2D Radial Acquisition Technique with Density Adaption in Sodium MRI

S. Konstandin1, A. M. Nagel2, P. M. Heiler3, and L. R. Schad1

1Computer Assisted Clinical Medicine, Heidelberg University, Mannheim, Germany, 2Department of Medical Physics in Radiology, German Cancer Research Center, Heidelberg, Germany

Introduction:
In this work we propose a 2D projection reconstruction method with variable gradient amplitudes to cover the k-space uniformly, as described elsewhere for the 3D case [1]. Signal-to-noise ratio is increased and the linear form of the radial trajectory is kept contrary to the twisting radial-line (TWIRL) trajectory [2] and interleaved spiral trajectory [3]. This method can be easily implemented at the MR scanner due to the simple gradient design and lower hardware requirements in respect of slew rate. Simulations and sodium measurements of the human head are shown for the density adapted 2D radial trajectory (DA-2DRT) compared to the conventional 2D radial trajectory (2DRT).

Methods:
Sodium measurements were performed on a 3.0 Tesla clinical whole-body MR scanner (Magnetom Tim Trio, Siemens, Germany). Using a variable-rate selective excitation pulse [4] the echo time is kept as short as possible. For density adaption the readout gradient must be shaped as shown in Fig. 1 to obtain uniform k-space coverage. The radial spokes were homogeneously distributed in k-space with equally spaced azimuthal angles \( \varphi (0 < \varphi < 2\pi) \). The k-space data was reconstructed using a convolution with a Kaiser-Bessel kernel [5] (W=4.0) followed by sampling onto a Cartesian grid and a complex 2D fast Fourier transform. The received k-space signal is divided into three parts: A = ramp, B = trapezoidal and C = density adapted part.

Results:
The amplitude and FWHM of the simulated PSF are shown in Fig. 2 for monoeponential \( T_2^* \) decay. The optimal readout window \( T_{RO} = T_{RO}^* \) for highest SNR, (Fig. 2c) is \( \alpha = 0.81 \) for trapezoidal gradients, \( \alpha = 1.19 \) for density adapted gradients considering hardware limitations and \( \alpha = 1.25 \) for full density adapted gradients. The associated SNR benefit is 1.19 for the full density adapted case and 1.17 for the less density adapted case. This SNR gain is only induced by the more efficient signal acquisition under \( T_2^* \) decay.

Discussion:
We present a new density adapted 2D radial sampling scheme which provides higher SNR, less blurring and less artifacts in the presence of magnetic field inhomogeneities than conventional projection reconstruction methods. In addition, its straightforward trajectory form simplifies the implementation at the MR scanner when compared to spiral trajectories. This sequence is well suited for sodium MRI and other applications where short echo times are required.

References: