In vivo 3D spectroscopic imaging of ^{19}F compounds using backprojection

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Introduction

Fluorine (^{19}F) MRI offers high intrinsic specificity and eliminates the need for pre-contrast imaging when compared to T_1 and T_2 based contrast agents, since ^{19}F does not occur naturally in the human body. Biocompatible perfluorocarbon structures have been demonstrated as MRI contrast agents in the form of emulsified nanoparticles[1] as well as polymeric micro-capsules[2]. The MR response of these contrast agents can be acquired as chemical shift artifact free hot-spot images using the Fluorine ultrafast Turbo Spectroscopic Imaging (F-uTSI) sequence as demonstrated before[3]. Here we demonstrate the use of backprojection imaging in order to acquire 3D F-uTSI data sets with a good spatial resolution and high sensitivity, and shorter acquisition times than all-phase encoded 3D spectroscopic imaging[4].

Method

In vivo experiments were conducted on black mice (C57BL/6) in accordance with regulatory and ethical guidelines. For anesthesia, a KMA mix (Ketamine 75 mg/kg; Medetomidine 1.0 mg/kg; Atropine 0.04 mg/kg) was used by means of intra-peritoneal (IP) injection, and continuous IP infusion to maintain anesthesia during in-vivo scanning. Polymeric microcapsules were prepared by a modified solvent emulsification-evaporation process in order to obtain core-shell microcapsules encapsulating perfluorooctyl bromide[5]. To introduce ^{19}F contrast, the mice were orally fed with a 300 µl of a 10% w/v solution of microcapsules about 2 hours prior to scanning. MR data were acquired on a 3T whole-body MRI scanner (Achieva, Philips Healthcare) equipped with dual ^{19}F/^{1}H imaging capability. Backprojection datasets were recorded as multiple 2D F-uTSI projections with varying angulation. Each projection was acquired with an in-plane resolution of 1 mm × 1mm, and by sampling a 32 × 32 k-space by echo trains following radial trajectories. The echo time, echo spacing and repetition time of the sequence were 5.6 ms, 5.6 ms and 1.0 s, respectively. The echo signals were sampled using a 32 kHz acquisition bandwidth and 500 Hz spectral resolution. Total time required to acquire a backprojection dataset with 10° angular resolution and 2 averages was about 38.5 minutes, while an angular step 5° resulted into a scan time of approximately 76 minutes. The projection dataset was converted into images by applying spectral integration and inverse Radon transform (Figure 1). Anatomical localization of the fluorine signal was achieved with high resolution (0.25 mm × 0.25 mm) ^{1}H images acquired along transverse, sagittal and coronal imaging axes using a gradient echo sequence. Subsequently, fluorine images were fused with anatomic images using geometric parameters associated with acquired data (Figure 2).

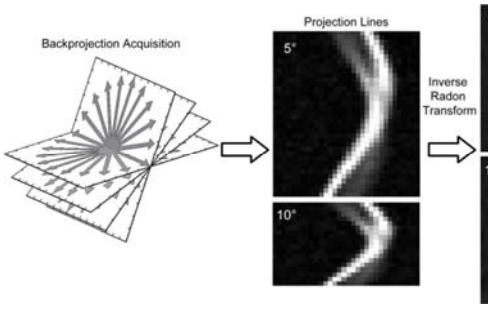

Figure 1 Backprojection data set is acquired using 2D F-uTSI, with echo trains following radial trajectories and varying angulation (left). Datasets obtained with angular resolutions of 5° and 10° consist of 36 and 18 projections respectively (center), and result into qualitatively similar slice images (right).

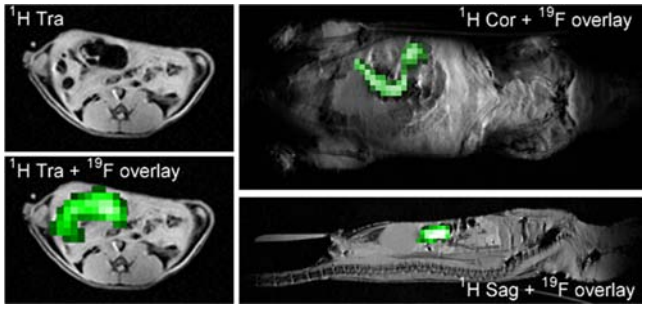

Figure 2 ^{19}F images were extracted from the volumetric dataset obtained after inverse radon transform. As seen in above overlays, backprojection imaging generates high resolution fluorine images, and allows successful localization in all directions.

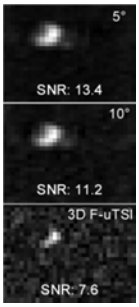

Figure 3 SNR of Backprojection and 3D F-uTSI images

Results and Discussion

Backprojection F-uTSI images obtained with an angular resolution of 5° and 10° are found to have up to 75% higher SNR and more detail, when compared to 3D F-uTSI (Figure 3). This allows a 32 × 32 × 32 spectroscopic imaging dataset to be acquired within a scan time that is approximately 40% shorter than a 3D F-uTSI acquisition with similar sequence timing and geometry.

Conclusion

Backprojection F-uTSI proves to be a strong alternative to all-phase encoded 3D F-uTSI. The technique provides data sets with excellent spatial resolution and sensitivity along all imaging axes, and offers the possibility of reducing total scan times without sacrificing image quality.

References

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