# Background Information

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## Siemens Healthineers Breast Tomosynthesis is setting new standards in early breast cancer detection

- **Breast tomosynthesis is a refinement of mammography**
- **The quality of breast tomosynthesis images depends on the tube angulation and the number of projections, and differs greatly within the industry**
- **Siemens Healthineers High Definition Breast Tomosynthesis offers the widest tomo angle currently available (50 degree) and the largest number of projections**
- **High Definition Breast Tomosynthesis increases breast cancer detection rates, improves diagnostic accuracy, and thus expands precision medicine**
- **The new mammography system Mammomat Revelation improves patient experience due to individual compression adjustments and faster diagnoses**

Breast tomosynthesis delivers X-ray images of the breast that provide more definite results than mammography, the current standard procedure for early breast cancer detection. Just like mammography, breast tomosynthesis is an X-ray examination designed to make changes in breast tissue visible. But unlike mammography, tomosynthesis makes projections of the breast from several different angles. The result is a 3D volume representation of the breast and thus an improved diagnostic accuracy so that patients can be treated earlier and more precise.

**Importance of early breast cancer detection**

Breast cancer is the most common form of cancer affecting women worldwide[1]. In 2015 alone, about 570,000 women around the world died of breast cancer[1]. Although methods of treating breast cancer are becoming more advanced, the principle that the earlier a tumor is detected, the greater the chance of recovery still applies[2]. Early breast cancer detection is therefore crucial for the health of women. As an important early detection method, in addition to breast palpation, breast cancer screening has become a global

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standard procedure in preventive medicine[3]. This involves inviting women in a particular age group to undergo a voluntary breast X-ray examination to spot changes in breast tissue structure and signs of potential breast cancer as early as possible. Unlike breast X-rays performed for diagnostic purposes in cases where there is already a serious suspicion of breast cancer, breast cancer screening is governed by precise, country-specific standards. These standards specify the permitted dose of radiation and make recommendations on the recall rate, the proportion of women who must be invited back for a further examination because the results of a screening process were either suspicious or not definite. A further key parameter in this connection is the detection rate, or the proportion of women whose breast cancer is actually identified as such during the screening process.

**Mammography – the current standard procedure in early breast cancer detection**

Full-field digital mammography, in which two-dimensional (2D) images of the breast are taken, is currently the standard procedure in early breast cancer detection. Normally, a two-view mammogram is performed, with projections from two different angles: a craniocaudal (CC) projection of the breast from above, and an angled, side-on view from the center outwards, known as mediolateral-oblique (MLO) projection. But each of these projections provides only a two-dimensional view of the breast. The breast tissue structures that are imaged in this way overlay each other, which means that some structures and lumps in the breast tissue are difficult to detect, or cannot be detected at all. If the X-ray hits dense breast tissue on its way through, a tumor lying behind that tissue can easily be missed. In the case of women with dense breast, conventional mammograms can sometimes be difficult to interpret on account of the overlaying of breast tissue[4]. Mammography may leave as many as 30 to 50 percent of malignant tumors undetected[5,6]. And conversely, the overlapping tissue structures in the image can also lead to false positives, i.e. the misinterpretation of this structure as a lesion. This can cause the patient to undergo treatment that is actually unnecessary.

**What do we mean by breast tomosynthesis?**

Breast tomosynthesis, a refinement of the mammography process, has been on the market since 2009 and provides images that have more impact and are more definite. The word tomosynthesis comes from Greek, and refers to layering (tomos) and combination (synthesis). In tomosynthesis, the X-ray source moves at different tomo angles over the breast, which lies on the detector, producing a series of individual projections that each

require only a very low dose of radiation. Depending on the manufacturer, the tomo angle measures between 15 degree and 50 degree, and the number of X-ray projections ranges between nine and 25[7-9]. High Definition Breast Tomosynthesis from Siemens Healthineers uses the highest tomosynthesis angle span currently available (50 degree)[10]. Within this range, the X-ray tube moves from left to right over the breast in less than 25 seconds and records a projection at approximately two degree intervals without having to pause each time. The result is a total of 25 individual projections, more than with any breast tomosynthesis system currently available[10]. These individual projections, however, must not be confused with the images that are ultimately provided to the physician for diagnosis. Instead, they provide the raw data that a mathematical image reconstruction program then uses to generate the tomosynthesis slices. These slices each show a thin layer of the breast (around two millimeters), with a one millimeter overlap in the tomographic representation. Each slice thus also partly includes information that is available on the adjacent image. The number of slices will depend on the size of the breast[10]. They show the breast tissue and its structures without overlays and in much greater detail than on traditional mammograms. It is possible to scroll back and forward through the slices on-screen – and thus view the breast tissue being examined in its full depth, layer by layer.

