

Simultaneous PET/MR of Atherosclerotic Plaques in Peripheral Artery Disease: Preliminary Results

Isabel Dregely¹, Stephan G Nekolla¹, Carl Ganter², Tobias Koppa³, Hua-Lei Zhang¹, Sylvia Schachoff¹, Anna Winter¹, Marijana Dzijan-Horn³, Markus Schwaiger¹, and Tareq Ibrahim³

¹Department of Nuclear Medicine, Klinikum rechts der Isar der TU München, Munich, Bavaria, Germany, ²Department of Radiology, Klinikum rechts der Isar der TU München, Munich, Bavaria, Germany, ³Department of Cardiology and Angiology, Klinikum rechts der Isar der TU München, Munich, Bavaria, Germany

Objectives: Non-invasive imaging techniques have the potential to identify high risk patients in atherosclerotic disease. Several studies have shown that the vulnerability of atherosclerotic lesions is related to plaque composition, which can be imaged using high-resolution MRI [1]. Other studies have shown that in molecular imaging, using positron emission tomography (PET), the uptake of 18F-FDG tracer correlates with vessel wall inflammation [2]. Our aim was to demonstrate the feasibility of simultaneous PET/MR in peripheral artery disease (PAD) to improve characterization of atherosclerotic plaques.

Methods: Four subjects with PAD were enrolled and provided informed consent in this IRB approved study. Imaging was performed on a whole-body simultaneous PET/MR scanner (Biograph mMR, Siemens, Erlangen, Germany). After injection of 350 - 470 MBq 18F-FDG, static emissions scans were acquired 90-160 minutes post injection in the upper leg. Simultaneously, MR imaging was performed. An 18-s Dixon sequence was acquired to obtain a μ -map for attenuation correction (AC) of PET data [3]. Subsequently, high resolution anatomical scans were acquired at the localization of the plaque using a 6-channel body matrix coil (Siemens, Erlangen, Germany). A time-of-flight (TOF) bright blood sequence was used to show vessels and degree of stenosis: 2D multi-slice, axial acquisitions with TR/TE 533/7.7ms, FOV 195x390mm², resolution 0.76x0.76mm², slice thickness 3.5mm, BW 114Hz/px. Plaque morphology was imaged using turbo spin echo (TSE) sequences with T1- and T2-weighting: 2D multi-slice, axial acquisitions with TR/TE 800/12ms for T1w and 3000/75ms for T2w, turbo factor 13, FOV 170x320mm², resolution 0.63x0.63mm², slice thickness 3mm, BW 130Hz/px, averages 2. Dark blood was achieved using either saturation bands (T2w) or double inversion recovery (T1w) preparation. Morphological image analysis was performed based on MR images, assessing vessel wall thickness and plaque components. The AC PET images were fused with the MRI scans and ROIs were drawn at the localization of the plaque and the nearby vein for normalization to the blood signal. Ratios of mean standardized uptake values (SUV) in plaque and vein ROI were calculated (TBR, tissue-to-background ratio).

Results: Fusion of simultaneously acquired PET and MR data enabled excellent image registration. This lead to an exact localization of the vessel on low resolution PET images using the anatomical information from high-resolution MR images (Fig. 2). Plaque morphology could be identified on high-resolution MRI TSE images (Fig. 3). The maximum wall thickness in the analyzed lesions ranged from 2.8 to 4.8 mm. Increased 18F-FDG uptake at the vessel location was observed in PAD patients with maximum SUV in the plaque ranging from 1.1 to 1.6 and TBR ranging from 1.2 to 2.2. Two patients showed uptake along the whole vessel within the PET FOV (Fig. 4a), whereas for two patients only focal uptake was observed (Fig. 4b). Interestingly, the location of maximum PET tracer uptake did not always match the location of luminal stenosis, where MRI was performed.

Conclusions: Our preliminary results show that complex atherosclerotic plaques in PAD can be characterized non-invasively with simultaneous PET/MR. Further, our results point to the synergistic value of simultaneous functional and morphological imaging, where macroscopic and functional alterations might not coincide. In future studies, histopathology of plaques obtained by atherectomy will be compared to validate in vivo imaging results.

References: [1] Skinner, M.P. et al. Nat Med 1, 69–73 (1995). [2] Rudd, J. et al. Circulation 105, 2708-2711 (2002). [3] Martinez-Möller, A. et al. J Nucl Med 50, 520-6 (2009).

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Figure 1. Time-of-flight (TOF) bright blood angiography shows location of stenosis in left leg of subject 2. At this location high resolution axial TSE images were acquired.

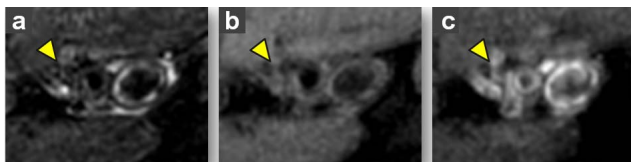


Figure 3. Multi-contrast, axial turbo spin echo images of the same plaque location show complex plaque morphology in subject 2: T2w TSE (a), T1w TSE (b), T1w TSE post injection of Gd-based contrast agent (c).

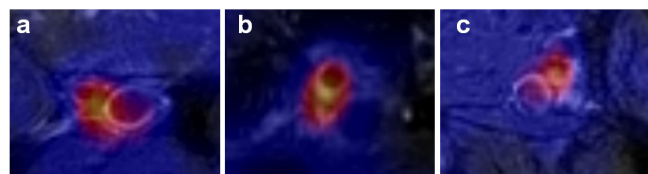


Figure 2. Fusion of high-resolution MRI TSE images with PET static emission scans enables exact localization of tracer uptake in arterial vessel wall in subject 2 (a), subject 3 (b) and subject 4 (c).

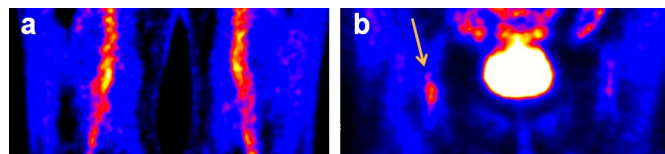


Figure 4. Different subjects with PAD show different PET uptake: whole vessel uptake in subject 2 (a), focal uptake in subject 3 (b).