High-Resolution 7.0 Tesla Post-Contrast Time-Of-Flight MRA of Intracranial Perforators

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Introduction: Intracranial perforating arteries are crucial for the perfusion of the deep gray matter structures of the brain. Due to the size of these small arteries (up to 0.8mm in diameter)[1], a high spatial resolution will be necessary for clear visualization of these vessels. Some of these small perforating arteries have already been visualized using 3 Tesla (T) MRI[2,3]. Ultrahigh-field MRI, like 7T, has the advantage of an increased signal-to-noise ratio (SNR) as compared to 3T MRI, enabling a higher spatial resolution without a significant increase in scan time. In previous reports, 7T MRI has been shown to be capable of visualizing the lenticulostriate arteries[1,4,5], the thalamoperforating artery[1], and the pontine arteries[6]. These previous studies were performed using Time-Of-Flight (TOF) MR angiography (MRA) techniques without contrast administration. A contrast agent might enable visualization of arteries with a cranial-caudal flow direction, which is technically challenging using TOF-MRA. We hypothesize that more and smaller arterial perforators from the main intracranial arteries can be visualized with high-resolution post-contrast 7T TOF-MRA. Therefore, in this study we evaluated high resolution 7T post-contrast TOF MRA of intracranial perforators in patients with cerebrovascular disease.

Materials and Methods: This retrospective study was approved by the Institutional Review Board of our institution. All patients gave written informed consent. Imaging was performed on a 7T whole body system (Philips Healthcare, Cleveland, OH, USA) with a 32-channel receive coil and volume transmit/receive coil for transmission (Nova Medical, Wilmington, MA, USA). A patient-specific clinical imaging protocol was obtained for all patients at 7T, consisting of at least a high-resolution TOF-MRA sequence, and a high-resolution Fluid-Attenuated Inversion Recovery (FLAIR) sequence. Before acquisition of the TOF-MRA sequence, 0.1mL/kg of a gadolinium-containing contrast agent (Gadobutrol, Gadovist 1.0mmol/mL, Bayer Schering Pharma, Newbury, UK) was administered. The following scan parameters were used: TOF-MRA sequence, Field-of-view (FOV) 200x190x50mm^3, acquired resolution 0.25x0.3x0.4mm^3, repetition time (TR) 15ms, echo time (TE) 3.4ms, scan duration approximately 9min; FLAIR sequence, FOV 250x250x190mm^3, acquired resolution 0.8x0.8x0.8mm^3, TR/TE/TI 8000/300/2250ms, scan duration approximately 13min. Two patients with suspected cerebral vasculitis and one with suspected Reversible Cerebral Vasoconstriction Syndrome (RCVS) were imaged with this protocol for clinical purposes.

Results: Imaging was successful in all three patients, with little motion artifacts. The following small intracranial perforating arteries were visible on the post-contrast TOF-MRA images in at least one of the patients: (i) the thalamoperforating artery arising from the posterior communicating artery (Figure 1), (ii) the recurrent artery of Heubner arising from the anterior cerebral artery (Figure 2a), (iii) the artery of Percheron arising from the P1 segment of the posterior cerebral artery (Figure 2b), (iv) the intracranial arteries supplying the anterior spinal artery (Figure 2c), (v) the pontine arteries arising from the basilar artery (Figure 2d), and (vi) the lenticulostriate arteries arising from the middle cerebral artery (Figure 3). The visualization of these small perforating arteries was enhanced due to the contrast administration. Especially, a better visualization of craniocaudally oriented arteries like the anterior spinal artery and its feeders was accomplished. On the other hand, the differentiation between small arteries and small veins was sometimes more difficult due to the contrast agent, as can be seen in Figure 2c, d.

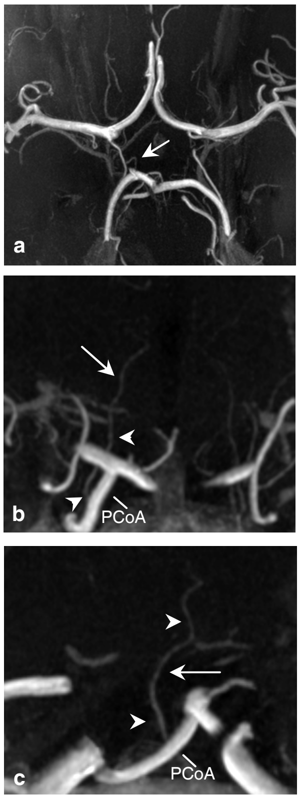

*Figure 1 -see above- 7T post-contrast TOF-MRA, slab Maximum Intensity Projection of the thalamoperforating artery (white arrow(head) **a-c**), arising from the posterior communicating artery (PCoA) viewed from different orientations:(**a**) transverse (thickness 10mm), (**b**) coronal (thickness 10mm), and (**c**) sagittal (thickness 6mm).*

