Breast CT in women with breast implants

The Institute of Diagnostic and Interventional Radiology in the University Hospital Zurich, Switzerland has been the longest-standing user of a dedicated new breast CT system equipped with a photon-counting detector. The team have just published a paper on the use of the new system in patients with breast implants [1]. We spoke to Prof. Andreas Boss, Senior Consultant responsible for breast imaging.

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Q Before we get to the use of the new breast CT system in detail, please describe the breast imaging unit at the University Hospital Zurich and the Swiss breast screening system in general.

OK. Let's start with our imaging equipment: this includes a mammography/tomosynthesis unit from Siemens Healthineers; a handheld US device and an automated 3D breast ultrasound (ABUS) both from GE; and two 3T MRI from Siemens Healthineers. In addition we have an AI-derived software system from the company b-rayZ for the analysis of breast density and mammography image quality. And as you mentioned we also have the new spiral breast-CT system from AB-CT.

All this equipment is put to a lot of use, since we see a lot of patients. Each year we carry out 2,500-3,000 mammographies and approximately 700 breast-CT examinations.

In Switzerland, the practical implementation of organized QC mammography breast cancer screening programs is the responsibility of the canton. Overall, approximately 60% of Swiss women in the age range 50-70 have access to such screening programs. However, many cantons — particularly in the German speaking part of Switzerland, including the canton of Zurich — have not yet implemented systematic organized screening programs. In these areas women who want to be screened typically have to resort to "opportunistic" screening examinations in a radiology institution (which is not necessarily covered by public health insurance). Depending on the particular risk profile and the risk awareness of the individual patient, opportunistic mammography breast cancer screening starts at the age of 40 years, typically with examinations every two years. One advantage of opportunistic breast cancer screening mammography compared to the organized screening program is that additional breast ultrasound can be carried out in patients with dense breasts. It is well known that the sensitivity of conventional mammography drops substantially in patients with dense breasts. In such cases adjunct ultrasound examinations significantly increase the detection rate for breast cancer. In our institution, a "lean" workflow is implemented. Thus, immediately after the screening mammography examination, the images are analyzed with the "b-box" AI medical device from the Swiss company b-rayZ to assess the breast density according to the ACR BI-RADS system. For women with the highest breast density categories, i.e. categories c-d, an additional ABUS examination is carried out by the technician.

We hear a lot about AI in radiology these days but an excellent example of its usefulness is in the determination of mammographic breast density. The BI-RADS breast density system doesn't use a quantitative score scale but instead uses both the amount and the distribution of breast tissue to attribute density to one of four categories (a, b, c, d). The result is that software tools relying on quantitative measurements of the amount of breast density are miscalibrated to a ACR BI-RADS score. Artificial Intelligence algorithms such as those in the b-box system can significantly improve classification,

Women at highest risk, e.g. with known BRCA mutations, are recommended to follow a more intense screening schedule, according to the guidelines of the Swiss Cancer League, which suggest that such women should undergo yearly breast MRI examinations.

All the above is a simplified description of our standard screening procedures, but a problem is that a large number of women in Switzerland are unwilling to undergo the often painful breast compression required for mammography or tomosynthesis. For such patients, we now offer breast cancer screening examination using the nu:view breast-CT system from AB-CT. [Figure 1]

Figure 1. The nu:view Mamma-CT system was developed and is produced by the German company AB-CT - Advanced Breast CT. The design of the new scanner allows compression-free imaging of one breast at a time. To do this, the breast CT system uses a rotating gantry on which the X-ray tube and photon-counting detector are mounted. During the image acquisition process, the gantry rotates around the breast in a downwards-oriented spiral trajectory. In the course of a single scan up to 12,000 projection images are acquired. A full spiral scan takes as little as 7 – 12 seconds. The radiation dose is similar to that of conventional mammography.

The breast-CT image quality is high with microcalcifications being clearly visualized. In addition, if the breast-CT examination is carried out with contrast enhancement, both soft tissue enhancement of the breast cancer and associated microcalcifications can be visualized at the same time, which cannot be done with any other imaging modality.

Q Now let's turn to women with implants.

Approximately 10-20% of the patients referred for breast-CT imaging have silicone implants, either for cosmetic purposes or for reconstruction after breast cancer treatment. Overall the number of women with silicone implants seems to be slowly but steadily increasing. Implants for cosmetic reasons are seen mostly in younger women, whereas silicone implants used in breast reconstruction are mostly seen in patients of higher age.

