Evolution of a Dedicated Coil for MRI-Guided Breast Biopsy

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The role of MRI in breast cancer

Magnetic resonance imaging (MRI) plays an established role in the diagnosis of breast cancer, particularly in cases where other modalities yield inconclusive results. Emerging evidence now suggests that its efficacy also extends to screening. In 2022, the European Society of Breast Imaging (EUSOBI) updated its recommendations, advocating for a more personalized approach to breast screening [1]. The recommendations include offering MRI to women with extremely dense breast tissue, a demographic that often faces diagnostic challenges.

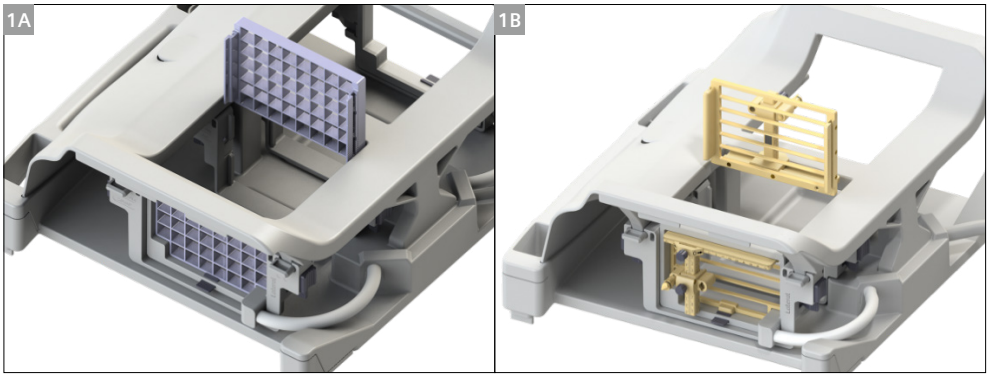
This evolution in the application of MRI is expected to drive increased use of and interest in this technique. While many healthcare facilities use second-look ultrasound to follow up on MRI findings, certain lesions require biopsy under MRI guidance. This article will explore the historical development of MRI-guided breast biopsy and of dedicated breast biopsy coils, highlighting their importance in the advancement of breast cancer diagnosis and patient outcomes.

MRI-guided breast biopsy: Definition, history, and advantages

MRI-guided breast biopsy is a minimally invasive procedure performed in the MRI room. It involves taking a tissue sample from a suspicious area in the breast. After using mammography, ultrasound, and/or MRI to identify the lesion, MRI is used to guide a needle that takes a tissue sample, which is then sent for histological examination [2, 3].

Using the advantages of high-resolution MR imaging, MRI-guided breast biopsy enables both precise localization and accurate tissue extraction [9]. This benefit applies even more so to patients whose lesions are located in regions that are difficult to reach (e.g., close to the chest). In this way, MRI guidance helps reduce the number of biopsies needed. Furthermore, the procedure can normally be performed as an outpatient service. The short recovery time means the patient can go home soon after the intervention.

The idea of using the benefits of MRI for guided biopsies emerged in the 1990s. After early adopters and initial studies in the late 1990s and early 2000s proved



1 Breast coils with the different biopsy systems. **(1A)** Breast BI 7 Coil with grid biopsy system. **(1B)** Breast BI 7 Coil with post-and-pillar biopsy system.potential to overcome this.

its feasibility, MRI-guided breast biopsy was able to develop its potential throughout the 2000s. Technological advances such as dedicated breast coils and biopsy needles made it increasingly accessible for clinical use by the end of the decade [4].

Numerous studies throughout the 2000s and 2010s proved the accuracy and safety of MRI-guided breast biopsy, and highlighted its specific advantages over other image-guided techniques in high-risk patients or those with dense breast tissue [5–8].

Thanks to further technological improvements like faster imaging sequences and more comfortable patient positioning systems, MRI-guided breast biopsy is now an efficient, well-established procedure and a valuable addition to breast cancer treatment and prevention – especially for challenging cases [2, 3].

