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Case Report

Lesion-mimicking DIXON swap artifact in contrast-enhanced subtraction breast MRI ☆

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ABSTRACT

Breast cancer is the most common cancer in women; approximately 1 in 8 women is diagnosed with breast cancer in their lifetime. Some women are at significantly higher risk of developing breast cancer, including women carrying mutations in the BRCA1/2, TP53, or other genes and women with other risk factors. Women with a high lifetime risk for breast cancer are frequently offered annual breast magnetic resonance imaging (MRI) examinations for early breast cancer detection. Breast MRI is commonly performed using a multiparametric imaging protocol, including dynamic contrast-enhanced T1-weighted acquisitions. The dynamic contrast-enhanced T1-weighted acquisitions are frequently transformed into subtraction series, allowing the focused visualization of areas with high signal intensity and masses associated with elevated contrast agent uptake, which are among the hallmarks of suspicious findings. Here, we report a case in which a suspicious lesion-mimicking swap artifact occurred using a T1-weighted contrast-enhanced DIXON acquisition technique in a high-risk breast cancer screening MRI examination.

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Case report

This report describes the case of a 37-year-old woman with high breast cancer risk. Her high risk of breast cancer was due to a confirmed mutation in the BRCA2 gene. BRCA2 mutations are responsible for approximately 70% of lifetime breast cancer risk, and most of these breast cancer cases are hormone receptor-positive [1,2]. The lifetime risk for ovarian cancer is estimated to be approximately 17% [1,2].

Women with a high risk of breast cancer are often offered annual breast magnetic resonance imaging (MRI) examinations [3]. The breast MRI examination as part of the high-risk screening at our institution was performed with a multiparametric protocol on a 3T MRI Scanner (Vida, Siemens Healthineers, Forchheim, Germany) with a dedicated 18-channel breast coil (Siemens Healthineers, Forchheim, Germany). The protocol included nonenhanced T2-weighted sequences (with / without fat saturation), diffusion-weighted imaging (DWI), and T1-weighted sequences before and 5 times after

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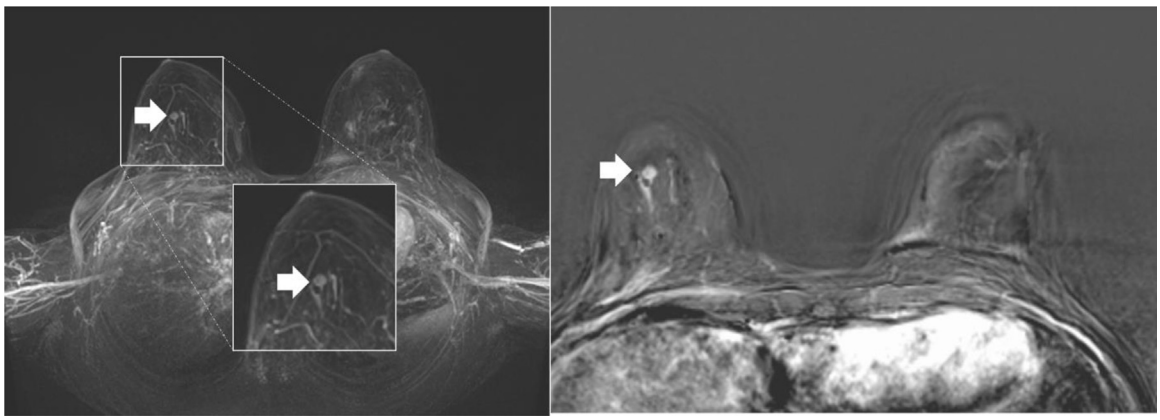

Fig. 1 – Postcontrast subtraction image of a 37-year-old woman with a BRCA2 gene mutation. The image was computed with the DIXON water-only images. In the right breast, a circular hyperintensity is present in both the maximum intensity projection (MIP; left image) and the single slice images (right image); it resembles a lesion with a pronounced signal intensity increase. Arrows depict the lesion.

contrast agent administration. Gadolinium-based contrast agent (GBCA, gadobutrol) was administered via intravenous injection (Gadovist 0.1 mmol/kg body weight, flow rate: 2.0 mL/s). T1-weighted acquisitions were acquired with the DIXON technique (slice thickness: 1.5 mm, acquisition type: 3D, repetition time: 5.4 ms, echo time: 2.46 ms, flip angle: 8°, acquisition matrix: 448 × 358). DIXON acquisitions make use of the different chemical shifts of water and fat, and derives images that selectively suppress tissue signals from either the water or fat fraction of the evaluated tissue [4–9]. This allows one to use a single DIXON acquisition sequence, which can then be deconstructed into four individual tissue contrasts: in-phase, opposed-phase, fat-only, and water-only. T1-weighted image acquisitions before and after contrast administration are then used to derive subtraction images and maximum-intensity projections (MIP) to visually evaluate the presence of suspicious findings.