There are typically two complications associated with silicone implants, namely rupture and capsule fibrosis. Both show typical patterns in breast-CT. In case of rupture, the so-called "linguine signs" which are caused by the broken elastomeric casing of the implant can be clearly seen. [Figure 2]. Capsule fibrosis is the other common problem of silicone implants, and is caused by a foreign body reaction of the surrounding tissue. Often, capsule fibroses show calcifications, which can only be visualized using breast-CT [Figure 3]. A common chronic complication is pain caused by capsule fibrosis, but it should be remembered that breast pain can also be caused by hormone-stimulated glandular tissue.

At the moment, there are no guidelines recommending specific imaging modalities for women with breast implants. Because of the potential risk of iatrogenic rupture of silicone implants caused by breast compression, conventional mammography is not performed at our institute in patients with breast implants.

Breast-CT is particularly well suited for screening patients with silicone implants not only because there is no compression involved, but also because the system can detect not just breast cancer but also precursor lesions associated with microcalcifications. Ultrasound could also be used for the examination of patients with silicone implants, however the diagnostic accuracy

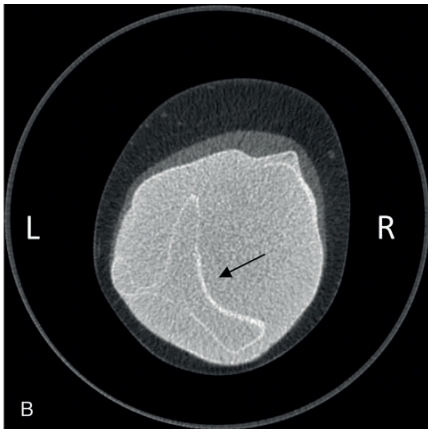

Figure 2. A 35-year old woman presenting with a family history of breast cancer and bilateral gel implants for six yrs. Breast CT clearly showed a positive Linguine sign (arrow) in the right breast indicative of an intracapsular rupture. Image adapted with permission from Ref 1.

of ultrasound alone in such cases is lower than that of breast-CT.

Q What are the particular radiological challenges in conventional mammography that women with implants present?

There are several. For example, the use of conventional mammography in such patients has the disadvantage that there can be superimposition of tissue by the implant, with the potential risk of masking lesions. As mentioned above, other dangers are that the implant may burst under the breast compression used in mammography In addition, the mammography examination itself can be more painful due to capsule fibrosis. Finally the combination of a lower compression used to minimize the risks of

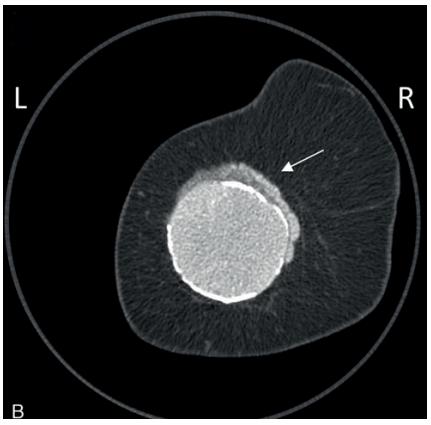

Figure 3. A 62-yr old woman who has had bilateral breast implants for 46 yrs presented to our clinic with bilateral breast induration. Severe calcifications surrounding the implant can be seen in the coronal breast CT image. Image adapted with permission from Ref 1.

rupture together with the absorbance by the silicone means that radiation dose could be higher in the mammography of patients with implants.

However, it has been shown that silicone implants do not affect the overall risk of developing breast cancer, so the recommended screening schedules remain identical for women with or without breast implants.

Usually, no specific radiology checks are required directly after the initial insertion of the breast implant. However, if there is any suspicion of acute or chronic complications, breast imaging becomes important.

Breast-MRI is an alternative for the investigation of implant rupture and capsule fibrosis since silicone implants can be visualized clearly in MRI using silicone-sensitive sequences, However MRI has significant drawbacks compared to breast-CT, principally the much longer examination time and the higher costs of MRI compared to breast-CT. The issue of cost is all the more relevant nowadays in that health insurance organizations are increasingly unwilling to cover the costs of purely cosmetic operations. An additional, performance-related drawback of breast MRI (which it shouldn't be forgotten, frequently involves the use of gadolinium-based contrast agents) compared to breast-CT is that neither microcalcifications nor calcifications associated with capsular fibrosis can be seen in MRI.

Thus all-in-all, breast-CT is an attractive procedure for women with silicone implants.

Q Since when have you had the nu:view breast CT system from AB-CT?

We actually purchased and installed the breast-CT at the University Hospital Zurich as far back as spring 2018, with approval for its use with patients being granted in August 2018, so now we have acquired a broad body of experience with it. At the time it was the first installation of the system in the world.

Since the nu:view system is a completely new approach to breast imaging, there was a steep learning curve at the beginning, both for technicians and radiologists. However now breast-CT examinations are no more challenging nor time-consuming for our technicians than conventional mammographies.

