Recommendations of the German Radiological Society's breast imaging working group regarding breast MRI

Aktualisierung der Empfehlungen der AG Mammadiagnostik der Deutschen Röntgengesellschaft zur Durchführung der Mamma-MRT

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Key points:

- Breast MRI is an essential part of breast imaging
- The recommendations for performing breast MRI have been updated
- A table provides a compact and quick overview. More detailed comments supplement the table.
- The "classic" breast MRI can be performed based on the recommendations. Tips for special clinical questions, such as implant rupture, mammary duct pathology or local lymph node status, are included.

Zitierweise

- Wenkel E, Wunderlich P, Fallenberg E et al. Aktualisierung der Empfehlungen der AG Mammadiagnostik der Deutschen Röntgengesellschaft zur Durchführung der Mamma-MRT. Fortschr Röntgenstr 2024; DOI 10.1055/a-2216-0782

Introduction

Based on recent publications and research the Working Group on Breast Diagnostics of the German Radiological Society has revised the recommendations for performing breast MRI from 2014 [1]. The updates include examination protocols including diffusion-weighted imaging. Explanations of standards that are considered as well established were deliberately omitted. In this regard we refer to the Breast Imaging Reporting and Data System (BI-RADS Atlas) of the American College of Radiology (ACR) [2] and the cited references. The recommendations presented here on examination technique are intended to further standardize the conduct of breast MRI. Comments have been added to clarify certain aspects (▶ **Table 1**).

▶ **Table 1** Recommendations on the Conduct of Breast MRI.

1 Medical History	Information on current clinical findings, previous percutaneous biopsies and operations or breast cancer-specific therapies should be available. If preliminary breast imaging examinations exist, the reports and images should be available at the time of the examination. Endogenous and exogenous hormonal factors (e. g. use of hormones, last menstruation) as well as individual risk factors (e. g. family history of breast or ovarian cancer) should be recorded. Information on breast implants should be requested before the examination.
2 Contraindications	The examinations must be performed in accordance with the generally applicable quality standards for MRI examinations and intravenous administration of contrast medium [3].
3 Field Power and Coil	Use of a bilateral multi-channel breast coil, examination on an MR scannner with a field strength of 1.5 or 3 Tesla. Adequate immobilization of the breast is required to avoid movement artifacts (comment).
4 Multiparametric Procedure	A standardized protocol preferably with an axial slice orientation, consisting of a T2w sequence, dynamic T1w 3D-GRE natively and after intravenous administration of contrast medium should be used. In addition, a diffusion-weighted sequence if the device technology is available (DWI, comment point 8). Further sequences and slice orientations are to be added individually based on the question being addressed (comment).
5 Contrast Media	Paramagnetic macrocyclic Gd-based contrast media, weight-adapted single standard dose, preferably cubital venous access, preferably mechanical injection (injection speed 2–3 ml/s), post-injection of ≥ 20 ml physiological saline solution.
6 T1-weighted Sequence with Intravenous Contrast Medium Administration/CM dynamics (DCE)	T1w 3D-GRE with or without fat suppression or DIXON technique natively and repetitively after intravenous administration of contrast medium with a total examination duration of at least 5 min, temporal resolution of the individual sequence ≤ 90 s, preferably approx. 60 s, slice thickness ≤ 3 mm, in plane resolution ≤ 1 × 1 mm (comment).
7 T2-weighted Sequence	Fat suppressed (inversion recovery, spectral or DIXON technique) with a slice thickness ≤ 4 mm, in-plane ≤ 1.5 × 1.5 mm, alternatively T2w sequence without fat suppression (comment).
8 Diffusion-Weighted Imaging (DWI) (optional)	Single-shot or multi-shot EPI-DWI sequence, 2 b-values, a low b-value should be between 0 and 50 s/mm^2 and a high b-value between 800 and 1000 s/mm^2, fat saturation is obligatory, TR ≥ 3000 ms, minimal TE, the phase encoding direction anterior-posterior and a saturation pulse on heart and lung is recommended. A spatial resolution of ≤ 4 mm and an in-plane resolution of ≤ 2 × 2 mm^2 is recommended. Automatic calculation of the ADC (apparent diffusion coefficient) map, on which the ADC value of the lesion can be measured directly (comment).
9 Time of Examination	To avoid unnecessarily delaying treatment decisions, breast MRI should be performed at any time during the menstrual cycle or after an operation or radiation therapy if indicated. For elective examinations in premenopausal women, examination in the 2nd week of the menstrual cycle (comment).
10 Hormonal Influences	A general discontinuation of hormonal contraceptives or hormone replacement therapy before the MRI examination is not necessary. If exogenous hormones are suspected to influence contrast medium (CM) uptake and to compromise imaging, it may be advisable to repeat the examination after interrupting hormone medication for 4–6 weeks (comment).
11 Reference Structures	Complete imaging of the breast including skin, subcutaneous tissue, fibrogladular tissue with axillary tail, fatty tissue, pectoral muscles and the internal thoracic artery. The Field of View (FOV) may need to be adjusted for the specific patient.

▶ **Table 1** (Fortsetzung)

12 Image Analysis and Post-Processing	Calculate subtraction images and maximum intensity projections (MIPs) of the dynamic CM sequences. Primary assessment of the of a MIP and an early T1w sequence after intravenous administration of contrast medium. An evaluation of contrast medium enhancement over time is carried out either by manually selecting the region of interest (ROI) or with the help of the corresponding automated evaluation software or visually. The ROI should be positioned in the region of the lesion with the strongest CM enhancement. The size of the ROI should be at least 3 pixels. The multiparametric evaluation includes a correlation of the contrast enhancing findings with the T2w sequence, the native T1w sequence and, if applicable, DWI with the ADC values.
13 Shortened Protocols	Not currently recommended in routine clinical practice (comment).
14 Assessment of Breast Implants	To assess the integrity of silicone-containing breast implants, use water- and silicone-sensitive T2w/T2-STIR sequences in the axial orientation with a slice thickness ≤ 4 mm, in-plane ≤ 1.5 × 1.5 mm (comment 4). In the case of implants and clinical questions regarding inflammatory changes or exclusion of malignancy, e. g. breast carcinoma, recurrent disease, breast implant-associated anaplastic large cell lymphoma (BIA-ALCL) or an increased risk of breast cancer, an examination with i. v. administration of contrast medium is required in addition to the T2w sequences for implant assessment.
15 Intervention	A clarification algorithm for suspicious findings detected by MRI must be available (comment).

Comments

3 Field Power and Coil

In addition to conventional field strengths, studies are currently being carried out with ultra-high-field scanners (7 T) and low-field scanners (0.55 T). The low-field scanners in particular, in combination with a dedicated breast coil and AI-based imaging methods, have the potential to acquire high-quality images and thus supplement the established field strengths.

4 Slice Orientation

An axial slice orientation is preferred for all sequences based on the standard protocol. Additional slice orientations may be helpful for specific questions, such as the exclusion of an implant rupture (possibly additional slices in the sagittal orientation) [4, 5], detailed milk duct imaging (possibly additional slices in the sagittal orientation) [6] or in the context of local lymph nodes staging (possibly additional slices in the coronal orientation).

6 T1-weighted Sequence with Intravenous Contrast Medium Administration/CM dynamics (DCE)

The T1w sequence with intravenous contrast medium is the crucial sequence for detecting breast carcinoma. The CM phase of the diagnostic sequence should be selected in such a way that optimal lesion contrast is achieved whilst background enhancement is still low. This is the case approx. 120 s after injection of a weight-adapted single standard dose of a paramagnetic macrocyclic Gd-based contrast medium by mechanical injection via a cubital venous access (injection rate 2–3 ml/s plus post-injection of ≥ 20 ml physiological saline solution). This means that the central k-space lines of a diagnostic sequence should be measured approx. 120 s after CM administration. At least one additional sequence should then be acquired to identify tumors with delayed CM enhancement or wash-out of a lesion with early CM-uptake.

When measuring a T1w 3D-GRE sequence without fat suppression, suitable echo times should be selected for in-phase imaging.

The native T1w sequence should always be evaluated, as it provides diagnostic information on protein-containing fluids, e. g. in cysts, milk ducts, hematomas and abscesses. It can also be used to assess lymph nodes and the bone marrow signal.

