TIME-RESOLVED ARTERY-SELECTIVE ANGIOGRAPHY BASED ON SUPER-SELECTIVE ARTERIAL SPIN LABELING

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Introduction

Selective visualization of the intracranial arteries is an important differential diagnostic tool in neuroradiology. Digital Subtraction Angiography (DSA) is considered as the gold standard to obtain this information. However, this method relies on catheterization, contrast agent injection, and X-Ray application. Non-contrast enhanced MRI methods are used widely to obtain images of the cerebral vasculature, but often without the possibility to selectively visualize an artery. In recent years, arterial spin labeling (ASL) methods were optimized to perform artery selective imaging for either brain perfusion or angiography [1,2]. In this study, a different readout approach for selective, non-contrast enhanced angiography using ASL MRI is presented.

Materials and Methods

In ASL, it is possible to alter the magnetic state of the inflowing blood spins, which changes their contrast with respect to the static tissue. The subtraction of two datasets, one with and one without inversion of the inflowing blood spins, respectively, results in angiographic images, similar to the gold standard DSA. Furthermore, a recently developed method named super-selective ASL allows for tagging of individual intracranial arteries, which is not limited to the major arteries (ACI, BA), but also allows tagging of smaller intracranial vessels [3].
Time-resolved imaging is achieved by increasing the delay time between tagging and readout. To keep the acquisition time at a clinically acceptable duration, keyhole imaging is proposed. The keyhole factor as well as the acquisition flip angle were optimized in simulations with respect to image quality and total scan time. These optimized parameters were subsequently used for image acquisition in six healthy volunteers. Scanning was performed on a 3T Philips Achieva MRI scanner with the following sequence parameters: 400ms labeling duration, 50-550ms post labeling delay in 100ms increments, 3D T1-TFE readout with a FoV of 210x210 mm^2,110 slices, Voxel size: 0.9x0.9x0.9 mm^3, 25° flip-angle, 50% keyhole factor, resulting in 5 min scan time.

