# Spiral Breast CT: Going Further with Photon Counting

In this article we introduce the innovative technical features of the nu:view breast CT system and describe recent clinical findings and the likely indications of this new equipment.

Offering significant advantages over other breast imaging modalities thanks to its innovative design and performance characteristics, dedicated breast CT is so far the only 3D breast imaging method that has been shown to reliably detect microcalcifications and mass lesions without any risk of obscuring lesions because of superimposed tissue. Contrast-enhanced imaging with the new technique enables sensitive detection of malignant mass lesions as well as of non-mass lesions. Overall, dedicated breast CT has been shown to be an appropriate modality for a number of clinical indications. Problem-solving is one such application; lesions that are ill-defined by other imaging modalities can easily be identified by 3D spiral breast CT and additional tumor characteristics assessed through contrast enhancement. Another field of application is preoperative staging of established breast cancer cases in order to determine the optimal therapeutic strategy. However, probably the largest potential of dedicated breast CT lies in screening, where currently many women drop out of standard screening mammography programs because of the discomfort and pain associated with the breast compression involved in conventional mammography. This problem is absent in spiral breast CT, which does not involve breast compression.

Breast imaging is the unavoidable backbone technology in the diagnosis of breast cancer, with the gold standard imaging method currently being digital mammography. Several other imaging modalities such as ultrasound and breast MRI also have well-established roles and recent methods such as breast tomosynthesis are increasingly being used in breast imaging. In addition, the potential of newer imaging modalities such as contrast-enhanced spectral mammography (CESM) or breast CT is under active evaluation to determine their optimal role in the workup of breast lesions.

Recently a dedicated breast CT system, nu:view, developed by the German company AB-CT (Advanced Breast CT) has become commercially available in Europe, after obtaining CE certification in 2018. A prototype of the scanner was installed as early as 2019 in our breast radiology department at Erlangen University Hospital for preclinical studies and since then it has been also used for routine clinical examinations. So far we have carried out more than 200 clinical examinations with the new device, principally for advanced diagnostic purposes.

## Current breast cancer diagnostics

The field of breast diagnostics is already supplied with many different imaging techniques, so on the face of it, a legitimate initial question is to wonder whether yet anoth-

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**The team of the multimodal breast imaging unit of the University Hospital Erlangen have accumulated extensive clinical experience with the new nu:view scanner from AB-CT – Advanced Breast-CT.**

er imaging approach is even necessary. However, even a cursory look at the various individual imaging techniques currently used in breast imaging shows that, on their own, none of them can provide optimal performance results for all of the various parameters necessary in modern breast examinations. Such parameters include the obvious ones of sensitivity, resolution and diagnostic accuracy but also encompass other issues as timely accessibility to the imaging modality in practice and, importantly, the acceptance of the technique by the women actually undergoing the examination. In modern breast diagnostics satisfactory results are mostly achieved through a combination of several individual examination modalities.

X-ray based methods: One problem with current x-ray based methods in mammography is the lack of real 3D resolution, which can lead to the masking of lesions because of the superimposition by fibroglandular tissue (FGT). This results in reduced sensitivity in the detection of mass lesions and microcalcifications, especially in dense breasts. Although digital breast tomosynthesis (DBT – a pseudo-3D technique) reduces such superimpositions, it has been found that in DBT microcalcifications appear less suspicious or can be missed completely[1].

Non x-ray based methods: Ultrasound is very operator-dependent, and MRI is very time-consuming, costly and therefore not available everywhere. In addition, MRI and ultrasound cannot reliably identify microcalcifications, which can be the only imaging sign of breast malignancies.

These points highlight the need for a new 3D breast imaging modality that can reliably visualize both mass lesions and microcalcifications. The dedicated spiral breast CT meets these requirements and may therefore serve as good candidate for future breast imaging.

## Technical characteristics of dedicated spiral breast CT

For the reliable visualization of microcalcifications, a spatial resolution of less than 0.2 mm is necessary. This is possible with the nu:view scanner thanks to its dedicated x-ray source and a newly designed single photon counting detector. The source has a focal spot size of 0.3 mm and is operated at a constant tube voltage of 60 kV. The detector has a pixel size of 0.1×0.1 mm and uses cadmium telluride crystals which directly convert x-ray photons into measurable electric charges, thus decreasing intrinsic noise and enabling the use of low radiation exposures. When imaging with a radiation dose equivalent to that which is typically used in conventional mammography, the dedicated spiral breast CT system provides images with a spatial resolution as low as 0.15 mm at a signal-to-noise ratio amply sufficient for image interpretation[2,3]. During a single scan of the imaging unit, up to 12,000 projections are acquired by the detector (1,000 Hz) and the total acquisition period lasts only 7–12 seconds, thus minimizing the risk of motion artifacts.

