

A 16-Channel Breast RF-Coil for Simultaneous PET/MR

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Introduction:

Novel integrated imaging techniques such as PET/MR can simultaneously provide metabolic and anatomical information. In quantitative PET, ¹⁸F-FDG tracer uptake has been shown to correlate with disease progression. The combination of PET with MRI has demonstrated increased specificity for the detection of malignant breast lesion and has potential for earlier prediction of pathologic response and detection of residual disease in the settings of tumor recurrence and neoadjuvant therapy [1, 2]. Technological developments in integrated PET/MR require the adjustment of components for unrestricted performance of both modalities. The presence of MR coils in the PET FOV causes attenuation of PET photons, which could hamper PET image quality and quantification. Here, we present design and implementation of a 16-channel (16-ch) breast coil optimized for integrated PET/MR (3T) systems. In phantom studies the MR and PET performance of the dedicated breast coil has been evaluated and compared to standard single-modality imaging setups.

Methods:

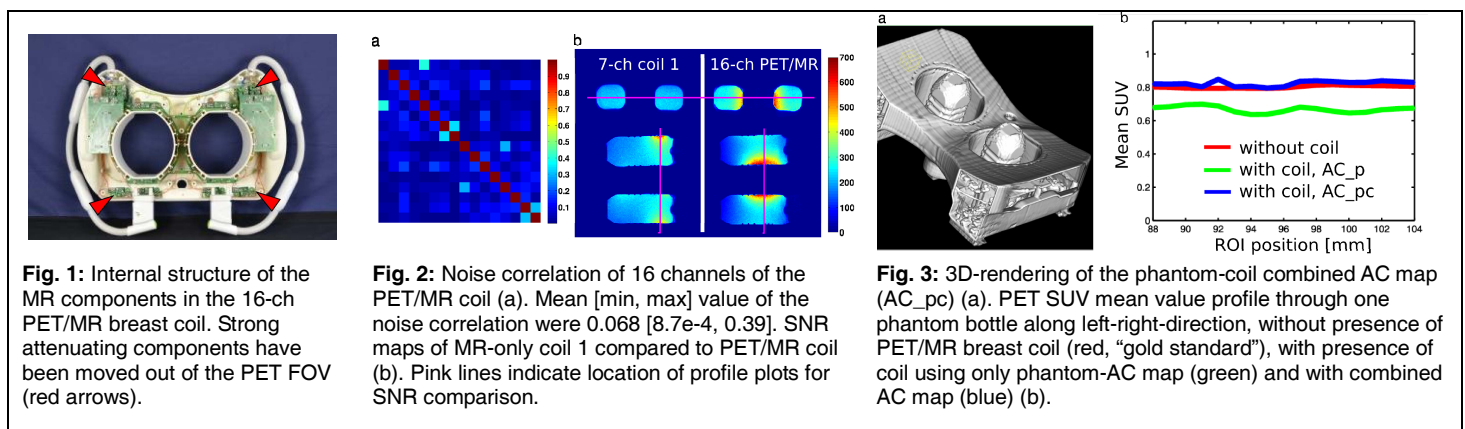
The 16-ch breast coil (PET/MR coil, Rapid Biomedical, Rimpar, Germany) has been designed to minimize attenuation of PET photons in a simultaneous PET/MR system (Siemens Biograph mMR, Siemens Healthcare, Erlangen, Germany). For this purpose strongly attenuating components of the RF coil electronics have been moved away from the PET FOV. The MR performance of the dedicated PET/MR coil has been compared to two standard MR-only breast coils: coil 1 (7-ch, designed for Siemens Verio 3T by InVivo, Gainesville, FL, USA) and coil 2 (16-ch, designed for Siemens Magnetom 3T systems by Rapid Biomedical, Rimpar, Germany). To assess sensitivity and parallel imaging performance, SNR maps and noise correlation of all channels were acquired using water bottle breast phantoms (two 1-liter bottles filled with water and Gd-DTPA). The overall effect of the presence of an RF coil on PET photon count statistics has been evaluated by comparing PET emission counts of the water bottle breast phantoms (see above plus 75 MBq ¹⁸F-FDG each) without vs. with presence of an RF coil. For this purpose, PET emission scans have been acquired in a PET/CT system (10 min emission, Siemens 64TruePoint PET/CT, 140 kV energy). We determined PET photon count loss for the PET/MR coil and MR-only coil 1 (see above). Further, a CT-based photon attenuation correction map of the coil (AC_c) has been implemented to correct for photon count loss and scatter of the PET emission data due to the coil presence. For this purpose a CT image of the coil has been acquired on the PET/CT system at 140 keV. The AC_c map was obtained using bilinear mapping of Hounsfield units to linear attenuation coefficients for PET photons at 511 keV [3]. In simultaneous PET/MR imaging, the AC map of the phantom (AC_p) is obtained by segmentation of a MR-Dixon acquisition [4] and combined with the CT-based AC_c map of the coil (yielding AC_{pc}). For evaluation of the AC correction method, PET emission data (10 min acquisition) is acquired without the coil present ("gold standard") and compared to emission data with the coil present and using either AC_p only or the combined AC_{pc}.

Results:

Figure 1 illustrates design optimizations for PET compatibility of the PET/MR breast coil. The MR performance evaluation of the PET/MR breast coil yields a mean [min, max] value for the noise correlation of 0.068 [8.7e-4, 0.39] (Fig. 2a). The SNR map of the PET/MR coil compared to MR-only coil 1 is shown in Fig. 2b. The mean value of a profile through the coronal (axial) SNR image (pink lines in Fig. 2b) yielded 46 % (8%) higher SNR for the PET/MR coil compared to the 7-ch coil 1 and 11% (0.3%) higher SNR compared to the 16-ch coil 2 (not shown in Fig. 2b). In the PET emission experiment, the presence of the PET/MR coil caused only a 15% percent reduction in overall true counts compared to 20% for MR-only coil 1. For PET imaging in the simultaneous PET/MR system, the implementation of a phantom-coil combined attenuation map (AC_{pc}, Fig. 3a) was able to correct for the count loss due to the PET/MR coil presence and resulting SUV values were comparable to the "gold-standard" experiment of PET emission data without coil presence (Fig. 3b).

Conclusion:

The design optimization of the 16-ch breast RF coil design for integrated PET/MR resulted in less PET photon count loss compared to state of the art MR-only breast coils. The MR performance evaluation showed that the PET/MR coil was comparable to MR-only coils. Accurate PET quantification could be achieved with the PET/MR breast coil in the PET FOV by implementing a CT-based template-AC map of the coil to be combined with the MR-acquired phantom-AC map.



References: [1] Buchbender C et al. J. Nucl. Med. (2012) 53:928-938. [2] Sanli Y, et al. Ann Nucl Med (2012) 26:345-350. [3] Burger C, et al. Eur J Nucl Med (2002) 29:922-927. [4] Martinez-Möller A, et al. J. Nucl. Med. (2009) 50:520-526.