Improved clinical DCE-MRI pipeline for high resolution, whole brain imaging: application to brain tumor patients

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Purpose

To develop novel DCE-MRI acquisition, reconstruction, and processing approaches that are targeted towards providing complete clinical assessment of brain tumors

Methods

A clinical prospective evaluation of a novel sparse sampling and constrained reconstruction scheme to enable whole brain DCE-MRI imaging (22x22x20 cm3 coverage at spatial resolution of 0.9x0.9x1.9mm3) is demonstrated. Our approach uses multiple sparsity constraints in the spatial and temporal domain, which are spatial wavelet, spatial total variation and temporal finite difference, all with low weights, to mitigate potential bias from any one constraint. We compare with a current clinical scan (Rate 2 SENSE: 22x22x4.2cm3 at spatial resolution of 0.9x1.3x7mm3) on 15 brain tumor (BT) patients. PK parameters (Ktrans, vp) were derived, and image quality scores (4 point Likert scale) from two experienced neuroradiologists were used to evaluate the anatomic images and PK maps. We also propose two novel constraints that leverage knowledge from the PK model, to improve the above constraints, and obtain reduced dependence on free parameters; these are evaluated in a retrospective undersampling study of 10 BT patients.

Results

We obtained higher image quality scores with our experimental scan compared to the clinical scan. The combined radiologists scores for each of the time-resolved, post-contrast, Ktrans images, respectively for the accelerated and clinical scans were 1.2+ 0.6 v/s 2.2+ 0.7 ($p<0.001$). Fig1 demonstrates two examples of improved volume coverage in imaging a patient with a 6cm glioblastoma multiforme tumor, and a patient with 14 metastatic lesions spread throughout the brain. In the retrospective study, the novel PK derived constraints achieved improved PK parameter map depiction at acceleration rates greater than 20; (not shown due to lack of space)

Conclusion

A novel high resolution whole brain DCE-MRI method using constrained reconstruction that is clinically feasible is demonstrated; which constituted a substantial 36 fold improvement in resolution and coverage compared to current clinical scans

Clinical relevance/application

The combined use of modern sparse sampling, and constrained reconstruction techniques enables whole brain isotropic resolution DCE-MRI which greatly improves the clinical value of DCE-MRI in characterizing brain tumors (eg. guaranteed imaging of large tumors, multiple small lesions, assessment of anti-angiogenic therapies for brain tumors).