Combined Clinical MR/PET: Feasibility of Simultaneous Imaging

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Introduction

Acquisition of anatomic and functional information is crucial for molecular imaging. A milestone was achieved in 1998 when functional imaging by positron emission tomography (PET) was combined with anatomical imaging by computed tomography (CT) within one integrated PET/CT scanner [1]. Although magnetic resonance imaging (MRI) has the distinct advantage to yield not only high-resolution morphologic but also a variety of functional information about e.g. perfusion, diffusion and metabolism, combined MR and PET imaging was up to now not feasible because conventional PET detectors are highly sensitive to even small magnetic fields. Goal of this study was to use a novel PET detector technology integrated in a conventional 3.0 T MR scanner for enabling simultaneous MR and PET image acquisition.

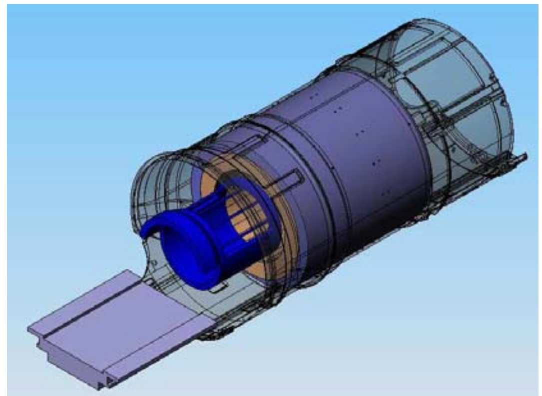

Figure 1. Design of the integrated MR/PET system

Methods

PET Detector. Novel PET detector technology has been developed based on lutetium-oxyorthosilicate (LSO) scintillation crystals and avalanche photodiodes (APDs) being invisible for the MRI system. Each detector consists of a 12x12 LSO matrix with an individual crystal size of 2.5x2.5x20 mm³ and is read out by a 3x3 APD array where the individual diodes have an active surface of 5x5 mm². Five LSO-APD block detectors form a cassette and are arranged in axial direction of the scanner. The entire PET scanner consists of 32 cassettes and has an axial field of view (FOV) of about 19 cm and an inner ring diameter of 35.5 cm.

MRI scanner. The MR compatible PET scanner was built into a standard clinical 3 Tesla MRI scanner (TRIO, Siemens Medical Solutions) in a way to match their FOVs. A standard bird cage transmit/receive head coil (Siemens Medical Solutions) was mounted on the MRI scanner bed and placed inside the PET scanner for simultaneous PET and MR data acquisition (Fig. 1).

PET and MR imaging. Imaging of a Hoffman brain phantom, filled with 37 MBq [^{18}F]Fluoride, was placed in the MR/PET system and PET data were acquired for 30 minutes. While PET imaging was performed, MR data were taken using a T2w TSE MR sequence. Additionally, a human volunteer study was performed with the PET insert in place by applying conventional MRI, time-of-flight MR angiography, diffusion-weighted MRI as well as proton MR spectroscopic imaging sequences.

Results and Discussions

Simultaneous acquisition of MR and PET data was feasible. The MR/PET images from the Hoffman brain phantom revealed an excellent quality without artifacts or image distortions (Fig. 2). Most importantly, the integrated PET scanner was completely invisible for the MRI system. Human MR imaging and spectroscopy results were also not influenced by the PET insert in place. Particularly, signal-to-noise ratio and spectral resolution of MR spectroscopy were not compromised. Accordingly, this novel hybrid MR/PET imaging technology improves spatial correlation while notably reducing data acquisition time compared to separate MR and PET imaging. The combination of morphologic and functional information from MR and PET will open a novel and powerful window for assessing morphology, function and metabolism provided by MR with molecular information provided by PET scanning. An ethical committee protocol for performing patient studies has just been approved allowing us to start with first patient examinations.

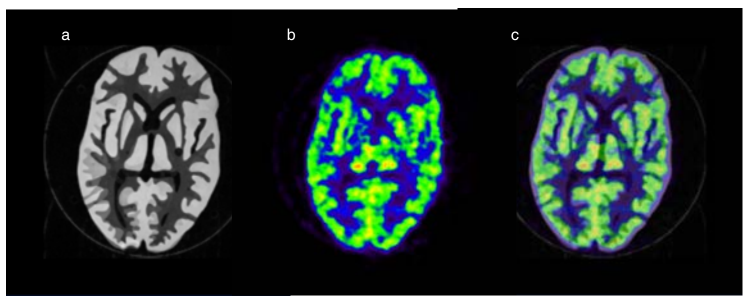

Figure 2. Simultaneously acquired (a) MR and (b) PET images as well as superimposed images of a Hoffman brain phantom

References

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[2] Pichler BJ, Judenhofer MS, Catana C, et al. Performance test of an LSO-APD detector in a seven-T MRI scanner for simultaneous PET/MRI. J J Nucl Med 2006; 47(4): 639-47