Thin-slice Acquisition using Saturation Spin Labeling (TASSL) MRA

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Target Audience: Physicians and scientists performing magnetic resonance angiography (MRA)

Purpose: Inversion-based arterial spin labeling (ASL) techniques have been used for two decades to create nonenhanced MRA of the cerebrovascular circulation and other vascular systems (1). With inversion-based ASL MRA, inverted arterial spins flow from the labeling region into and through a thick 3D slab. Potential limitations of inversion-based ASL MRA include signal loss within distal vessels due to T1 relaxation during transit of the labeled spins, and reduced scan efficiency due to the requirement for a long inflow time (typically ≈1 sec). We propose a new saturation-based approach for ASL MRA called *TASSL* that improves scan efficiency and reduces sensitivity to arterial transit time. The technique was tested in the circle of Willis (COW) and peripheral arterial system.

Methods: The protocol was approved by the institutional IRB. Imaging was performed in healthy subjects and patients with peripheral arterial disease (PAD) at 1.5 Tesla or 3 Tesla (Siemens AG, Erlangen, Germany). Thin-slice Acquisition using Saturation Spin Labeling (TASSL) MRA involves the acquisition of two image sets. Both image sets are acquired using a spoiled gradient-echo pulse sequence. In one, a tracking arterial saturation RF pulse is applied once per sequence repetition; a control saturation RF pulse is applied in the other to balance magnetization transfer effects (2). The thickness of the arterial saturation region was ≈35mm with gap ≈10mm. Other imaging parameters included: repetition time ≈20 ms, excitation flip angle ≈14 degrees, sampling bandwidth ≈100-200 Hz/pixel. A prototype version of the TASSL technique was tested in two regions: COW (3D) and peripheral arteries (2D). For COW, overlapping thin 3D slabs were acquired with slice thickness ≈0.8mm. Comparison was made to standard 3D time of flight and/or ASL using pseudo-continuous and pulsed inversion labeling. For peripheral MRA, 40-48 slices were acquired per table position with slice thickness of 3mm and comparison was made to quiescent-inflow single-shot (QISS) and/or contrast-enhanced MRA.

Results and Discussion: TASSL MRA provided excellent depiction of labeled arteries with nearly perfect suppression of background tissue and venous signal intensity. In the circle of Willis, small branch definition matched or exceeded that of 3D TOF. TASSL depicted more distal arterial branches than inversion-based ASL **(Fig. 1A)**. In the peripheral arteries, TASSL MRA generally matched or exceeded the quality of QISS MRA, while proving insensitive to arrhythmias **(Figs. 1B and C)**.

Our initial results suggest that TASSL has potential advantages compared with inversion-based ASL MRA. Improved scan efficiency allowed the acquisition of multiple overlapping thin 3D slabs, which would not be practical with less efficient inversion-based ASL MRA. In the peripheral arteries, TASSL eliminated the need for ECG gating. Image quality was comparable to QISS MRA, although at the expense of longer scan time and risk of subtraction artifact due to patient motion.

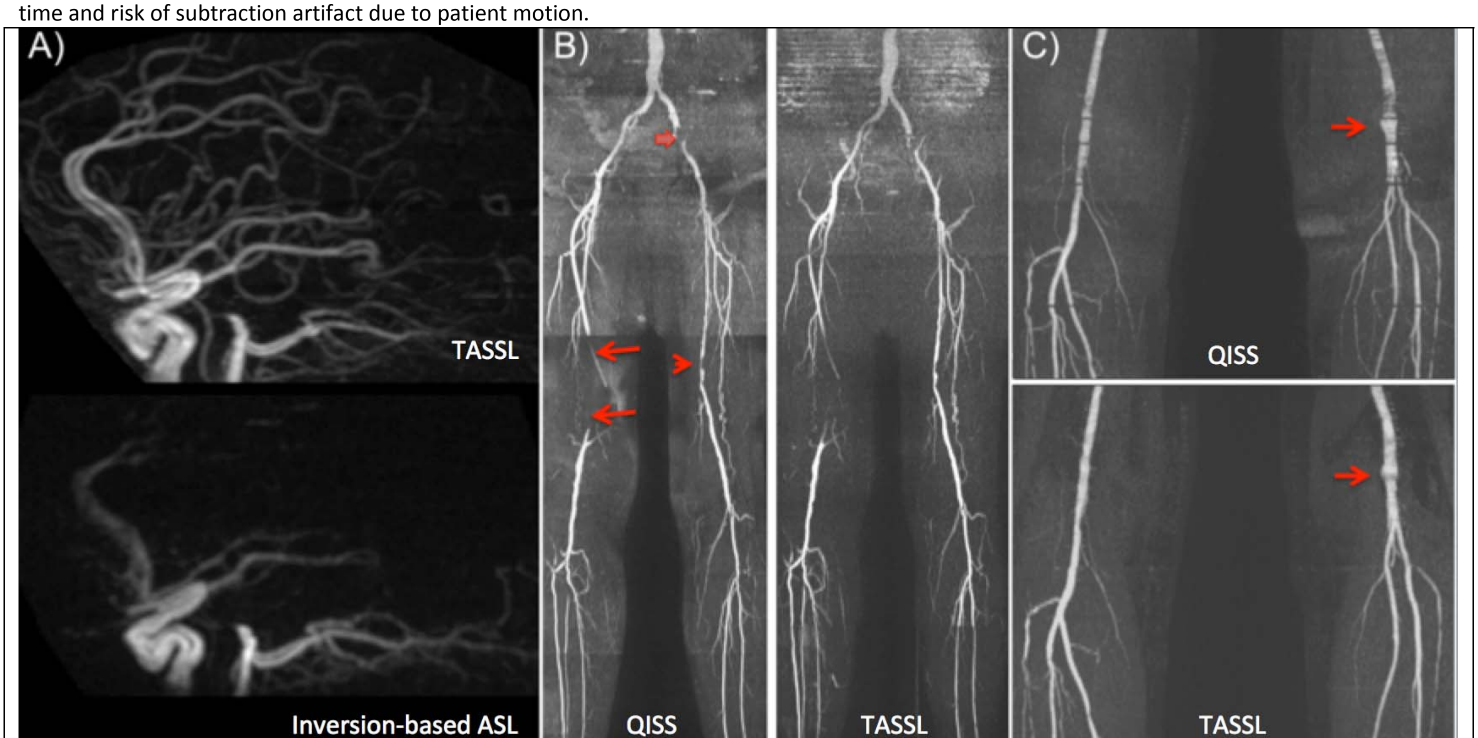

Fig. 1. A) Healthy subject. TASSL MRA (top) shows improved small vessel details compared with pseudo-continuous inversion-based ASL MRA (bottom). B) Patient with PAD. QISS (left) and TASSL (right) show the occluded right superficial femoral artery (arrows), and stenoses of the left external iliac (open arrow) and superficial femoral (arrowhead) arteries. C) Patient with left popliteal aneurysm (arrow). ECG-gated QISS MRA was degraded by poor gating due to atrial fibrillation. However, the ungated TASSL MRA was unaffected by the arrhythmia.

Conclusion: TASSL is a promising ungated, saturation-based ASL approach for nonenhanced MRA. It can be used to acquire intracranial MRA with near-perfect background suppression, and can be used for ungated nonenhanced MRA of the peripheral arteries. Further work will be required to determine advantages and drawbacks compared with existing techniques.

Reference: 1. Thomas D, et al. Methods Mol Biol. 2011; 711:327-45. 2. Wong EC, et al. NMR Biomed. 1997; 10(4-5):237-49.