**What are the strengths of breast tomosynthesis?**

The method described above makes it possible to detect the slightest changes, structures and lumps in the breast tissue that lie beneath each other and may not be picked up in full, or at all, by a mammogram[2]. In other words, breast tomosynthesis does a better job of detecting tumors[11]. This is known as improved sensitivity. Microcalcifications, which may point to cancer, are also clearly visible with this method due to the Enhanced Multiple Parameter Iterative Reconstruction (Empire) Technology by Siemens Healthineers, a unique combination of iterative and machine learning algorithms, showing better contrast, image quality, visibility of calcification, and fewer artifacts, i.e. structures in the imaging that do not conform with reality[12]. Additionally, breast tomosynthesis is more reliable in recognizing changes in breast tissue[13,14].

**Quality determined by tomo angle and number of projections**

The 50 degree angulation of the tomosynthesis systems used by Siemens Healthineers is the result of a balance between data quality, data volume, and the length of the examination. The wide angulation has a quite particular purpose in this procedure. The

greater the tomo angle, the better the layers can be separated and tissue overlays avoided[15-19]. Thus a larger angle improves the depth resolution[16]. The number of projections is also extremely important in terms of the quality of the breast images. The more projections can be generated, the more information the dataset will hold, which can then be used to reconstruct more clear tomosynthesis slices. Many scientific studies show that a greater angular range may lead to better image quality.[16,20] Reaching a diagnosis based on the tomosynthesis images takes more time overall than with the two mammograms that have previously been the norm. But the payoff comes in the higher tumor detection rate. Although some radiologists are inexperienced with tomosynthesis because it is a method that has only recently been developed, studies show a fast rise in the learning curve for radiologists in performing diagnoses based on tomosynthesis[21,22].

**Synthetic 2D image and 3D representation of the breast with reconstruction of tomosynthesis data**

For early detection of breast cancer, physicians rely on comparing older images of the breast from previous years against more recent images. This enables changes in breast tissue to be detected and followed up. Because mammography has previously been the standard procedure in early breast cancer detection, however, the older images are mainly two-dimensional mammography images that are not comparable with the slices obtained using tomosynthesis. A traditional 2D mammogram would therefore have to be performed in addition to the tomosynthesis procedure, but this would significantly increase the dose of radiation to which the patient is exposed. A solution is provided in the form of a synthetic 2D image, e. g. the Insight 2D image from Siemens Healthineers, calculating the synthetic 2D image from the available tomosynthesis dataset. In terms of presentation, it is closer to a mammography image and can therefore be used as a navigational tool in addition to the tomosynthesis slices as well as for comparisons with prior images. Besides the tomosynthesis slices and the synthetic 2D image, however, the dataset from the tomosynthesis process can be used to produce a third form of image: Insight 3D from Siemens Healthineers. Algorithms draw on the tomosynthesis dataset to produce a synthetic, rotating 3D model of the breast that requires no additional radiation. Presented this way, the breast appears on-screen as a clear, almost tangible 3D object. Studies stated that Insight 3D shows the distribution of microcalcifications within the breast more clearly[23,24]. The 50 degree tomo angle used by Siemens Healthineers makes this form of representation possible.

**Development of the Siemens Healthineers tomosynthesis process**

The idea underlying tomosynthesis has a lengthy history: as early as the 1930s, scientists tried to generate 3D images based on information from 2D X-rays[2]. It was against this background that Siemens-Reiniger Werke developed the first "Universal Planigraph," a precursor of the tomography system that we now know as computed tomography (CT)[2]. The new opportunities afforded by digital image processing ultimately made the tomosynthesis imaging procedures possible. To refine them, Siemens Healthineers can draw on an extensive wealth of experience built up during more than 40 years of developing 3D imaging. Thus, for example, breast tomosynthesis makes use of algorithms that have already been successfully used in other Siemens Healthineers technologies. This is ultimately reflected in the high image quality obtained with breast tomosynthesis from Siemens Healthineers.

In 2009, Siemens Healthineers introduced its first tomosynthesis system, which was approved by the US Food and Drug Administration (FDA) in 2015 for use in the USA. Soon after, the company introduced the next generation of tomosynthesis systems: High Definition Breast Tomosynthesis, the latest generation of tomosynthesis from Siemens Healthineers, which was approved for use in the USA in the spring of 2017. The special features of High Definition Breast Tomosynthesis are the Empire technology with its combination of iterative and machine learning algorithms, and the options of Insight 2D and 3D representation. High Definition Breast Tomosynthesis from Siemens Healthineers is the first and, so far, the only tomosynthesis system approved by the FDA as a standalone screening method that does not require an additional mammogram or synthetic 2D image[25]. High Definition Breast Tomosynthesis from Siemens Healthineers thus shows that sufficiently high tomosynthesis image quality does away with the need for the patient to undergo additional mammography and the extra exposure to radiation that implies.