We evaluated the images and rated them according to the American College of Radiology (ACR) Breast Imaging Reporting and Data System (BI-RADS); fibroglandular tissue (FGT) was considered category D, whereas background parenchymal enhancement (BPE) was considered category A. Upon evaluating the first postcontrast T1-weighted water-only subtraction MIP (derived from the subtraction series approximately 60 seconds after contrast agent administration), an apparent high-signal-intensity lesion approximately 8 mm in diameter with an adjacent linear signal intensity increase in the FGT was noted in the right breast. This finding was confirmed in the single-slice evaluation (Fig. 1). The lesion continued to appear in the subsequent T1-weighted water-only image subtraction series of the contrast-enhanced images with a slightly varying appearance (Fig. 2). However, it did not appear in the respective T1-weighted in-phase images (c.f. also Fig. 2). The lesion was also not visible within the FGT in any of the DWI acquisitions (b-values: 50, 750, and 1500 s/mm^2), the nonenhanced T1-weighted images in-phase images, or the T2-weighted fat-saturated acquisitions (Fig. 3). Further ultrasound and X-ray mammography examinations in the patient were unsuspicious.

Discussion

The ACR guidelines stipulate that breast MRI examinations follow a multiparametric protocol and include the acquisition of different tissue contrasts. This commonly includes morphologic acquisition series acquired before the contrast agent administration, such as T2-weighted acquisitions, and mapping techniques, such as DWI, to visualize correlates of the

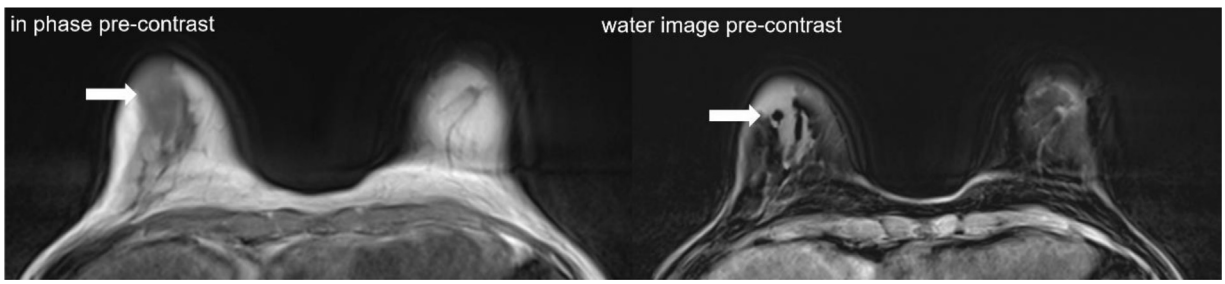

Fig. 2a – Depiction of the in phase precontrast T1w-acquisition with DIXON technique revealing an area within the fibroglandular tissue of the patient (arrow, left image) with a subtle isle-alike inhomogeneity and the corresponding precontrast water-only image of the DIXON acquisition visualizing the corresponding artifact.

