Slice multiplexed chemical exchange saturation transfer

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Purpose To develop a slice multiplexed CEST acquisition that achieves larger slice direction spatial coverage with the same scan time.

Introduction CEST labels endogenous chemical compounds and has been applied in a wide range of clinical applications [1]. However CEST acquisition is usually limited to single slice as different frequency saturations are played out which may interfere with adjacent slices. On the other hand, certain applications call for the need of a larger spatial coverage in slice direction due to the heterogeneity of the region of interest. An example could be glioma, which may be associated with edema that responses differently in APT measurement from the tumor. In this work, a slice multiplexed CEST acquisition is proposed, in which two or more slices that experience the same CEST saturation are simultaneously acquired. In this way, multi-slice coverage may be achieved in CEST with the same acquisition time as in the single slice case.

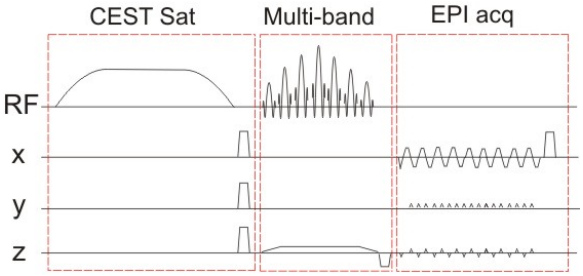
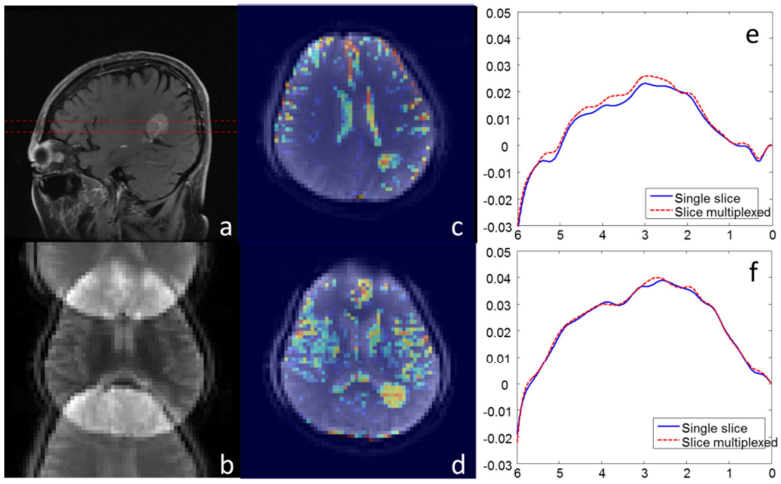


Figure 1 pulse sequence of multi-band CEST acquisition

Method The proposed slice multiplexed CEST sequence that is based on a gradient echo EPI acquisition is shown in **Fig.1**. Non-spatial selective CEST saturation with crusher gradients is followed by a multi-band excitation RF, which could be a Hadamard RF or cascaded RFs if non-parallel slices are desired. The multiplexed slices may be later separated as in conventional multi-band imaging. To achieve an optimal *g*-factor, a relative FOV shift between the aliased slices is desired, which may be realized by introducing phase offsets among adjacent k-space lines. However as single shot acquisition is often needed due scan time constrain, a phase blipping strategy [2] is used to produce the FOV shift of the aliased image.

Experiment A validation study of the proposed slice multiplexed CEST was performed with a patient diagnosed with glioma, consent form was obtained prior to the scan. The location of the tumor was first confirmed using a T2 weighted contrast enhanced acquisition, based on which the prescription of the CEST acquisition was performed. Conventional single slice CEST and slice multiplexed CEST were performed. In the former case, two slices covering the top edge and bottom edge of the tumor separated by 2cm were separately acquired with WASSR [3] and CEST. In the latter case, multiplexed acquisition of the two slices was also made in WASSR and CEST. The saturation RF used was a Fermi pulse. WASSR acquisition covered a spectrum from -1ppm to 1ppm in step of 0.1ppm with RF duration of 200ms and amplitude of 0.1ut; CEST acquisition covered a spectrum from -6ppm to +6ppm in step of 0.25ppm with an RF duration of 1s and amplitude of 1ut. Identical imaging parameters were maintained between the two acquisitions, with a TR of 3 second, the total scan time for single slice acquisition was 7:18, whereas that for slice multiplexed acquisition was 3:39.



Results **Fig.2a** shows the positions of the two multiplexed slices and a representative slice multiplexed image is shown in **Fig.2b**. Reconstructed images of the top and bottom slices are shown in **Fig.2c** and **Fig.2d**, overlaid with APT map at 3.5ppm. No residual ghosting artifact was seen due to the favorable aliasing pattern and the tumor regions were clearly delineated on the APT maps. The calculated Z-spectrum of ROIs covering the tumor regions in the top slice and bottom slice are shown in **Fig.2e** and **Fig.2f** for both single slice acquisition (solid line) and slice multiplexed acquisition (dashed line). It is seen that the Z-spectrum plots obtained in the two cases are highly consistent despite scan time saving. It is interesting to observe that the APT level in the top slice is actually lower than that in the bottom slice, which might be due to the heterogeneity of the tumor region.

Figure 2 (a) location of the two multiplexed slices (b) slice multiplexed slice; reconstructed (c) top and (d) bottom slice images overlaid with APT map at 3.5 ppm; calculated Z-spectrum of the tumor region in (e) top and (f) bottom slice using single slice and slice multiplexed acquisition.

Conclusion and discussion In this work, slice multiplexing is introduced in CEST acquisition to exploit the fact that CEST saturation is non-spatial selective. The feasibility and performance of this method was demonstrated through an APT CEST study of glioma. Little difference was observed in quantitative comparison the with single slice acquisitions. The improved spatial coverage is beneficial for assessment of heterogeneity in tissue of interests, as well as better alignment in multi-contrast imaging.

Reference [1] P. Zijl, et al. MRM. 2011; [2] K. Setompop, et al. MRM 2012; [3] M. Kim, et al. MRM 2009.