Our radiologists also quickly adapted

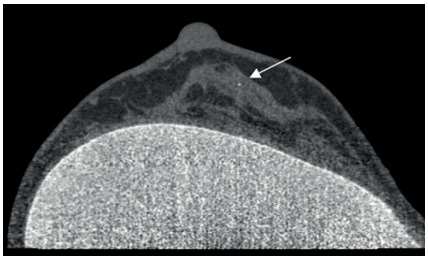

Figure 4. Single microcalcification seen in the axial plane in a 65-yr old woman with bilateral gel implants. Image adapted with permission from Ref 1.

to the reading of the datasets. Initially, detecting microcalcifications in the 3D datasets was a challenge, as they appear less prominent than in mammography because of the high isotropic spatial resolution. In practice we adapted to this by creating maximum-intensity-projections with our PACS viewing system with slice thicknesses of the order of 2-3 mm, which allows microcalcifications to be detected with an accuracy similar to that of mammography [Figure 4]. The reading time for an individual breast-CT examination for all four data sets (standard and highly resolved datasets on each breast) is in the order of 2-3 minutes.

Q What did your study of the performance of the system in women with implants entail?

In our retrospective observational study [Ref 1, Ruby *et al*], we described our experience in the first 21 women with implants who underwent breast-CT. The majority of these women had bilateral breast implants for cosmetic reasons, with one patient having a single breast implant after breast resection for cancer. Regarding dense breasts, we used the same procedure as in mammography and in breast-CT examinations of women without implants, namely we carried out additional ultrasound examinations.

Both the silicone inside the breast implant and the elastomeric capsule/shell enclosing the silicone have high radiation absorption and can therefore easily be seen in the breast-CT datasets. Implant folds, which are a common finding in intact implants, are clearly visualized in breast-CT, as are the Linguine signs which indicate implant rupture. [Figure 2] Extensive capsule fibrosis was detected in 3 out of the 21 patients. In one patient extensive calcifications were found in the capsule fibrosis, and was best detected in breast-CT. In the surrounding glandular breast tissue, we were able to show that both microcalcifications and soft tissue lesions can be detected, which justifies the use of breast-CT in patients with breast implants not just for diagnostic and screening purposes, but also for follow-up examinations after breast cancer.

One shortcoming of breast-CT in many cases is the absence in the datasets of the part of the breast that is close to the thoracic wall, which is also common in mammography examinations of patients with breast implants. From this point of view, breast MRI with its complete coverage of the breast could have an advantage. While we're on the subject of MRI, I currently still see breast-MRI as the preferred modality for patients with a high risk of breast-cancer (family history of breast cancer, known BRCA mutations), due to its broadly accepted high sensitivity for the detection of breast cancer. However, as mentioned before, MRI has its own significant disadvantages.

Q How is the new system integrated into the work-flow of your breast imaging service ?

The large majority of patients undergoing breast-CT at our institution are referred to us specifically for breast cancer screening because they are unwilling to repeat the painful breast compression experience they had in a previous mammography/tomosynthesis examination. We receive excellent feedback from those patients, with more than 90% expressing positive acceptance of the new technique. Because of this we have a growing number of women referred to us for breast-CT.

However if women for whom mammography is indicated have no problem with breast compression, we still go for conventional mammography.

We find that the diagnostic accuracy of breast-CT is comparable to mammography. As the absorption of breast glandular tissue and soft tissue lesions is very similar, an additional ultrasound examination is required in patients with dense breasts, which is also the case for mammography.

Q Any future developments you would like to see?

At the moment, one short-coming of our breast-CT system is the relatively long reconstruction time of 20-25 minutes per exam. Since the radiologist's decision on any additional ultrasound exams can only be taken after the images are available, the overall examination time can be relatively long for patients who may need supplemental ultrasound exams. Shortening the reconstruction time would clearly be helpful.

The vast majority of breast CT examinations we carry out are without contrast-medium. Because of the additional efforts required for contrast media administration, e.g. the placing of a peripheral venous access and preparation of the contrast itself, we restrict our use of contrast medium in practice to only a very small number of patients with highly suspicious findings. Given this, plus the fact that the breast-CT can only carry out a dynamic examination on one breast at a time, an interesting new technological development would be to use the spectral information from the photon-counting detector to calculate a virtual non-enhanced dataset. Then, contrast-media injection would be more applicable in patients since each breast could be examined with a virtual dynamic examination.

Q And the overall conclusion on the potential of the technology?

To summarize our experience with breast-CT in patients with silicone implants and its role in a regimen using supplemental ultrasound in patients with dense breasts we found that it is a breast imaging modality of high accuracy and with a radiation dose similar to mammography. With its many advantages over alternative imaging modalities, breast-CT has the potential to become the modality of choice for both breast cancer screening and diagnostic imaging.

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