Imaging of lenticulostriate arteries at 7 Tesla

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Introduction Lenticulostriate arteries (LSAs), also called deep perforating arteries, are associated with lacunar infarctions [1]. These arteries have small diameters ranging from approximately 0.3 to 0.7 mm and are, therefore, difficult to image. Digital subtraction angiography (DSA) is capable of imaging these vessels [2], but this method is invasive, while the contrast between vessels and background is limited and, using biplane DSA, the origins of the LSAs are difficult to assess due to overprojection of other arteries. 3D time-of-flight (TOF) magnetic resonance angiography (MRA) would be capable to resolve superimposed lenticulostriate arteries, but even at 3 Tesla, these small arteries are difficult to image with the TOF technique. The purpose of this work is to explore the possibilities of 3D-TOF (without contrast agent) at 7 Tesla to image the small LSAs.

Methods Imaging was performed on healthy subjects on a 7 Tesla whole body system (Philips Medical Systems, Cleveland, USA), equipped with a volume transmit and 16 channel receive head coil (Nova Medical, Inc.). A standard angiogram (turbo field echo) was performed to locate the circle of Willis from which the LSAs originate. A turbo field echo sequence was planned in a coronal plane to include the middle cerebral arteries and first segment (A1) of the anterior cerebral artery. The slab was tilted by approximately 45 degrees, to avoid saturation of the blood in the internal carotid arteries (red area in Figure 1). Imaging parameters are: FOV 110x110x28 mm^3, acquired voxel size 130x260x800 µm, flip angle 25°, TR 23 ms, TE 5 ms. A rest slab (blue shaded area in Figure 1), suppressing the venous blood at the anterior part of the brain, was applied once per 10 excitation pulses. The scan duration was approximately 10 min.

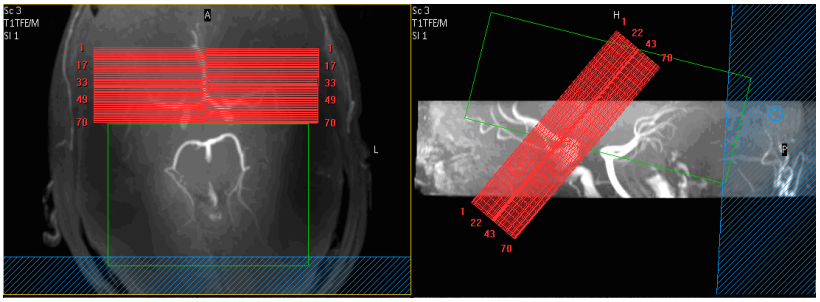

Fig. 1. Planning of the slab for the high-resolution time-of-flight sequence.

Results A maximum intensity projection (MIP) of the total imaging volume clearly shows the multiple LSA branches originating from the middle cerebral artery and these perforating arteries can be followed over a long distance (Figure 2). In the detail image (right panel of Figure 2), we show a thinner section MIP, which specifically shows the origin of a perforating artery from the A1 segment of the right anterior cerebral artery and then running parallel to the middle cerebral artery, which is consistent with the anatomical location of the recurrent artery of Heubner.

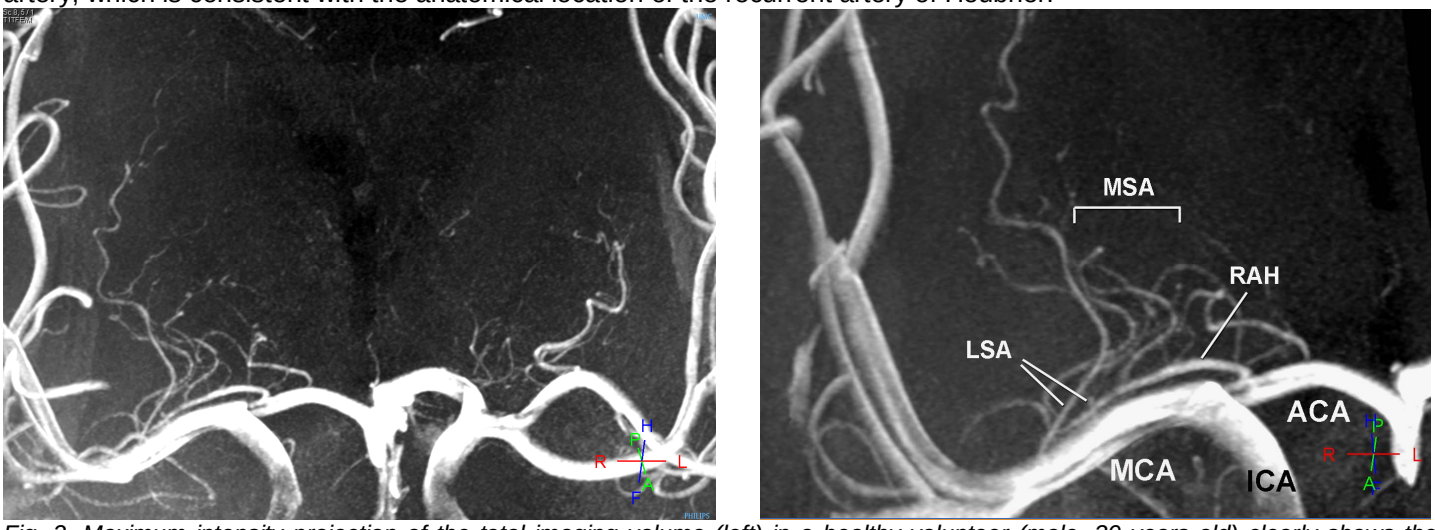

Fig. 2. Maximum intensity projection of the total imaging volume (left) in a healthy volunteer (male, 30 years old) clearly shows the lenticulostriate branches of the middle cerebral artery and anterior cerebral arteries. A detail image of a thinner MIP volume is shown on the right. MCA: middle cerebral artery, ICA: internal carotid artery, ACA: anterior carotid artery, LSA: lateral striate arteries, MSA: medial striate arteries, RAH: recurrent artery of Heubner.

Discussion and conclusion These results show that it is possible to visualize the lenticulostriate arteries with MRI at 7 Tesla, using a straightforward time-of-flight sequence and optimized planning to maximize the inflow effect and decrease the saturation of the blood in the distal internal carotid artery. These saturation effects decrease the visibility of the LSAs with a normal transversal imaging volume. Since MRI does not impose radiation dose to the subject, this method will allow to study the anatomy of these small vessels in healthy subjects, and also allows for follow up imaging in patients with known cerebrovascular disease and might thus contribute to the understanding of the origin of lacunar infarctions.

[1] Marinković S, et al. Clinical anatomy 2001;14:190-195. [2] Kang HS, et al. AJNR Am J Neuroradiol 2005;26:306-312.