3D Cardiac Cine Imaging with Vastly Undersampled Isotropic Projection Imaging (VIPR)

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Introduction: Cardiac exams today require skilled localization to consecutively study different regions of the heart. In standard exams, a stack of thick 2D slices is acquired over multiple breath-holds. The accuracy of volume measurements can be affected by the compromised through-plane resolution and misregistration of the slices between multiple breath-holds.

Purpose: To investigate the use of undersampled 3D projection reconstruction (PR) for cine imaging of the entire heart with isotropic resolution in a single breath-hold

Methods: VIPR (Vastly undersampled Isotropic Projection Imaging) is a 3D projection trajectory in which every readout passes through the center of k-space. Significant reductions in scan time are achieved with radial undersampling. The projections are aligned so that the endpoints lie evenly distributed on the surface of a sphere and they are sampled in interleaved sets. The location of the R-waves in respect to the projections were detected by the internal ECG unit of the scanner and stored for retrospective gating with an offline reconstruction. Four healthy human volunteers and one patient were imaged using a cardiac phased array coil with four elements. Data were acquired with a spoiled gradient echo sequence during the intravenous injection of Gadodiamide. The readout length was reduced to 128 samples to minimize the streak artifacts in the highly undersampled cine frames. A total of 15,000 projections (30,000 half echoes) were acquired in 20 interleaves over a spherical volume with a diameter of 40 cm.

Results and Discussion: Retrospective ECG gating allows for the adjustment of the reconstructed temporal resolution depending on the supported SNR after scan completion. Our current protocol supports five to seven frames per heart cycle. Compared to 2D techniques with better in-plane resolution, VIPR does not compromise the through-plane resolution, which allows for reformatting in arbitary orientations without loss in resolution and might be benefitial for post-processing tasks such as volume measurements. Improvements in the temporal and spatial resolution of the technique are currently limited by the streaking artifacts from high signal structures such as fat and are under further investigation.