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Improved image quality with a receive-only coil for the Bruker MPI scanner

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Abstract

Sensitivity and resolution in MPI depend, amongst others, on the used scanner hardware and the iron concentration in the measured sample. Typically, to reconstruct samples with low iron amount, in the system matrix (SM) based reconstruction, only low frequency components with high signal-to-noise ratio are used, which limits the achievable spatial resolution. Here, Bruker's preclinical MPI scanner is used to compare the image quality of samples at decreasing iron concentrations measured with either the built-in transmit-receive (TxRx) coil or a dedicated smaller receive-only (Rx) coil. The results show that the Rx coil allows visualization of significantly lower iron concentrations. Additionally, the image quality of measurements with the TxRx coil can be enhanced by using the SM of the Rx coil for reconstruction, which is beneficial for objects that do not fit into the Rx coil.

I. Introduction

The application of MPI in preclinical research depends on its sensitivity and image quality, which depends amongst others on the used scanner hardware, including the receive coil. Improvements in signal-to-noise ratio (SNR) are achieved by reducing the size of the receive coil and using a gradiometric design [1]. However, reducing the coil size is only feasible for small objects under investigation. Image quality also depends on the reconstruction, in system matrix (SM) based methods on the SM which is commonly acquired with the same hardware. For reconstruction, frequency components are chosen based on their SNR in the SM; selecting low-frequency components with high SNR allows for reconstructing low iron concentrations, while higher frequency components relate to spatial resolution [2].

In this work, the image quality in the Bruker MPI scanner is investigated with phantoms containing decreasing iron concentrations, measured with the in-built transmit-receive (TxRx) coil or with a dedicated receive-only (Rx) coil. Furthermore, reconstructions are performed with phantom measurements using the TxRx coil and the Rx coil's SM, similar to the hybrid SM approach from [3].

II. Methods and materials

We conduct measurements with the Preclinical MPI 25/20 FF (Bruker BioSpin GmbH & Co. KG, Ettlingen, Germany) that has a built-in TxRx coil (d=160 mm). For higher sensitivity, Bruker offers a gradiometric Rx coil (d=45 mm). All measurements are performed in 3D with a drive field amplitude of 12 mT, 2.5 T/m gradient strength, 100 averages and using perimag® (plain, $c_{\text{stock}} = 8.5$ mg(Fe)/ml, micromod Partikeltechnologie GmbH, Rostock, Germany). The SMs are acquired on a grid of $23 \times 23 \times 13$ voxels with 1 mm^3 voxel size. The phantoms are 5 µL particle suspensions ranging from 4250 ng(Fe) down to 43 ng(Fe) total iron amount. Mea-

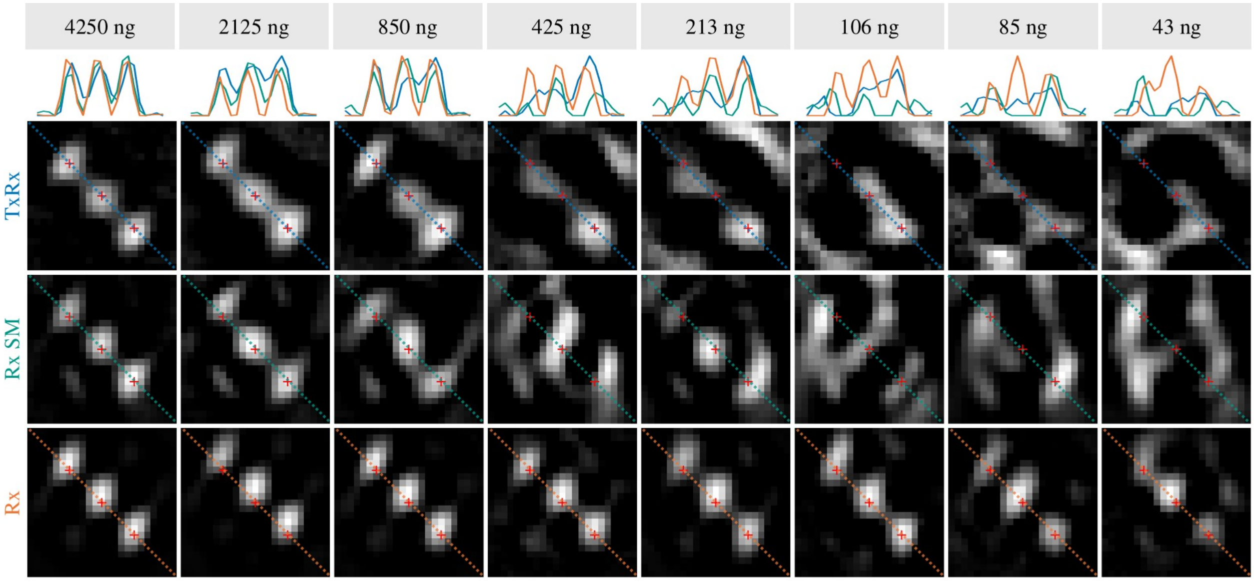

Figure 1: Reconstruction results (central slice) for the particle dots with different amounts of iron at three different positions (actual position marked by red crosses), with SM and phantom measurement from TxRx coil (top row) or Rx coil (bottom row) or SM from Rx and phantom measurement from TxRx (middle row). Line profiles along the dotted diagonal are displayed above the images with the same coloring as the diagonals. Image intensity is scaled to the maximum for each image individually.

surements of these phantoms at three different positions in the xy-plane are averaged afterwards to emulate three-dot phantoms. Image reconstruction is performed using the Kaczmarz algorithm with regularization, run for 1 iteration. Regularization and SNR cutoff are chosen based on the image quality independently for every measurement. Frequencies below 80 kHz are always discarded.

III. Results and discussion

Figure 1 shows that using the TxRx coil, the three particle dots can be visualized for iron masses ≥ 850 ng(Fe) per dot, while the Rx coil allows visualization until at least 85 ng(Fe). Based on a sensitivity estimation in a LNA-noise dominated solenoid coil [1], the smaller diameter of the Rx coil was expected to improve the sensitivity by a factor of 7. For the TxRx data, only at 4250 ng(Fe) the three dots can be separated, as can be seen in the line profiles above the images. The line profiles also show that for ≥ 850 ng(Fe), a clearer separation is achieved when using the Rx SM for reconstruction of the TxRx phantoms. This is beneficial if the object under investigation is too large to fit in the Rx coil. However, there are more artifacts in the reconstructed images with the Rx SM, as there was no correction for transfer function or sensitivity of the coils prior to reconstruction. Furthermore, the results show that the sensitivity, in terms of lowest iron amount that can be visualized, is determined by the coil used for the object measurement, while the SM used for reconstruction merely enhances image quality.

IV. Conclusion

The Rx coil provides better image quality down to lower iron concentrations than the original TxRx coil. For larger objects under investigation measured with the TxRx coil, the Rx SM can be used in the reconstruction to achieve better spatial resolution. In the future, suitable corrections to match the data of the two coils will be investigated.

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Author's statement

Conflict of interest: Authors state no conflict of interest.

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