Post-and-pillar vs. grid biopsy

There are two primary methods for performing MRI-guided breast biopsies: the grid technique, and the post-and-pillar technique [2].

In the grid technique (Fig. 1A), the coordinates of the lesion are mapped using sagittal slices onto the grid marker. The lesion then is reached by inserting the biopsy needle through the appropriate hole in the grid [9].

The post-and-pillar method (Fig. 1B) involves mapping the lesion using axial slices onto the marker in the coordination system. It offers the possibility to adjust the point of intervention to the millimeter by moving the needle holder in sagittal and coronal directions, or even angulating it.

Both methods have the advantage of enabling precise localization of the lesion while maintaining the breast in a consistent position.

The post-and-pillar method was patented in 1995 by Hubert Noras as the first MRI-compatible biopsy system. Today, it is primarily used in Europe, while the grid biopsy method is mainly used in the United States.

Dedicated breast biopsy coils: Requirements

Dedicated breast biopsy coils are essential tools for leveraging the full potential of MRI by enhancing diagnostic accuracy and interventional precision. Consequently, the design requirements are high [10].

Above all, the MRI bore places limits on the size of the coil: There must be enough space for both placing the patient and performing the intervention – yet the coil and patient still have to fit into the bore. Therefore, the design needs to be both very open and very stable.

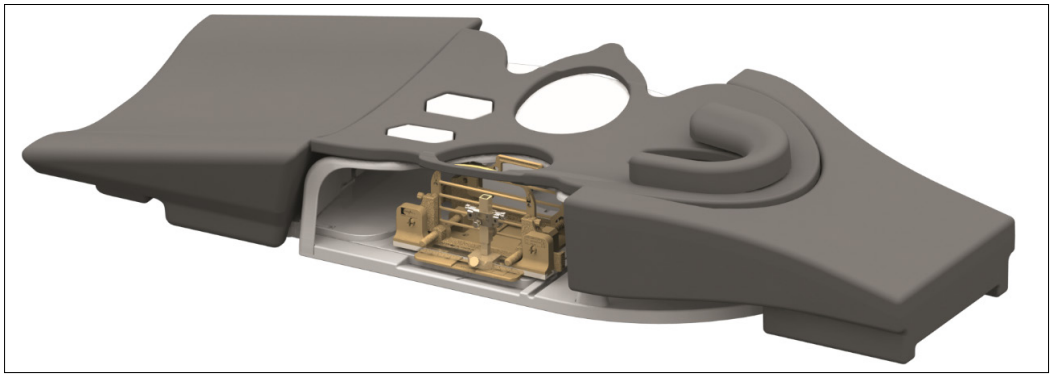
The coil should be suitable for different breast volumes while offering an easy option to immobilize and fixate the breast. For detecting and targeting the lesion, high-resolution imaging with great homogeneity and good signal-to-noise ratio is needed. To enable successful interventions, the device must be compatible with an efficient biopsy system like the post-and-pillar or grid technique.

To guarantee an effective workflow, the components should be lightweight and simple to store and handle. The coil also needs to be comfortable for the patient to lie on.

The 4-Channel BI Breast Coil

The 4-Channel BI Breast Coil (Fig. 2) was developed and produced by NORAS MRI products. It was released in 2009 and is exclusively distributed by Siemens Healthineers. The 4-Channel BI Breast Coil is specifically optimized for MRI-guided breast biopsy and features a light, open, and ergonomic design. It enables fast preparation and provides lateral, medial, and cranio-caudal access to the breast. Both the post-and-pillar and the grid biopsy method can be used.

With its four channels, the 4-Channel BI Breast Coil can also be used for breast diagnosis.



2 The 4-Channel BI Breast Coil with the post-and-pillar biopsy system.

Breast BI 7 Coil

The 4-Channel BI Breast Coil offers many key features needed for MRI-guided breast biopsy. However, its clinical use has shown that there is still room for improvement. To meet these needs, Siemens Healthineers and NORAS MRI products developed the Breast BI 7 Coil (Fig. 3). This coil is manufactured in Germany by NORAS MRI products and has been sold exclusively by Siemens Healthineers since 2017.

