Thin Slab Pseudo-continuous Arterial Spin Labeling

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Introduction

Pseudo-continuous arterial spin labeling (PCASL)[1] produces the largest signal changes and the greatest SNR among arterial spin labeling (ASL) techniques. However, its high labeling efficiency depends on the direction and velocity of the feeding arteries. In some application, the direction of the feeding vessels may be complex/unknown or the velocity of the feeding vessels may be reduced or the labeling plane may cut through the interested imaging slab. Thin slab Flow-sensitive alternating inversion recovery (FAIR)[2,3] is often used in such uncertain applications. Here we propose and implement a method for an in-slab inversion based on PCASL technique. The in-slab inversion was achieved by placing two labeling planes above and below the interested slab.

Theory

PCASL achieves its labeling using pulsed RF and gradient waveforms. With the pulsed waveforms, the labeling planes occur at $z=n/(\gamma G_{ave}\Delta t)$, where n is integers, γ is the gyromagnetic ratio, G_{ave} is the average gradient between two RF pulses, and Δt is the distance between two consecutive RF pulses. If a 180^0 phase shift is introduced between two consecutive RF pulses in PCASL label sequence, each labeling plane will be shifted to half way towards the adjacent labeling plane from its original PCASL labeling planes. With 180^0 phase shift, the labeling planes occur at $z=(n+0.5)/(\gamma G_{ave}\Delta t)$. To label a slab, all other labeling planes except the first two labeling planes are not desirable. Therefore the first zero crossing of the RF response $2/(\gamma G_{max}\delta)$ where G_{max} is the gradient amplitude during the RF pulse and δ is the duration of each RF pulse, are required to be less than the second aliased-labeling plane (located at $1.5/(\gamma G_{ave}\Delta t)$). For the control of the method, the same RF pulses will be used as in the label but with average gradient zero so that all aliasing labeling planes get suppressed.

Methods

The sequence was implemented on a GE 3 Tesla scanner. The labeling parameters were as follows: a Hanning window shaped RF pulse of 500µs, an average B1 of 0.7µT, a gradient amplitude during the RF pulse of 1.8mT/m, and an average gradient amplitude of 0.63mT/m. A labeling duration of 1.45 s with three post-labeling delays of 0.25 s, 0.5 s and 0.75 s were applied. The labeling was performed prior to single-shot fast spin echo (SSFSE) imaging sequence: a single axial slices with slice thickness of 1 cm, field of view of 24 cm and TR of 5 s. The ASL difference images were averaged with 19 control and label pairs.

Results & Discussions

ASL difference images showed clear perfusion contrast: higher perfusion in gray matter than white matter. The difference image with 0.25 s showed some ASL signals still in large vasculature while the difference image with 0.75 s appeared more like perfusion weighted. The slab selective PCASL technique was successful at labeling blood for a thin slab. Further work will assess its efficiency with different labeling parameters and the relative efficiency with other slab labeling techniques.

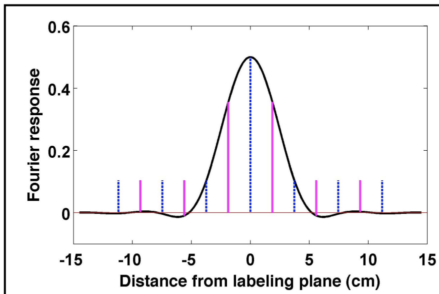

Fig 1. Aliased labeling planes from original PCASL sequence (dotted blue) and from slab-selective PCASL sequence (solid magenta).

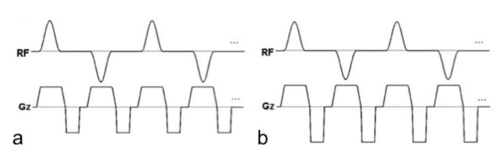

Fig. 2. The proposed slab selective PCASL Sequence: (a) the labeling pulse sequence with $B1_{ave} = 0$, $G_{ave} \neq 0$ and (b) the control pulse sequence with $B1_{ave} = 0$, $G_{ave} = 0$.

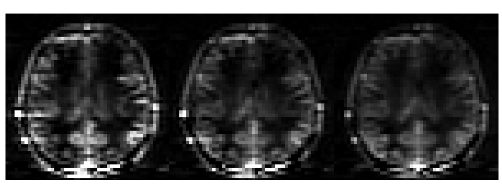

Fig. 3. Example slab selective PCASL perfusion images acquired at post-labeling delays of 0.25s (left), 0.5s(mid) and 0.75s (right).

References

1. Dai et al, Magn Reson Med 2008;60(6):1488-1497. 2. Kim et al, Magn Reson Med 1995;34(3):293-301. 3. Kwong et al, Magn Reson Med 1995;34(6):878-887.