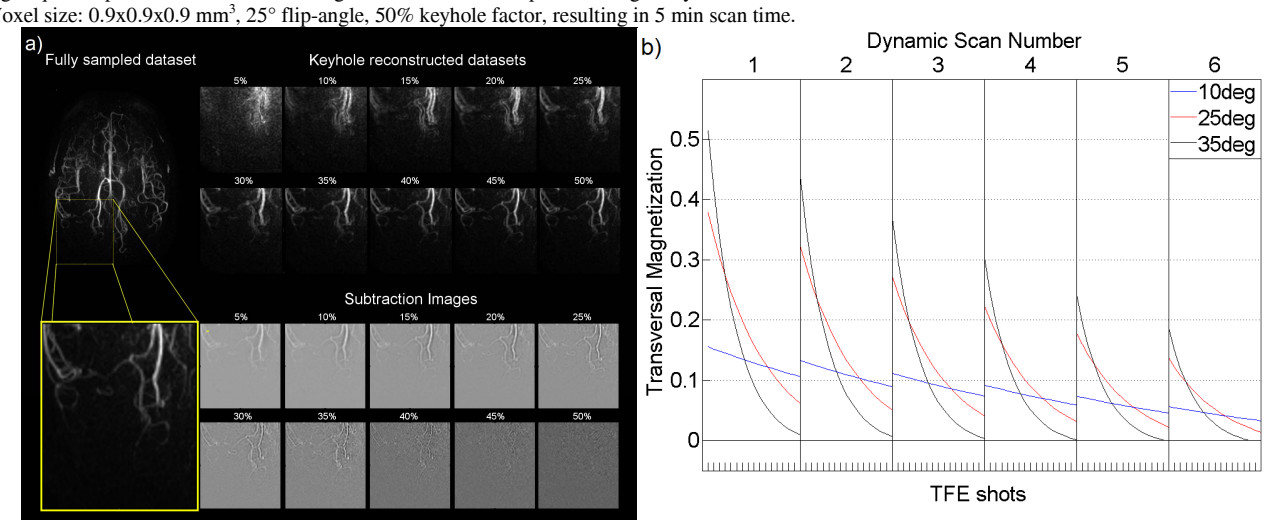

Fig. 1a: Retrospective k-space filtering of the full dataset with a total scan duration of 30 minutes. Increasing contribution from the central k-space frequencies increases the image quality with respect to blurring. At 50% no differences between the undersampled and the full dataset could be observed. This finding was verified in subtraction images and in a semi-quantitative blurring analysis (data not shown). b: Signal evolution during readout for three generic flip angles at 6 different post labeling delays (i.e. Dynamic Scans). A flip angle of 25° resulted in the best compromise between obtainable signal and signal loss (RF spoiling).

Results and Discussion

Retrospective analysis of a fully sampled dataset demonstrates that a keyhole factor of 50% provides sufficient image quality (Fig. 1a). The flip angle optimization resulted in an optimal value of 25° for this setting, compromising between obtainable signal and signal loss caused by RF spoiling (Fig. 1b).
In all volunteers, selective angiograms could be obtained in all three major arteries (ACIs, BA) with an isotropic resolution of less than 1mm. Fig. 2 a-c shows the individual arteries. The resulting images were combined into a color-encoded frame to provide a holistic picture of the cerebral vasculature (Fig. 2d). Future work should be directed towards tagging of smaller intracranial arteries, especially for the selective evaluation of AVM feeding arteries.

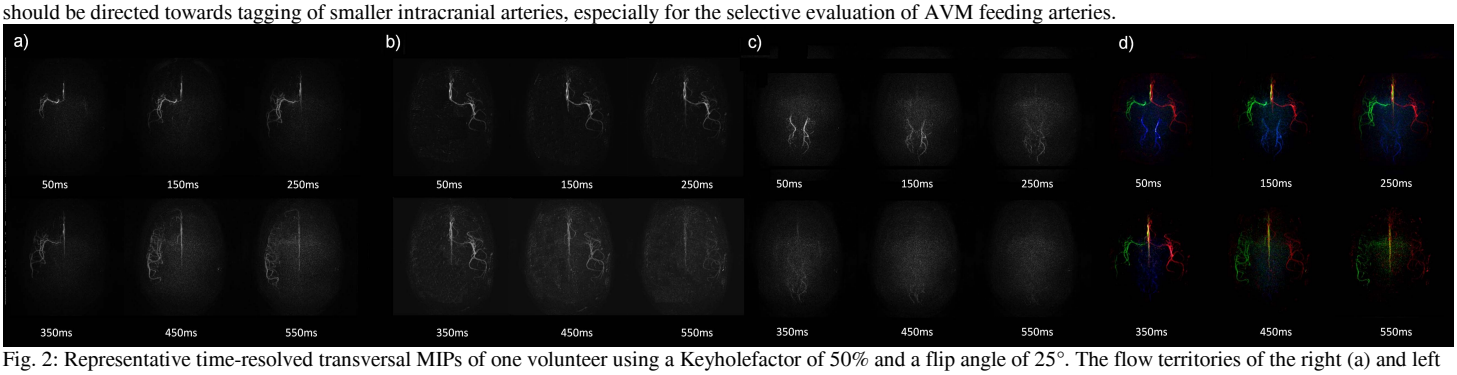

Fig. 2: Representative time-resolved transversal MIPs of one volunteer using a Keyholefactor of 50% and a flip angle of 25°. The flow territories of the right (a) and left (b) ICA, as well as the posterior circulation (c) can be individually visualized. Color-encoding (d) gives a holistic picture of the whole cerebral arterial status.

Conclusion

Super-selective ASL combined with keyhole scanning allows for time-resolved, artery selective acquisition of the cerebral arteries in a clinically acceptable scan time of 5 minutes.

References

[1] Helle et al Proc. ISMRM 2011: 650 [2] Nakamura et al Radiol Phys Technol 2013, 6: 327-34 [3] Helle et al Magn Reson Med 2010, 64: 777-86