Just like the 4-Channel BI Breast Coil, the Breast BI 7 Coil is a dedicated coil solution – created to enable successful MRI-guided breast biopsies and detailed diagnostic imaging.

Its open design provides wide medial or lateral biopsy access to the breast and is compatible with both post-and-pillar and grid biopsy systems. To enable a safe and accurate intervention, the Breast BI 7 Coil has an integrated, contactless LED lighting system. Its seven-channel phased array configuration with high element density guarantees high-resolution imaging with excellent SNR and high homogeneity, including illumination of the axilla.

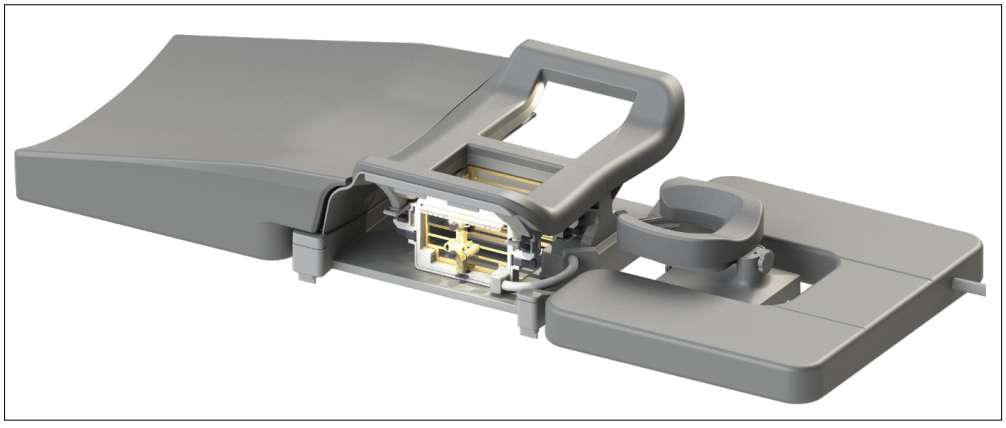
Thanks to its outstanding image quality, the Breast BI 7 Coil can also be used for diagnostic imaging. For this purpose, besides the option of medio-lateral fixation (Fig. 4A), the coil can be combined with a cranio-caudal fixation system (Fig. 4b). Using it with axial slices leads to shorter scan times and reduces motion artifacts.

Performing diagnosis and the biopsy itself with only one coil not only significantly simplifies and accelerates the overall workflow, but also enhances the interventional precision, as breast tissue and lesion are kept in a constant position throughout the procedure.

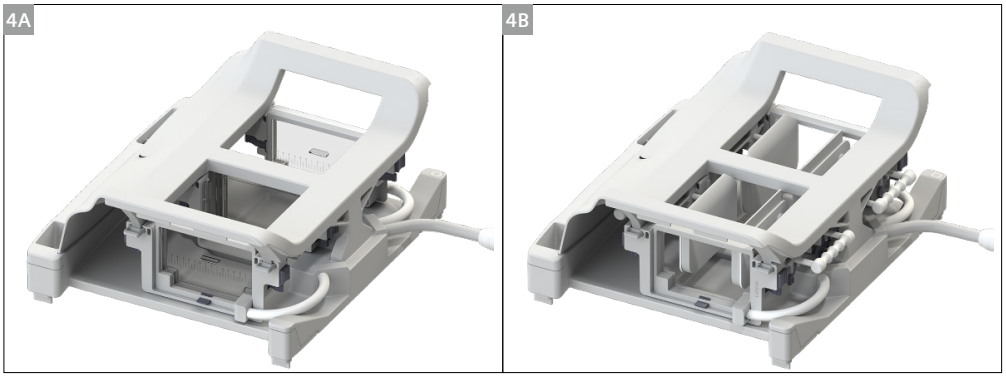
Compared to the 4-Channel BI Breast Coil, where the arrays are partially located in the patient rest cushion, all the channels of the Breast BI 7 Coil are integrated into the coil frame. This makes the coil more durable for frequent use. Also, the comfortable patient rest can hold an even bigger breast volume of up to 11 liters.