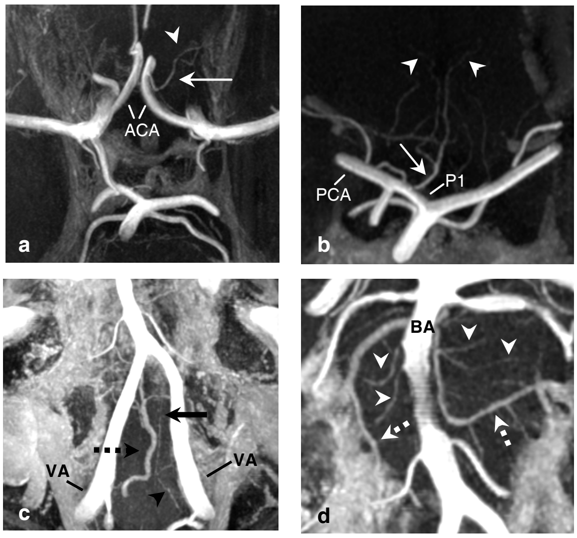

*Figure 2. 7T post-contrast TOF-MRA of (**a**) the recurrent artery of Heubner (white arrow(head), transverse slab Maximum Intensity Projection (MIP), thickness 10mm).(**b**) the artery of Percheron (white arrow(head), coronal slab MIP, thickness 10mm),(**c**) the intracranial feeders of the anterior spinal artery (black arrow(head)) with an adjacent vein (dashed black arrow, transverse slab MIP angulated anterior-posterior in line with the basilar artery, thickness 10mm), and (**d**) the pontine arteries (white arrow(head)) with an adjacent vein (dashed white arrow, transverse slab MIP angulated anterior-posterior in line with the basilar artery (BA), thickness 5mm). ACA: Anterior Cerebral Artery; PCA: Posterior Cerebral Artery; VA: Vertebral Artery*

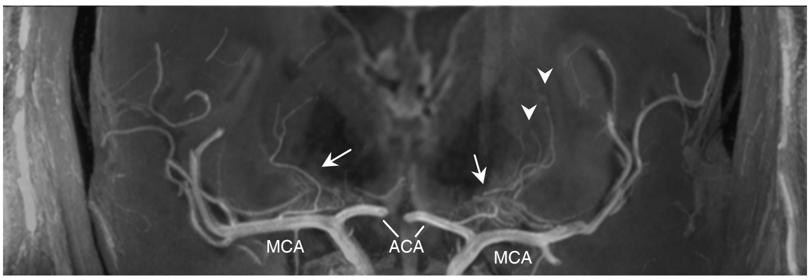

***Figure 3.** Fusion image of the 7T post-contrast TOF-MRA (coronal slab Maximum Intensity Projection image, thickness 10 mm) with the corresponding 7T FLAIR image showing the lenticulostriate arteries (white arrow(head)). ACA: Anterior Cerebral Artery; MCA: Middle Cerebral Artery*

Conclusion: In conclusion, post-contrast TOF-MRA at 7T has the ability to show multiple perforators including the recurrent artery of Heubner, thalamoperforating artery, pontine arteries, the artery of Percheron, the lenticulostriate arteries and the feeders of the intracranial anterior spinal artery. Due to the high spatial resolution in all three anatomical planes, reconstructions were possible without losing spatial resolution, as was shown for the thalamoperforating artery. Also, the feeders of the intracranial anterior spinal artery, which originate from the distal vertebral arteries and have cranial-caudal flow direction, could be visualized for the first time on the post-contrast 7T TOF-MRA. The presented sequence may therefore have additional diagnostic value in the clinical evaluation of patients suspected of pathology of the small (perforating) arteries.

References: *[1]Conijn M, et al. Eur Radiol 2009; [2]Chen YC, et al.Am J Neuroradiol 2011; [3]Itabashi R, et al.Clin Neurol Neurosurg 2012; [4]Kang CK, et al. Magn Reson Med 2009; [5]Cho ZH, et al. Stroke 2008; [6]Kang CK, et al. J Magn Reson Imaging 2010*