Development of MRI T2\* Mapping Model for N-Periodic ka-SPGR Sequence: A Promising Technique for Parkinson’s Disease Biomarker Detection

**brief introduction 2 min**

Disease and solution

* PD early detection 🡪 excessive iron in SN 🡪 especially at small nigrosome region (mm size)
* Pure tissue, MRI signal T2 decay exponentially
* Reality is T2\* dependent, taking into account field inhomogeneity
* When the amount of iron increases, T2\* drops, which can be identified and used as a biomarker for PD.
* T2\* time constant related to tissue and field inhomogeneous the iron caused
* Can be used to identify PD and healthy SN (show data)
* One traditional way to calculate T2\* value – Multi-echo SPGR

Problem

* Motion at the brain (video from the paper)
* Motion robust desirable

New method

* Not simply time decay dependent, due to the MRI sequence used.

**Theory 2 min**

* MRI – radiofrequency sequence, tip magnetic spins with different flip angles and phase shift.
* Using short TR and TE = TR/2, applying RF spoiling 🡪 yields N different steady state. (Previous can be considered as 1 steady state)
* Using short TR, imaging as accumulating of the signal from the previous echo time with corresponding phase modulation weighting at acquisition. Using N periodic RF-spoiling, able to extract N different echos.
* Shown in the analytical solution of RF-spoiling, each steady state signal is nothing more than configuration states weighted by specific phase modulation (quadratic related)

**Methodology 2 min**

obviously, the described sequence is difficult to find a solution using analytical solution, so we do a computer model. Check through different TR and N.

tip and shift according to the spin, measure the transverse component (measured by MRI machine)

Brief intro: computer simulation ka-SPGR 🡪 optimal ka-SPGR parameters 🡪 mri scan compare with gold-standard method (accuracy, efficiency)

**Method**

* Computer simulation model of the ka-SPGR sequence, test different Ns and TRs
* Bloch simulation (only tissue-dependent parameters are considered)
* Off-resonance profile
* Field inhomogeneities added, based on SN (amount of inhomogeneities caused by iron)

True performance modelling

* Monte Carlo simulation (zero-mean Gaussian noise, complex and real )
* Fitting the F-states

**Result**

* Find optimal parameters – minimum average bias (want it to be optimised for this detection range)
* Variation, within 5%, from previous paper’s gold-standard method measured T2\* value percentage bias.

**Method**

Scan with ka-SPGR and multi-echo SPGR, matching point position

To perform matching!!!

Echo time and the TR

Flip angle 20 and 90

**Results 2 min**

* Acquired T2\* map image, align colour means T2\* values align
* Percentage error, within 10%, take into account the gold-standard method variation
* SNR signal to noise efficiency, T2\* value, time

**conclusions**

* Optimal parameter period 7&12, TR 6ms.
* Bias and variation are acceptable for PD detection using computer simulation and phantom experiments.

Improvement and limitation