Multi-echo FLASH

Use Matlab (Pete) to process the raw data, do the coil combination from the scanner and then export as a DICOM file, instead of directly using the DICOM file generated by the scanner, consistency.

* + - ka-SPGR

Summing images acquired with corresponding phase modulation weighting as described in the theory part to get each configuration state in k-space. Then shift each configuration state to the centre of the k-space, partial Fourier filling the k-space to get k-spaces containing only one configuration state. Inverse Fourier transforms k-spaces to get the configuration state’s images.

Use Matlab (Pete) for the reconstruction described above and export it as a DICOM file.

In order to minimise the influence of the exponential fitting algorithm, the number and position of points used to fit the exponential curve should be the same when comparing the two methods. Therefore, to match the acquired data points on the T2\* exponential curve for two methods (Figure X), the multi-echo FLASH TEs start with ka-SPGR’s TE and following by an increment equal to ka-SPGR’s TR as shown in Table X. A 20° flip angle is used to match with ka-SPG aiming at comparing 2 method efficiency, and a 90° flip angle is used to obtain an accurate T2\* ground truth value. Also, the image size and voxel size are matched for all scanning performed.

By adding RF-spoiling, N different and periodically repeating steady-state signals S(n) are yielded, and each signal is the summation of the phase modulation weighted T2\* decayed signal at the time (TE+F\*TR), which is shown by the analytical solution of S(n) below [Intro10],

An equivalent operation to the convolution supported by Fourier transform property is used in the simulation, which is multiplying the F-states signal by the Fourier transform of Lorentzian - an exponential curve with the time constant 1/T2’ = 1/γΔBinhomo.

The modelled noise is randomly generated and applied 1000 times on each F-states simulated with the period, TR and T2\* values within the range in Table X.

A range of ka-SPGR coefficient is also selected due to the following reason, a period less than 3 does not provide enough data points for fitting the exponential curve, and a TR smaller than 2ms is not achievable by a scanner, also, a period greater than 12 or TR greater than 10ms both resulting in a long acquisition time. Therefore, only the performance of spins with T2\* (13-53ms), when applying 3 to 12 periodic ka-SPGR sequences with different TRs in the range from 2ms to 10ms, are simulated.

On top of the selected range, Monte Carlo experiments are performed to analyse the T2\* measurement performance. With the noise applied to the model, 1000 acquisition is made

The modelled noise is randomly generated and applied 1000 times on each F-states simulated with the period, TR and T2\* values within the range in Table X. By fitting each noise-added F-states, 1000 measured T2\* can be obtained for each ground truth T2\* value for different periodic ka-SPGR with different TR.

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This analysis is based on comparing 7 and 12-periodic ka-SPGR T2\* results with the ground truth T2\* obtained using 90° flip angle multi-echo FLASH. Percentage error is calculated for each voxel, and a dot plot of percentage error in different spheres (different T2\*) is used to visualise the distribution and variation of T2\* measurement percentage errors. Therefore, analyse the 7 and 12-periodic ka-SPGR sequences PD biomarker measurement accuracy.