7 T2-weighted Sequence

The T2-weighted sequence with fat suppression is primarily used to detect water-containing structures and cystic lesions. A slice thickness of 4 mm with an in-plane resolution of ≤ 1.5 × 1.5 mm is sufficient.

In contrast to this the T2-weighted sequence without fat suppression is primarily used to assess tissue architecture. It should therefore be measured with an in-plane resolution of ≤ 1 × 1 mm and slice thickness ≤ 3 mm.

8 Diffusion-Weighted Imaging (DWI)

In recent years, DWI has become increasingly important in breast MRI to differentiate malignant from benign contrast enhancing mass lesions. The mandatory suppression of the fat signal in EPI sequences can be achieved with the SPAIR (Spectral Attenuated Inversion Recovery) technique (EUSOBI recommendation) [7], STIR (Short Tau Inversion Recovery, as an alternative, only before CM administration), with spectral fat saturation or water selective excitation (water excitation). DWI should be performed before DCE, as the presence of contrast medium can lower the measured ADC values [7]. If DWI is nevertheless measured after intravenous administration of contrast medium, there is no significant influence on the diagnosis unless no fat supression in STIR technique is used. ADC thresholds may need to be adapted [8].

The calculated ADC maps enable a quantitative classification of the diffusion restriction. The ADC value is measured by drawing a ROI with a size of at least 3 pixels on the ADC card. If the scanner software allows, the ROI should be drawn in a signal-intense regi-

on of the lesion on the high b-value image and transferred as a copy to the ADC map. Direct copying of the ROI from the contrast medium series is not possible due to the typical geometric distortion of EPI sequences. Similarly to drawing the ROI on contrast medium images, necrotic or fibrotic lesion components with no contrast medium uptake should be avoided.

A generally valid threshold value for malignant and benign lesions is not yet recommended by the EUSOBI due to an assumed device and sequence dependency of the ADC values. Typical ADC values for malignant contrast enhancing mass lesions are $\leq 1.0 \times 10^{-3}$ mm^2/s. Mass lesions with ADC values $\geq 1.5 \times 10^{-3}$ mm^2/s can be classified as benign with a high degree of certainty. Mucinous carcinoma is typically an exception due to its low cellularity and high mucin content. In two multicenter studies on devices from different manufacturers, an ADC value of $\geq 1.5 \times 10^{-3}$ mm^2/s was confirmed to avoid eventually biopsies in benign findings [9, 10].

9 Time of Examination

In the case of planned examinations, e. g. as part of breast cancer screening in high-risk women and follow-up care for women with an increased risk of breast cancer, the timing of breast MRI should be adjusted to increase diagnostic accuracy.

Scheduling elective MRI examinations in premenopausal women is preferably recommended in the second week of the menstrual cycle to minimize any potential background enhancements.

Regarding residual tumor after breast conserving therapy the MRI should be performed immediately after the operation (within the first 4 weeks post-surgery) [11, 12]. Granulation tissue and fatty tissue necrosis can present conspicuous contrast agent enhancements, particularly in the first 6 months after an operation or within the first 12 months after radiotherapy. This may render these types of tissues difficult to distinguish from carcinoma foci. A waiting period of at least 6 months postoperatively or 12 months after radiotherapy is therefore recommended [13]. There are currently no systematic studies on the optimum timing for the examination. According to clinical experience, the changes after an operation or radiotherapy vary greatly from individual to individual. Enhancements caused by fatty tissue necrosis can decrease over time, but can also persist for years.

A breast MRI can be performed at any time after a percutaneous biopsy. If a post-biopsy examination is considered to provide limited information due to bleeding, inflammation or edema, a repeat biopsy may be necessary after checking on the patient's history and clinical consequence.

10 Hormonal Influences

Background parenchymal enhancement (BPE) is a physiological phenomenon influenced by endogenous and exogenous hormones, among other things. There is no direct correlation between background enhancement and the proportion of fibroglandular tissue [14]. In general, background CM enhancement is stronger premenopausally than postmenopausally [15] and varies through the menstrual cycle. Background CM enhancement is most pronounced in the luteal phase [16–19], which has led to the recommendation that an examination in the second week of the menstrual cycle is preferable. Several studies investigating the effects of BPE on diagnostic performance found a higher biopsy rate, but no significant decrease in sensitivity and carcinoma detection rate in women with higher BPE [20–22]. In order to avoid unnecessary delays in treatment decisions, breast MRI should be performed independently of the menstrual cycle, especially in the case of newly diagnosed breast carcinoma [23, 24].

