Rapid R2 mapping: A comparison between ultrafast SE-SS-PARSE and FSE

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TARGET AUDIENCE: MRI Researchers and clinicians working with conventional spin echo (CSE) and fast spin echo (FSE) techniques and interested in rapid, accurate and quantitative mapping of irreversible transverse relaxation rate R2 (inverse of the transverse relaxation time T2).

PURPOSE: Rapid R2 mapping is of significant interests to MRI scientists and can be applied in many research areas, including in-flow perfusion studies[1], dynamic contrast agent studies[2] and identification of iron-deposition associated neurodegenerative diseases[3]. The recent introduced SE-SS-PARSE (single-shot parameter assessment by retrieval from signal encoding) is an ultrafast and direct R2 mapping technique[4]. By modeling the signal changes during the data sampling, SE-SS-PARSE theoretically promises a more accurate and robust data measurement. The purpose of this study is to evaluate the accuracy of R2 mapping in SE-SS-PARSE by comparing it with FSE, a commonly used and rapid R2 mapping method.

METHODS: A four tube phantom with *in-vivo-like* R2 values was constructed. Each tube was filled with a different concentration of agarose gel to span a physiologically relevant range of R2 values. SE-SS-PARSE and FSE data were acquired using the 4 tube phantom on a 4.7T Varian MRI System (Varian Inc., Palo Alto, CA). SE-SS-PARSE and FSE shared similar imaging parameters: FOV 12.8cm, matrix size 64x64, slice thickness 2mm. Data acquisition and reconstruction strategies were quite different between SE-SS-PARSE and FSE. SE-SS-PARSE sampled data in k,t-space (t refers to time) along a rosette shaped trajectory (Figure 1), and directly reconstructed a R2 map through nonlinear fitting of the measured data to our signal model[4]. In particular, a progressive length conjugate gradient (PLCG) algorithm was used to perform the nonlinear fitting[4]. Echo time (TE) for SE-SS-PARSE was 148ms. The FSE sequence was implemented with a 90 degree RF pulse followed by eight refocus (180 degree) pulses, and the R2 map was computed through a pixel-by-pixel fitting of the mono-exponential signal intensity decay. Reference R2 values in each tube were determined by fitting the decay curve of R2-weighted data acquired using CSE method at different TE. Both FSE and CSE used a set of TE of [12, 14, 20, 30, 60]ms.

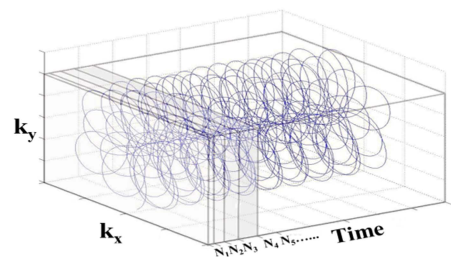

Figure 1 Rosette k,t-trajectory. N1, N2, N3, … represent the data length that the PLCG algorithm progressively fitted at each time.

RESULTS: Figure 2 compares R2 maps generated using SE-SS-PARSE, FSE, and the "Gold Standard" CSE technique. Mean and standard deviations (SD) from ROIs selected within each tube are computed and summarized in the Table below. Pixels near the tube edges were excluded to avoid partial volume and susceptibility effects. Although in general R2 values generated using FSE have mean and SD closer to the reference value, R2 values from the top and the right tubes using SE-SS-PARSE technique is more accurate than FSE. The overall R2 values computed among 3 techniques are similar. It should be emphasized that the total data acquisition time for SE-SS-PARSE, FSE and CSE were 148ms, 152s and 408s, respectively.

Tube Location	$\overline{R2}$±SD		
	SE-SS-PARSE	**FSE**	**CSE(Reference)**
Left	16.33±1.12	16.04±1.26	15.32±0.75
Top	8.76±1.04	6.98±0.47	8.05±0.45
Right	8.11±0.41	7.43±0.48	8.53±0.47
Bottom	10.83±0.83	9.42±0.78	11.39±0.60

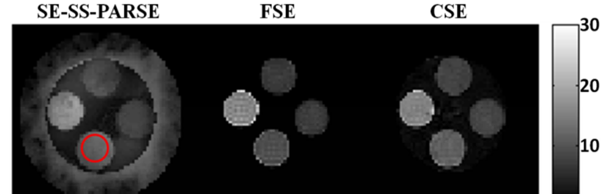

Figure 2. R2 maps generated using SE-SS-PARSE (left), FSE (middle), and CSE (right). The red circle indicates an example ROIs selected in the bottom tube.

DISCUSSION: The SE-SS-PASRE technique produces R2 maps that have a similar level of mean and SD accuracy compared with the commonly used FSE technique. Differences between the SE-SS-PASRE and FSE results may be due to the estimation errors derived from various sources. In particular, bias errors in SE-SS-PASRE may due to the signal model discrepancy, and the mismatch between the evaluation k-band (square) and acquisition k-band (circle). Random errors in SE-SS-PASRE were caused by measurement noise. In locations with large susceptibility effects, the PLCG algorithm may fail to converge to the proper solution. Great care was taken in adjusting field shims before data collection to ensure the convergence in PLCG. In addition to R2 mapping, SE-SS-PARSE can simultaneously estimate magnitude, frequency and R2' (the irreversible relaxation rate) maps. This technique may be extremely useful in monitoring instant signal changes in fMRI and neuroimaging studies.

CONCLUSION: An ultrafast and direct R2 mapping technique, SE-SS-PARSE is compared with the commonly used and rapid R2 mapping method, FSE. CSE provided references R2 values. It is found that SE-SS-PARSE is capable of producing accurate R2 mapping with a much shorter acquisition time compared to FSE.

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