# Slice Accelerated EPI for Dynamic-Susceptibility Contrast Enhanced (DSC) MRI

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**Introduction:** Dynamic-susceptibility contrast enhanced (DSC) MRI, which rapidly acquires MR signal following gadolinium contrast agent bolus injection, is a dynamic method to measure perfusion and related hemodynamic parameters. Various perfusion parameters derived from DSC-MRI data, such as cerebral blood volume (CBV), cerebral blood flow (CBF), mean transit time (MTT), and the time-to-maximum of the tissue residue function (Tmax), have been shown to be prognostic markers and therapeutic guidance tool for ischemic stroke [1]. With the need to balance spatial coverage, spatial resolution, and SNR, typical clinical EPI-based DCS-MRI scan is performed with 1-2 seconds temporal resolution. Recently developed slice accelerated EPI can greatly reduces volume acquisition time (TR) and has been shown to allow sub-second sampling rate for fMRI with whole brain coverage [2]. Slice acceleration techniques simultaneously excite multiple slices with multiband RF pulses and use parallel imaging to separate aliased slices [3-5]. In this study, we investigated the feasibility of using slice accelerated EPI for DSC-MRI measurement and experimentally demonstrated the effect of reduced sampling rate on the DSC-MRI perfusion analysis.

**Methods:** With IRB-approval and written consent, 4 volunteers participated in this study. All experiments were performed using a 3.0T Siemens clinical MRI scanner (Magnetom Skyra; Siemens Healthcare, Erlangen, Germany) with 20-channel head and neck receiver coil. The slice accelerated DSC-MRI was performed using a gradient-echo EPI sequence with multiband RF excitation and simultaneous multi-slice acquisition. Imaging parameters included: TR/TE = 509/35 ms, slice acceleration factor = 3, CAIPIRINHA FOV shift factor = 3 [5], excitation flip angle = 65º, slice thickness = 4 mm, 1565 Hz/pixel bandwidth, 220×220 mm$^2$ FOV, 128×128 matrix size, partial fourier factor 6/8, 12 total imaging slices, slice spacing 20%. Dynamic images were acquired for 2 minutes following intravenous injection of Gd-DTPA contrast agent (Magnevist, Berlex) with 0.1 mmol/kg body weight dose. Image reconstruction was performed online at the console. DSC data were analyzed offline. SVD-based deconvolution method was used to compute tissue residue function [6]. AIF was selected from the left or right middle cerebral artery. Data down sampled 3 times were used to simulate unaccelerated long TR acquisition. The CBV, CBF, MTT, and Tmax parametric maps were calculated from fully sampled data (TR = 509 ms) and down sampled data (TR =1527 ms) for comparison.