After radiotherapy has been completed and the post-therapeutic changes have subsided, less background enhancement is typically observed in the treated breast.

A decrease in BPE is observed during endocrine therapy of breast carcinoma using selective estrogen receptor modulators (tamoxifen) or aromatase inhibitors. This is particularly the case with tamoxifen [25–27]. In contrast, taking external hormones can lead to increased background enhancement.

During pregnancy and breastfeeding, sonography is the primary imaging method of the breast and axilla. Gadolinium-based contrast media pass through the placenta and enter the fetal circulation. Due to the unclear risk to the fetus, gadolinium-based contrast media should not be used at any stages of pregnancy unless there is a clinical mandatory indication. The decision should be made in an interdisciplinary conference after regarding the risk-benefit ratio. Performing a breast MRI during pregnancy should primarily be avoided.

There is little data in the literature on performing a breast MRI during the breastfeeding period. Background CM enhancement increases during lactation. According to a recent study, the diagnostic accuracy of locoregional staging of histologically confirmed breast carcinoma is not significantly influenced by lactation [28]. According to the current guidelines of the European Society of Urogenital Radiology for contrast media, breastfeeding can be continued after administration of macrocyclic gadolinium-based contrast media. It is possible to pause breastfeeding for 12–24 hours if this is preferred by the mother.

13 Shortened Protocols

The basic principle of shortened protocols is based on performing one measurement using a standard T1w sequence before the i. v. and a maximum of 2 measurements after the i.v. administration of contrast medium. The reduction of repeat acquisitions after contrast medium injection, reduces the measurement time required in the magnets and the image evaluation time [29, 30]. The shortened protocols described in the literature differ greatly. Some working groups used additional T2w sequences or a DWI [30–33]. In other shortened protocols, the measurement after the administration of contrast medium was performed with a high temporal resolution sequence [34, 35]. Overall, the studies also show great heterogeneity with regard to the study population and the sequences used [36, 37] Restricting the evaluation to MIP images limits the sensitivity [38, 39]. Background enhancement and motion artifacts can compromise the interpretation of MIP images. A shortened protocol appears to be attractive within an early detection program for asymptomatic women and is the focus of current research. Outside of screening studies, shortened protocols should not be used, particularly for addressing complex clinical questions.

15 Intervention

If previously undocumented suspicious findings are detected in the breast MRI, these must be clarified further. For this purpose, a second-look sonography and comparison with prior images are primarily recommended.

If additional examinations such as tomosynthesis or contrast-enhanced mammography reveal a correlate that can be reliably identified with the corresponding MRI findings, an intervention using these procedures can also be performed as an alternative to MRI-guided biopsy if an appropriate biopsy option is available [40–43].

Malignant mass lesions, in particular, often show a correlate in second-look sonography [44]. If the suspicious lesion cannot be clearly detected with the alternative methods, an MRI-based intervention is required. The possibility of MRI-supported intervention should be available on site or guaranteed in the form of a cooperation agreement at an external location. The examination protocol should be a native T1w 3D-GRE sequence, and preferably two series after the intravenous administration of contrast medium should be used. The minimal invasive biopsy should be performed as vacuum assisted biopsy. The information in the literature regarding the number of samples to be taken in MRI-guided vacuum-assisted biopsy varies widely; in general, adequate tissue sampling is required (e. g. ≥ 12 samples with a 9 G needle). The correct biopsy site is documented in the images by showing the biopsy cavity. It must be ensured that the localization of the biopsied lesion can also be reliably identified postinterventionally (e. g. by positioning a clip). A post-interventional mammogram (in lateral and cranio-caudal projection) can be helpful here. A follow-up MRI is recommended after 6 months for benign, radiologically-pathologically correlated findings of imaging category 4 or 5 in the interdisciplinary S3 guideline for the early screening detection, diagnosis, treatment and follow-up of breast carcinoma] [45] even though this is no longer considered necessary by some authors [46, 47].

Interessenkonflikt

Die Autorinnen/Autoren geben an, dass kein Interessenkonflikt besteht.

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