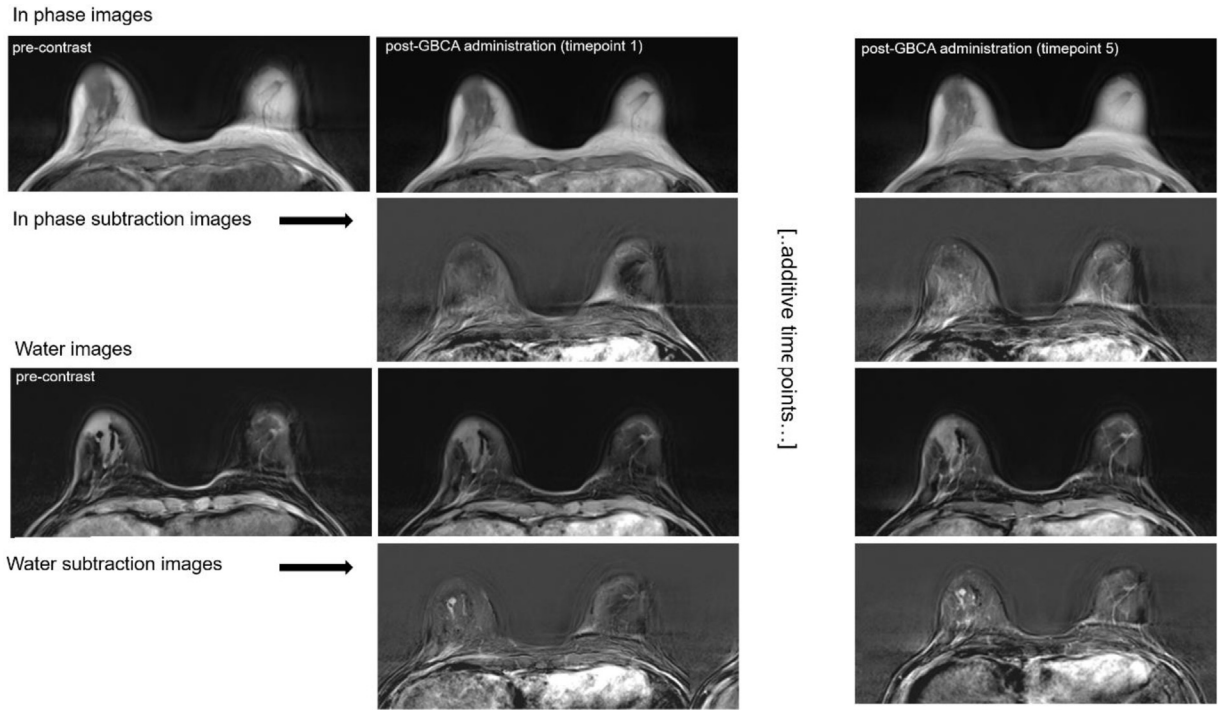

Fig. 2b – Extract of the dynamic series of the T1-weighted series (in-phase, in-phase subtraction, water-only images and water-only subtraction images) depicting the lesion mimicking artifact in the water series.

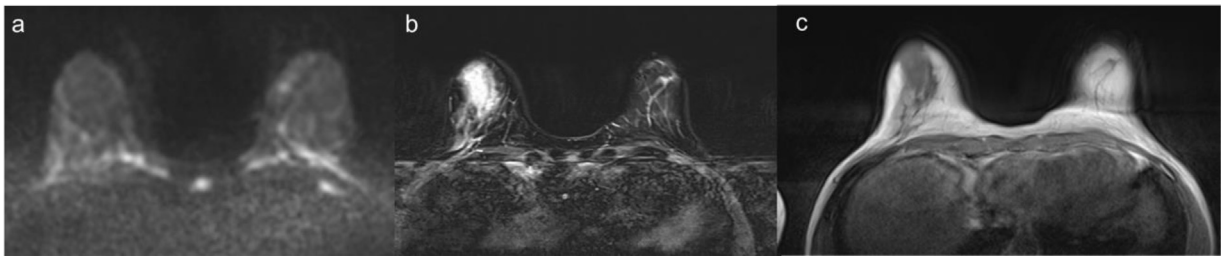

Fig. 3 – Further images of the slice displayed in Figure 1. a) Diffusion-weighted image at b = 1500 s/mm², b) T2-weighted image, and c) T1-weighted DIXON in-phase image are unsuspicious.

tissue microstructure. Pivotal core component of such multiparametric breast MRI protocols are T1-weighted acquisitions before and after GBCA injection, which can be transformed into subtraction series that selectively depict the tissue areas with increased enhancement due to the GBCA.

Because breast tissue is composed and interposed of fat and the fibroglandular structures, fat saturation techniques are commonly used in the acquisition of T1-weighted series. The DIXON technique is a fat suppression technique routinely used for breast MRI, providing robust and reliable fat saturation [6–9].

However, the DIXON technique can be prone to fat–water swapping artifacts (commonly termed “swap artifacts”) [7]. Such artifacts are caused by a computation mistake in the image postprocessing that is necessary to derive the water-only image from the acquisition due to, for example, field inhomogeneities. This results in the incorrect assignment of fat and water fractions to an individual voxel or region. Whilst concerning the individual voxel during the calculation, swap artifacts commonly have a distinct geographic appearance in the shape of (nonexisting) geographic regions.

In our case, the swap artifact mimicked several typical characteristics of a suspicious breast lesion, including a focal mass with a seemingly reactive signal intensity increase in the adjacent FGT on the contrast-enhanced T1-weighted DIXON water subtraction. A thorough evaluation revealed that the lesion was associated with a similarly shaped hypointense area on the T1-weighted DIXON water-only precontrast images, which resolved in the subsequent repetitive acquisitions of the dynamic contrast-enhanced series. The lesion could not be identified on the subtraction series derived from the T1-weighted DIXON in-phase acquisitions. Combining this information with the lack of any correlation in the diffusion-weighted data and T2-weighted images (and unsuspicious ultrasound and X-ray mammography), we concluded that the suspicious finding was most likely attributable to a DIXON

swap artifact. This swap artifact caused a high signal intensity finding on the subtraction data derived from the T1-weighted DIXON water-only acquisition, with its shape mimicking a suspicious breast lesion. The technical approach of deriving the subtraction data by subtracting the image information of the precontrast acquisition from the postcontrast acquisition caused the DIXON swap artifact to resemble a lesion-like finding in the subtraction series of the breast MRI examination.

When used to acquire dynamic T1-weighted images after GBCA injection, contrast-enhanced breast MRI with the DIXON technique might occasionally depict swap artifacts on the subtraction series when the DIXON water-only contrast is used to derive the subtraction data. Such swap artifacts can mimic a suspicious lesion even with an adjacent signal intensity increase, as demonstrated in our case. Nonsubtracted T1-weighted DIXON water-only series and subtraction data derived from in-phase series might aid in deciphering such lesion-mimicking artifacts.

Conclusion

DIXON techniques in breast MRI can issue swap artifacts on subtraction data, which in some cases might mimic suspicious lesions. Careful evaluation of all DIXON contrasts is therefore advisable.

Patient consent

For the case report written informed consent for publication of the case was obtained by the last author of the case report.

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