$\boxed{\text{P27}}$ Calibrating d-PFG Filtered MRI Using a Novel Anisotropic Diffusion Phantom

Michal Komlosh[1], *Evren Ozarslan*[1], *Martin Lizak*[1], *Ferenc Horkay*[1], *Peter Basser*[1]

[1] National Institute of Health

Introduction: Diffusion MRI methods can provide valuable microstructural information about tissues and porous media within an imaging volume [1-3], however, calibrating them is problematic owing to the lack of suitable anisotropic diffusion MRI phantoms. Here we constructed an anisotropic diffusion MRI phantom to calibrate diffusion MRI sequences and validate models that relate the diffusion MRI signal to the MRI pulse sequences and material microstructure. We then use this phantom to calibrate a d-PFG filtered MRI experiment to measure and map mean pore size [4].

Materials and Methods: This new phantom consists of four 2 mm thick water-filled glass capillary arrays (GCA) (Photonis USA). The nominal pore diameter of two wafers is 10 µm; that of the other two is 25 µm. D-PFG filtered NMR sequences were acquired by applying two wave vectors sequentially, and by varying the angle between them from 0° to 360°. A 7 T vertical-bore Bruker DRX microimager was used with PFG NMR parameters: $\delta = 3.15\,\mathrm{ms}$, $\Delta = 75\,\mathrm{ms}$, and G between 0 and 221 mT/m; and MRI parameters: TR/TE = 7000/12 ms, FOV = 30 mm and slice thickness = 2 mm. An operator-based modeling framework [5-7], which predicts the MRI signal attenuation due to restricted diffusion within packs of impermeable cylinders as well as a free water compartment for each d-PFG filtered MRI sequence, was used to estimate the pore diameter map. ROI analysis was used to measure the average pore diameter and pixel-by-pixel analysis was applied to create a mean pore diameter map.

Results and Discussion: ROI analysis of the d-PFG filtered MRI data yields a pore diameter of 27.7 ± 0.1 and 27.75 ± 0.04 µm for the 25 microns ID wafers and 9.94 ± 0.09 and $10.0 \pm 0.1\,\mu$m for the 10 microns ID wafers. A composite GCA phantom, constructed by stacking wafers to produce a known distribution of pore diameters, can be used to calibrate diffusion MRI methods like AxCaliber [2].

Conclusion: While a variety of media have been used successfully to calibrate diffusion NMR experiments, this anisotropic phantom and its associated mathematical framework appears to be the first one to be able to calibrate diffusion MRI experiments, including single, double, and multiple PFG MRI or wave-vector based methods. Since the GCAs are stable over a large range of temperatures and are available in various pore sizes and wafer thicknesses and diameters, various embodiments of this phantom can be used in a variety of applications ranging from material sciences to clinical and biological MRI.

[1] PJ Basser, et al. Biophys J 66, (1994).
[2] Y. Assaf, et al. Magn Reson Med 59, 1347, (2008).
[3] Y. Assaf, et al. Magn Reson Med 52, 965, (2004).
[4] ME. Komlosh, et al. Proceeding ISMRM 18, 3399, (2010)
[5] E. Ozarslan et al., J Chem Phys, 130, 104702, (2009)
[6] Grebenkov, Rev Mod Phys, 79, 1077, (2007).
[7] E. Ozarslan et al., J Chem Phys, 128, 154511, (2008).