**HD Breast Tomosynthesis with a 50 degree angulation for the first time available for biopsies**

Mammomat Revelation, the new mammography system from Siemens Healthineers, provides the highest depth resolution available on the market[26-28]. With it, also biopsies, in other words the taking of tissue samples, can be performed leveraging this wide tomosynthesis angle of 50 degree. The HD Breast Biopsy solution allows targeting suspicious areas with one click with a one millimeter accuracy. The new integrated

specimen imaging tool facilitates the immediate control of the biopsy directly at the mammography system. The clinical workflow is improved by eliminating the need for a second imaging system and by reducing compression time for the patient. Additionally, the breast compression process is softened and the compression force is automatically and individually adjusted. Coupled with ergonomic SoftComp Paddles, the Personalized Soft Compression function allows for better breast positioning, a more consistent image quality and reduces discomfort during the exam. Moreover, Mammomat Revelation is the first mammography system that provides automated breast density measurements at the point of examination, allowing personalized imaging workflows. This enables direct, personalized risk stratification and adjunct imaging can be initiated before the patient leaves. Patients get results faster, which also minimizes uncertainty. All in all, HD Breast Tomosynthesis improves patient experience and expanding precision medicine by improving diagnostic accuracy.

**Siemens Healthineers Breast Tomosynthesis provides a higher detection rate with a lower radiation dose**

A number of scientific screening studies confirm that tomosynthesis significantly improves diagnostic accuracy in early breast cancer detection compared to standard mammography, and enables a higher breast cancer detection rate[10,11,14]. In Europe a prospective screening study using the Siemens Healthineers tomosynthesis system was performed at Lund University in Malmö, Sweden, between 2010 and 2017[10,29]. The study covered 15,000 women in round numbers aged between 40 and 74[10,29]. They underwent both two-view mammography, and one-view tomosynthesis* for each breast. Using one-view tomosynthesis, more tumors were found compared to two-view mammography. This result is particularly striking because one-view tomosynthesis needs about 33 percent less radiation than two-view mammography, the current standard procedure[10]. For women, this means that tomosynthesis can detect breast cancer better than mammography – and with a lower dose of radiation, based on the findings of the Malmö Breast Tomosynthesis Screening Trial.

In addition to a lower radiation dose, there could also be a significant time saving: the Malmö study shows that diagnosis based on single-view breast tomosynthesis alone needs just one-third of the time needed in other studies for diagnosis using two-view mammography and two-view breast tomosynthesis together[10]. In 90 percent of the cases,

the tomosynthesis method was applied with up to 50 percent less compression force necessary for a standard mammography examination. This is a further benefit next to the shortened time, potentially encouraging more women to attend screening[10,29]. Comparable to other European screening studies,[13,14,30,31] the Malmö study recorded a higher recall rate, which was still far below the limit prescribed in Europe[10]. This increase is mainly the result of the fact that the recall rate in the Malmö study rose in proportion to the detection rate: in other words, more women were asked to return for further diagnosis, but at the same time the physicians also found more malignant tumors than with mammography. In the second half of the study, there was a decline in the recall rate again[22]. For this reason, we may also assume that the recall rate will fall as experience with the diagnostic process increases[22]. Training seems to be the basis for a successful diagnosis also according to another study that proves one-view digital breast tomosynthesis is read better by experienced readers than by inexperienced readers[32].

The results of the Malmö study reinforce the importance of high image quality with the tomosynthesis procedure. High image quality is the prerequisite for enabling physicians to obtain more definite results using breast tomosynthesis compared to mammography, while using less radiation. The angle delivers the highest depth resolution and has the potential to increase the quality of the tomosynthesis image[26,33]. The quality of the tomosnythesis images depends to a large extent on the imaging angle and the number of projections. High-quality breast tomosynthesis helps increase the detection rate of breast cancer and diagnostic safety for both physicians and women. With the wide tomo angle (50 degree) and 25 projections, Siemens Healthineers High Definition Breast Tomosynthesis sets new standards for quality of breast tomosynthesis, and thus makes a significant contribution to early breast cancer detection.

* “1-view tomo only” is not FDA approved in the U.S.

This background information and pictures are available in our Media Gallery.
For further information on mammography and breast tomosynthesis, please see:
www.healthcare.siemens.com/mammography/news.

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