tomosynthesis (6.1/1000 cancers [77 cancers] detected with 2D mammography alone vs. 8/1000 cancers [101 cancers], with 2D mammography and tomosynthesis) with a 27% increase [29]. This increased detection rate was observed irrespective of breast density, was particularly significant for invasive cancers (+40%), and was associated with a lower rate of false positive findings (—15%) compared with 2D mammography alone. A further study by other researchers confirmed the increased cancer detection rate (+43%) and reduced recall rate (—22%) [30].

Gilbert et al. in a retrospective multicenter study initiated in December 2010 compared the use of tomosynthesis to that of 2D mammography in organized screening programs [31]. They found that the specificity was increased by using 2D mammography combined with 3D tomosynthesis when compared with 2D mammography alone (93% vs. 86%; $P < 0.001$), but the sensitivity was not improved.

Diagnostic mammograms

A few studies have investigated the use of tomosynthesis for diagnostic purposes. Subject to this limitation, it seems likely that tomosynthesis should enable clinicians to better estimate lesion size [32,33], particularly for small lesions or in patients with high breast density [34] and facilitates BI-RADS scoring due to the better image quality obtained [8,27,33,35].

The combination of 2D mammography and tomosynthesis should also improve the detection of masses and other abnormalities associated with breast cancer [19,33,36]. This should lead to a higher rate of true-positive findings and an improvement of the diagnostic performances of radiologists [37] with more evidence to support the diagnosis of malignancy (architectural distortion/spiculated margins) [26]. It