# Optimized Fast Simultaneous Non-contrast Angiography and intraPlaque hemorrhage (fSNAP) imaging for intracranial arteries

Jia Ning[1], Shuo Chen[1], Jinnan Wang[2,3], Xihai Zhao[1], Chun Yuan[1,2], and Huijun Chen[1]

[1]*Center for Biomedical Imaging Research & Department of Biomedical Engineering, Tsinghua University, Beijing, China,* [2]*Department of radiology, University of Washington, Seattle, WA, United States,* [3]*Philips Research North America, United States*

**Target audience:** Clinicians and MR physicists

**Introduction:** Simultaneous Non-contrast Angiography and intraPlaque hemorrhage (SNAP) imaging has been proposed to image the stenosis of artery and intraplaque hemorrahge (IPH) lesions in the atherosclerotic plaques in one scan [1]. It was originally developed for carotid artery imaging and later on successfully applied on intracranial arteries [2]. However, the scan time of SNAP is long because SNAP consist a TFE based reference (REF) acquisition for phase sensitive reconstruction. Recently, fast SNAP (fSNAP) sequence which acquires low-resolution REF in a separate scan is proposed in carotid artery, but need complicated phase correction due to the background phased difference caused by separated scan [3]. In this study, an optimized fSNAP containing high-resolution inversion recovery (IR) acquisition and low-resolution REF acquisition in the same scan was proposed and tested in intracranial arteries.

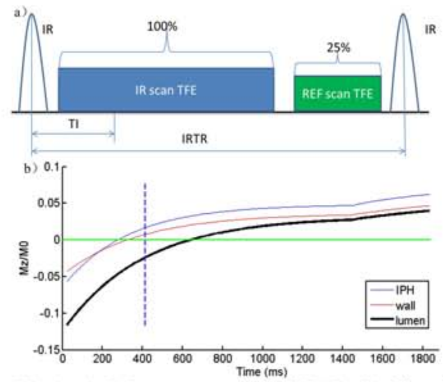


**Fig.1**: a) Pulse sequence of fSNAP; b) Signal recovery curves of three main components. The blue dash line indicates the optimal TI.

**Method:**

*Theory:* The sequence of optimized fSNAP is shown in Fig. 1(a). After one inversion pulse, a TFE based high-resolution IR acquisition and a low-resolution REF acquisition is performed sequentially. Within one repetition time of IR (IRTR), the low-resolution REF scan should have the same background phase which can be simply used in phase sensitive reconstruction without any correction. Also, the k-space filling order of IR scan is arbitrary, allowing flexible inversion time (TI). The aim of the optimization was to select proper TI and FA to maximize the cost function:

$$\xi = \left|C_{IPH-wall} \times \left|S_{blood}\right|\right| / \left|C_{IPH-wall} - \left|S_{blood}\right|\right|$$

Where $C_{IPH\text{-}wall}$ is the contrast between IPH and wall, and $S_{blood}$ is blood signal [1].

*Image acquisition:* Seven healthy volunteers (6 males, mean age 23 years) and one patient (male, 53 years) with stenosis were recruited in this study after obtaining their informed consents. All scans were conducted on a 3T whole body scanner (Achieva TX, Philips Medical System, Best, The Netherlands) with a custom-designed 36-channel neurovascular coil. SNAP and the optimized fSNAP shared these parameters: 3D scan mode, TR/TE 10/5.5ms, IR scan flip angle 11º, REF scan flip angel 5º, FOV 160×160×50mm³, acquired voxel size 1×1×1mm³, interpolated to 0.5×0.5×0.5mm³, NSA 1, flow compensation on. For SNAP, TI: 500ms, IRTR: 1970ms. For optimized fSNAP, the optimized parameters were TI: 414ms, IRTR: 1800ms, R/I ratio: 25%. The signal recovery curve of blood, IPH and wall are showed in Fig. 1(b). At the time point of TI, the best contrast is obtained with negative blood signal and positive signal of other tissue. Reconstructions were performed online.

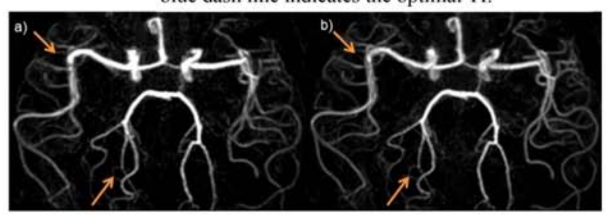


**Fig.1**: MRA of one healthy volunteer comparison between a) optimized fSNAP b) SNAP. arrows point the small branches.

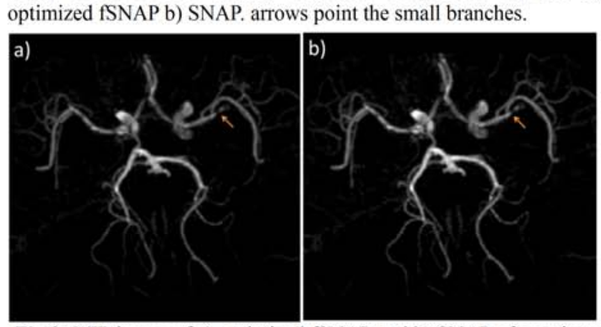


**Fig.3:** MIP image of a) optimized fSNAP and b) SNAP of a patient. Arrows indicate the stenosis.

*Image analysis:* MRA were generated for SNAP and optimized fSNAP by inverting the signal intensity and then performing maximal intensity projection (MIP). The contrast to noise ratio (CNR) of optimized fSNAP and SNAP is calculated as $\left|mean(S_{blood}) - mean(S_{tissue})\right| / std(S_{background})$, where $S_{blood}$, $S_{tissue}$ and $S_{background}$ are the signal of blood, brain tissue (areas inside the brain and outside the lumen), and background (areas outside the brain), respectively. Paired t test was conducted to check if there was significant difference of CNR between optimized fSNAP and SNAP.

**Results:** The optimized fSNAP MRA shows similar quality to SNPA MRA, showing the fine detail of small branches of intracranial arteries (Fig.2). As shown in Fig.4, there is no significant difference between the CNR of optimized fSNAP and SNAP (p=0.97). In terms of detecting stenosis, the optimized fSNAP performs as excellent as SNAP (Fig.3). The scan time of the optimized fSNAP (100s) is 37.5% less than that of the original SNAP (160s).

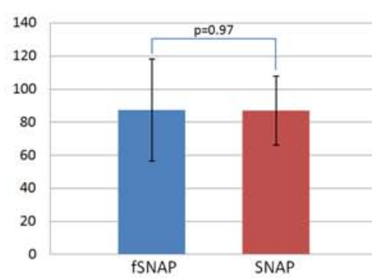


**Fig.4**: CNR comparison between optimized fSNAP and SNAP; the mean and SD were shown as column and bar, the p value of paired t test was shown.

**Discussion and conclusion:** In this study, an optimized fSNAP is proposed for intracranial arteries imaging. The proposed optimized fSNAP can provide similar contrast for MRA with much shorter scan time (saving 37.5% time) than traditional SNAP. Although further validation in patients is still needed, the optimization scheme provides a great opportunity for optimized fSNAP to detect intraplaque hemorrhage/thrombosis in intracranial arteries. Moreover, arbitrary k-space filling technique allows more flexible contrast adjustment than traditional SNAP and it can be further optimized for various applications, such as other vascular beds.

**Reference:**

[1] Wang J et al. MRM 2013; 69:337-345; [2] Wang J et al. MRA club 2013; 121; [3] Chen H. ISMRM 2012; 1163.