3D-Rotational Phase-Contrast MR Angiography

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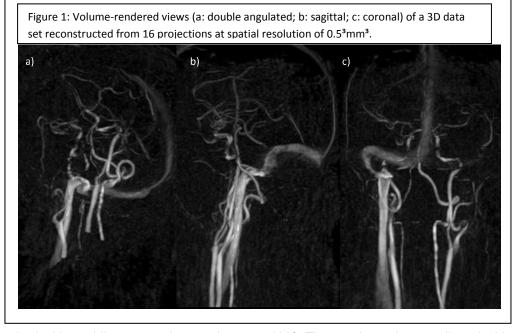
Introduction

For many applications of MRI angiography (MRA), high spatial resolution images obtained in reasonable scan times are required. For significantly decreasing the image acquisition time, projection reconstruction based approaches have been proposed, using highly undersampled two-dimensional projections [1,2]. These methods have e.g. been successfully applied to temporally resolved MRA [3]. In this contribution, a new reconstruction technique for sparsely sampled MRI projection data is introduced. In contrast to the published work, the new reconstruction technique exploits the sparseness of the object as prior knowledge for regularization of the undersampled reconstruction problem. The proposed technique has been applied to high spatial resolution MRA data of the head/neck region.

Methods

5 volunteers (4 male, 1 female, mean age 33 +/- 10) were enrolled in this feasibility study. The MR rotational angiography protocol was performed at a clinical MR whole body scanner (Achieva 3.0 T, Philips, the Netherlands) using a 16 Channel neurovascular head neck coil with parallel imaging capabilities. After a rapid survey and a coil reference scan, necessary for the parallel imaging reconstruction, 16 (no parallel imaging) and 32 (parallel imaging, SENSE factor = 2) thick slab

Figure 1: Volume-rendered views (a: double angulated; b: sagittal; c: coronal) of a 3D data set reconstructed from 16 projections at spatial resolution of 0.5³mm³.

phase contrast angiograms were acquired with equidistant angular spacing over 180°. The rotation axis was aligned with the patient's FH direction. The imaging volume was planned to cover the entire vasculature of the head / neck region. Sequence parameters were as follows: FOV 320 x 200 mm, spatial resolution 0.5 x 0.5 mm, slab thickness 100 mm, T_E /T_R = 6.6/14 ms, flip angle 10°, flow encoding in 3 directions 25 cm/s, acquisition time 365s. Reconstructions were calculated using an iterative algorithm optimized for the reconstructing of sparse objects from few projection data by minimizing of the L1 norm of the reconstruction [4]. The algorithm was originally proposed for 3D X-ray coronary angiography reconstruction; for the present application the similar nature of parallel-beam X-ray projections and the MR thick slab angiograms is exploited.

Results

In all cases, good image quality could be obtained from the 16-projection acquisition as well as from the 32-projection acquisitions. The delineation of the vascular structures appears more distinct in the 32-projection case. An example of a reconstructed 3D data set is provided in Fig.1.

Discussion

The application of the proposed L1-norm minimizing reconstruction algorithm appears to be promising for the reconstruction of sparsely filled images form sparsely sampled projection data. With the current straightforward implementation, a reduction of measurement time by a factor of 12.5 could be achieved without significantly sacrificing image quality. Further improvement in imaging acceleration is expected in combination with more deliberate acquisition schemes such as introduced in [3].

References: [1] MRM 2000;43:91-101, [2] MRM 2000;43:171-176, [3] MRM 2006; 55:30-40 [4] IEEE TMI 2008;27:1548-1555