The lightweight design (only 9 kg) and the modular set-up make the Breast BI 7 Coil fast and simple to install for the intervention, and easy to clean afterwards.

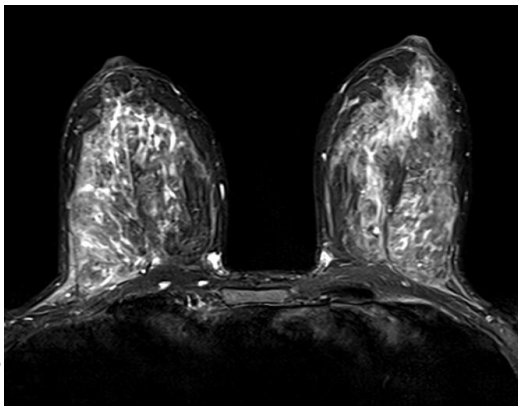
The Breast BI 7 Coil is compatible with the ATEC® Breast Biopsy System (Hologic Inc., Marlborough, MA, USA) and the EnCor Enspire™ Breast Biopsy System (BD, Franklin Lakes, NJ, USA).



3 The Breast BI 7 Coil with the post-and-pillar biopsy system.



4 **(4A)** The Breast BI 7 Coil with a medio-lateral fixation system.
(4B) The Breast BI 7 Coil with a cranio-caudal fixation system.



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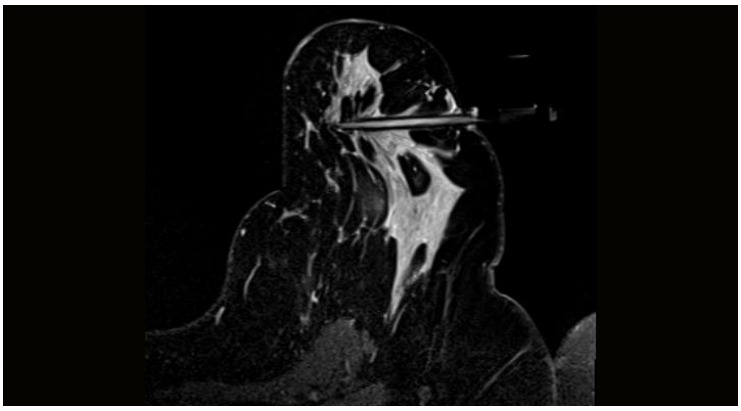
5 A high-resolution T2w image acquired with the Breast BI 7 Coil on a 3T MAGNETOM Vida using the deep learning reconstruction technique Deep Resolve. FOV: 360 x 360 mm; resolution: 0.4 x 0.4 x 4.0 mm^3; acquisition time: 1:36 minute.



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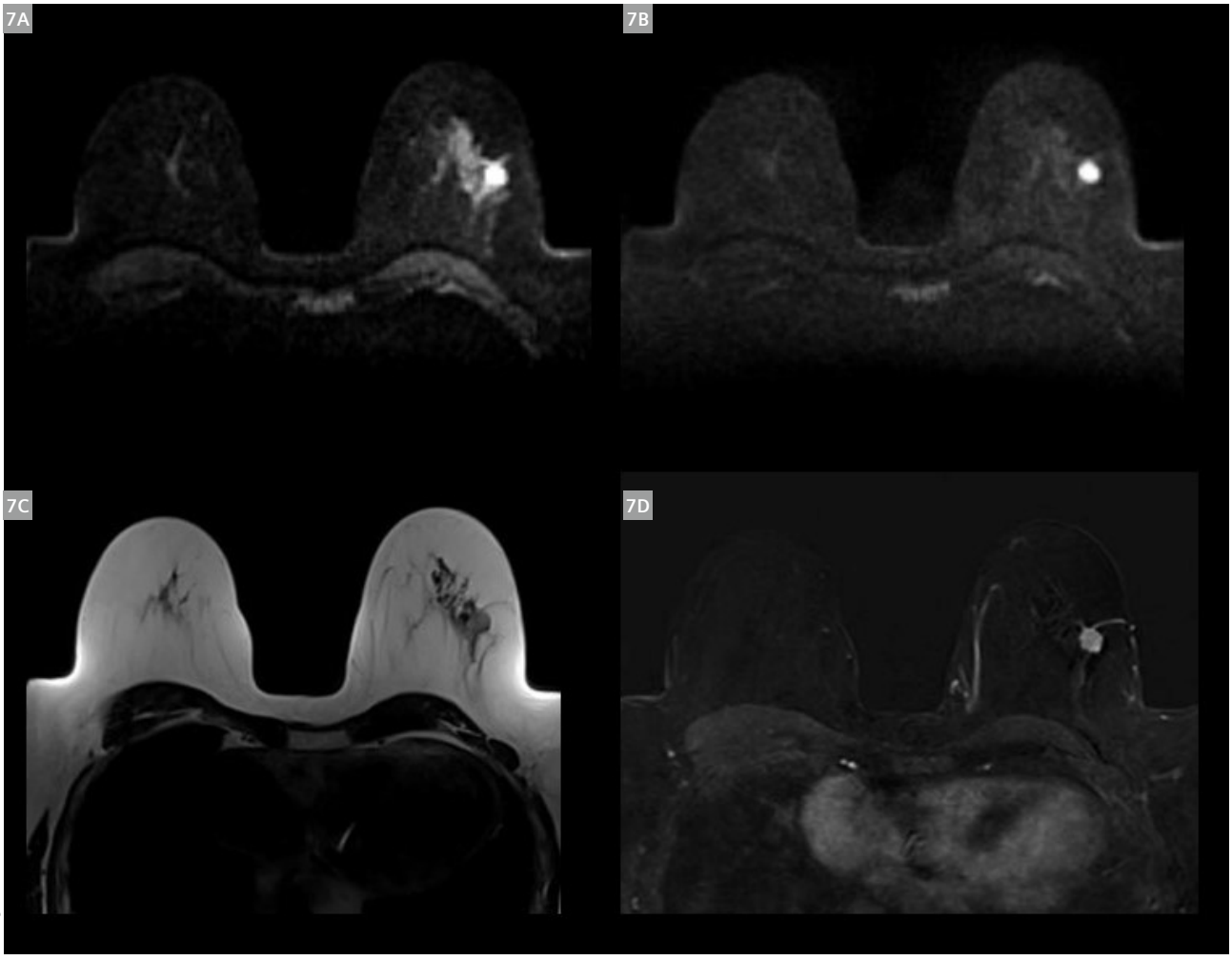
6 Clinical case of a patient with a suspected lesion on mammography. Breast MRI showed an area of non-mass enhancement. The MRI-guided biopsy revealed adenosis with no evidence of malignancy. The biopsy was performed using the grid method with the Breast BI 7 Coil on a 1.5T MAGNETOM Sola. *Images courtesy of Johan Dehem, M.D., Jan Yperman Ziekenhuis, Ieper, Belgium.*



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7 Clinical case of a patient with ductal carcinoma. **(7A)** DWI (b-value = 50 s/mm^2), **(7B)** DWI (b-value = 800 s/mm^2), **(7C)** T2 Dixon, **(7D)** T1 VIBE subtraction image after contrast injection. The images were acquired with the Breast BI 7 Coil on a 1.5T MAGNETOM Sola. *Images courtesy of Johan Dehem, M.D., Jan Yperman Ziekenhuis, Ieper, Belgium.*

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