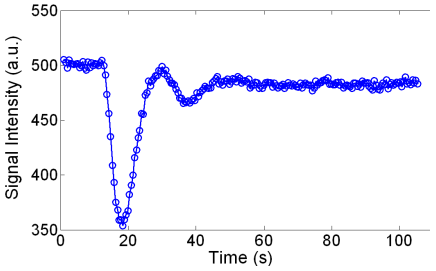


**Fig 1.** Tissue signal intensity time curve of slice accelerated DSC-MRI.

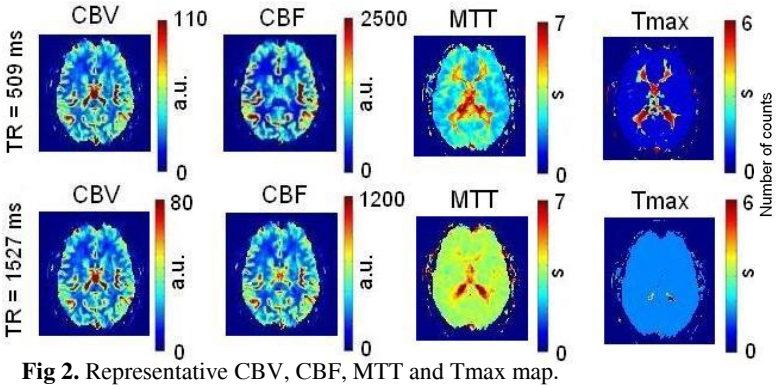


**Fig 2.** Representative CBV, CBF, MTT and Tmax map.

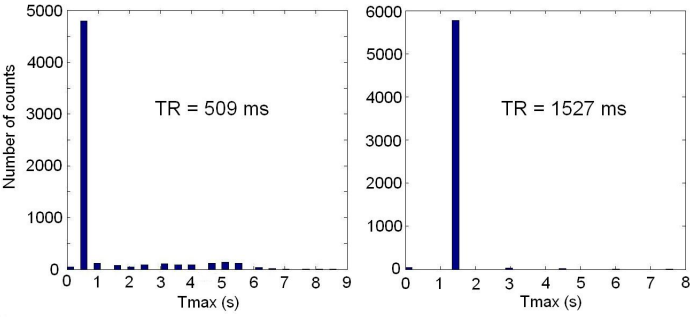


**Fig 3.** Histogram of Tmax from TR = 509 ms and TR = 1527 ms.

**Results:** Slice accelerated DSC-MRI was successfully performed on all volunteers. A representative brain tissue signal time curve is shown in Figure 1, demonstrating the fast temporal sampling with 12 slices and a 509 ms TR. Figure 2 compares the representative perfusion parametric maps obtained from TR = 509 ms and TR = 1527 ms data. The CBV maps from TR = 509 ms and 1527 ms look qualitatively similar, but the spatial distributions of CBF maps seem quite different. While the MTT maps from TR = 1527 ms show relatively small variation in the brain parenchyma, the MTT maps from TR = 509 ms show tissue dependent contrast. Additionally, the Tmax maps from TR = 509 ms show more subtle spatial variation than the Tmax maps from TR = 1527 ms which appear to bin at the TR (1.527 s) across the brain. The histogram of Tmax from the exhibited slice in Figure 2 also reveals the Tmax distribution difference (Figure 3). Furthermore, in the bottom slice(s) of the acquisition volume, the MTT and Tmax maps of TR =509 ms show elevated values in the posterior part of the brain (arrows, Figure 4). In contrast, these watershed regions of MTT and Tmax cannot be seen on the maps of TR = 1527 ms (Figure 4). This may indicate delay and dispersion effect and the MTT and Tmax's sensitivity to sampling rate (TR) [7].

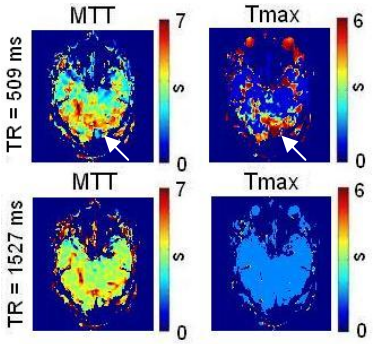


**Fig 4.** Elevated MTT and Tmax in the posterior part of the brain from TR = 509 ms vs TR = 1527 ms.

**Conclusion:** Our study demonstrates for the first time the feasibility of using slice accelerated EPI for DSC-MRI measurement and shows the evidence of association between sampling TR and perfusion parameters. The MTT and Tmax maps with faster TR sampling (509 ms) of perfusion data provide more image contrast than slower sampling rate (1527 ms). The difference in MTT also contributes to the variation of CBF spatial pattern. Faster data acquisition should reduce discretization errors in the perfusion measurement, especially for Tmax, as the measured Tmax is rounded-off to integer multiples of TR. Future studies need to apply delay and dispersion correction techniques in the perfusion analysis and investigate how faster TR may impact patient care of ischemic stroke.

**References:** [1] Arsava J Neurochemistry 2012 [2] Smith, Proc Natl Acad Sci U S A 2012 [3] Larkman, JMRI 2001 [4] Moeller, MRM 2010 [5] Setsompop MRM 2012 [6] Ostergaard et al, MRM 1998 [7] Calamante, Stroke 2010

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