Similar to breast MRI, the neovascularity of tumors can be visualized by intravenous administration of contrast agent. Not only can mass lesions be better visualized by contrast media uptake, but the visualization of non-mass lesions is even possible [Figure 1]. This makes breast CT the only modality in breast diagnostics

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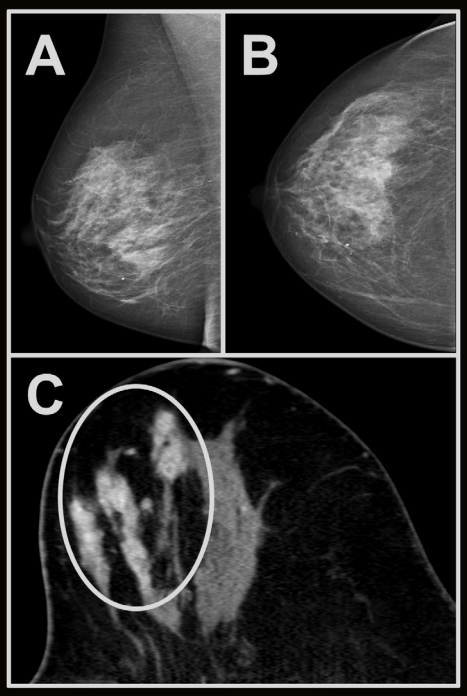


Figure 1. Images from a 59-year old woman with bloody nipple discharge without any correlating lesion in two-view mammography (A, B). Contrast-enhanced dedicated spiral breast CT revealed an enhancing non-mass lesion in the lower outer quadrant (circled in image C), which was confirmed as a high-grade ductal carcinoma in situ (DCIS) on histopathology.

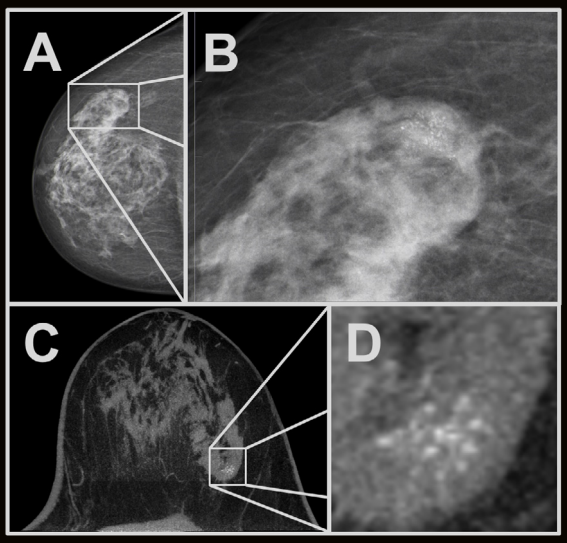


Figure 2. Mammography and breast CT images from a 79-year old patient with microcalcifications in the outer quadrant in the right breast. (A) mammography in CC-view; (B) magnification of image A; (C) dedicated spiral breast CT image and (D) magnification of image C. Histopathology confirmed ductal carcinoma in situ (DCIS).

that can visualize both imaging characteristics of ductal carcinoma in situ (DCIS), namely microcalcifications [Figure 2], and non-mass enhancement.

### Possible indications for Breast CT

SCREENING: Mammography screening has been shown to reduce cancer related deaths in breast cancer and is currently key for the establishment of early diagnosis. However, the level of the participation of women in screening programs leaves much to be desired. For example, the German breast screening program, only 49 percent of all eligible women actually participated in the program in 2017[4]. One reason for this is the discomfort experienced by women during the mammography examination itself and in particular with the breast compression, which causes real pain for many women[5]. Dedicated breast CT does not involve compression of the breast and uses a completely different body positioning from the classical upright stance of mammography. In breast CT, the woman lies prone on a patient table with the breast hanging freely in the imaging unit through an aperture in the patient table. Understandably, this procedure has been proven to significantly increase patient comfort compared to mammography by eliminating compression-related pain[6]. Thus, dedicated spiral breast CT is an appropriate methodology for opportunistic breast cancer screening particularly for women who would otherwise decline participation in or drop out of conventional mammography screening. The use of dedicated breast CT for opportunistic screening has already been described and is routinely carried out at the University Hospital Zurich[7] .

PREOPERATIVE STAGING: Pre-therapeutic staging of breast cancer is important to determine optimal therapeutic strategy and whether breast conserving therapy is possible. However the determination of tumor extent, satellite lesions or DCIS can be challenging, especially in dense breasts. Breast MRI has been shown to change the previously determined extent of planned surgical procedures in up to 23 percent of cases mainly due to the identification of additional lesions[8]. Like MRI, dedicated spiral breast CT shows malignancies as enhancing lesions, and has thus proved to be an excellent alternative to breast MRI, especially in situations where MRI is not readily available or in cases with contraindications to MRI examination [Figure 3]. However, it should be noted that for lymph node staging with breast CT, an additional ultrasound examination is necessary, since breast CT does not cover the axilla.

PROBLEM-SOLVING: Currently breast MRI is the modality frequently used for problem solving in breast imaging cases where analysis is difficult and precise diagnosis not yet established. Likewise, dedicated spiral breast CT can be a method of choice in clinical decision-making in cases with equivocal lesions [Figure 3]. With an advantage over MRI in that the examination takes less time, breast CT provides 3D-imaging without the need for breast compression and results in improved localization of lesions in the breast without distortions. Through contrast-enhanced imaging, dedicated spiral breast CT could aid in discriminating probably benign from malignant lesions and be an aid in the consideration of whether to take a breast biopsy or not. Breast CT also serves as a valid alternative to breast tomosynthesis or contrast enhanced spectral mammography, with in addition the advantages of real 3D imaging and increased patient comfort.

## Conclusion

Dedicated spiral breast CT is a new imaging modality with striking and proven performance characteristics; the technique has already found its way into daily clinical practice. It is not only suitable as an imaging option in tertiary care institutions, but also for use in radiology practices who want to offer their patients an alternative for breast screening and as a powerful problem-solving modality.

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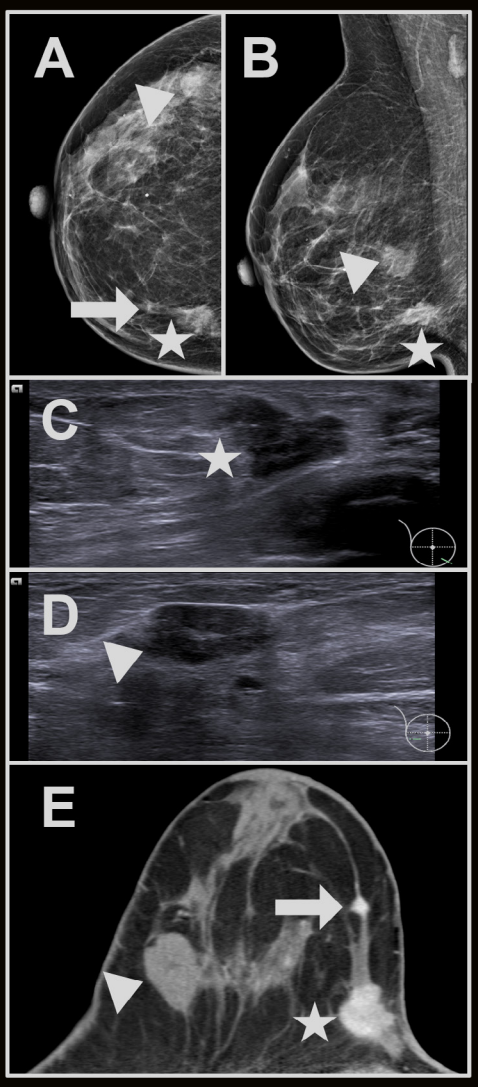


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**Figure 3. Example of the potential of breast CT for both problem-solving and also preoperative staging in a single examination. 63-year old woman with a palpable breast carcinoma in the lower inner quadrant of the right breast (indicated by stars in A, B, C, E). Mammography and ultrasound revealed a second lesion in the lower outer quadrant of the right breast (arrowhead in A, B, D), which was suspected as hamartoma. Dedicated breast CT confirmed the benign nature of the lesion through the lack of contrast enhancement (arrowhead in E). Incidentally, breast CT revealed a second contrast-enhancing lesion in the lower inner quadrant of the right breast (arrow in E), which proved to be multifocal cancer that had been missed on ultrasound and in initial mammography (arrow in A).**

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