Ultrahigh Field (>7T) Time-of-Flight and Phase Contrast Magnetic Resonance Angiography of the Intracerebral Arteries

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Purpose: While contrast enhanced Magnetic Resonance Angiography has become the gold standard in the evaluation of most vascular disease processes, it still has some drawbacks in the evaluation of the cerebral vasculature. First of all, the fast recirculation time leads to marked venous signal in the images if the contrast bolus is not precisely timed with the acquisition. Second, even though MR contrast agents are safe, side effects are not excluded. And third, repeatability of the exam is complicated due to the need for repeated contrast injections and signal overlap due to earlier injections. As a result, non-invasive methods like time of flight (TOF) and phase contrast (PC) MRA have still clinical value[1,2]. The implementation of high and ultrahigh field MRI systems reinvigorated these techniques due to the promise of higher signal to noise ratio and higher resolution. Therefore, the purpose of this study was to evaluate the feasibility of TOF and PC MR Angiography of the cerebral arteries in a whole body 7T MR scanner and to compare the results with clinical MR systems at 1.5T and 3T.

Material and Methods: PC and TOF MRAs were acquired in a 7T MR scanner (Achieva, Philips) and in clinical 3T (Achieva, Philips) and 1.5T (Signa, GE) scanners using birdcage head coils. 3D PC (TR:8-15ms; TE:3-4ms; FA:12-20°; FoV: 240mm; Matrix:512x384; averages:1) and 3D TOF (TR:15-25ms; TE:3-4ms; FA:18-20°; FoV:240mm; Matrix:512x384; averages:1) sequences with a slice thickness of 0.75mm were acquired in the axial plane covering the vascular anatomy of the circle of Willis and above. PC and TOF images were acquired in similar acquisition times of about 5 minutes. The depiction of distal branches of the middle, posterior and anterior cerebral arteries was assessed.

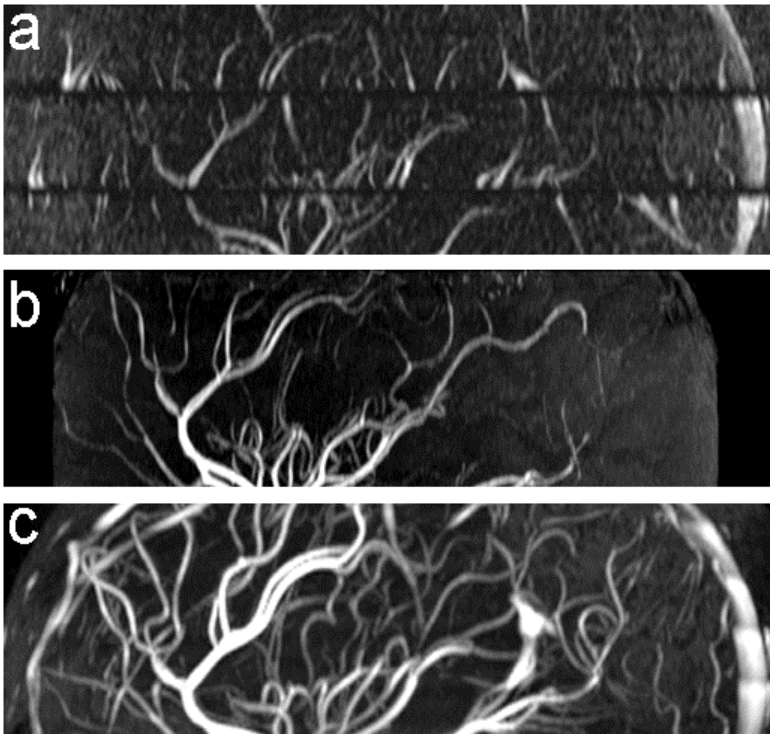

Figure 1: MIPs of 3D TOF MRAs of a 23 year old, female volunteer at 1.5T (a), 3T (b) and 7T (c). Axial images were acquired with a slice thickness of 0.75mm and similar acquisition parameters at all field strengths (TR:15-25ms; TE:3- 4ms; FA:18-20°; FoV:240mm; Matrix:512x384; averages:1). Acquisition times were about 5 minutes at all field strengths. Signal to noise ratio in the three images are 11.3 (1.5T), 52.9 (3T) and 103.9 (7T).

Results: Both methods demonstrated the same small arterial branches superior to the circle of Willis. Besides the first order branches, e. g.frontopolar a., callosomarginal a. and pericallosal a., also second and third order branches, paracentral a. and medial frontal branches, were seen. The PCMRAs exhibited a better background suppresion compared to the TOF sequences. In comparison to clinical 1.5T/3T images, unenhanced MRA of the brain at 7T provides superior vessel contrast and conspicuity. Ultrahigh field MRAs demonstrate higher order branches with smaller calibers than conventional MRAs.

Conclusions: This study demonstrates the feasibility of both TOF and PCMRA of the brain in a whole body 7T MR scanner with improved arterial contrast and vessel conspicuity compared to lower clinical field strengths. The need for contrast enhanced MRA of the cerebral vasculature may be eliminated in ultrahigh field systems. TOF and PC MRA at ultrahigh field allow to depict third order branches of the circle of Willis in a reasonable amount of time (about 5minutes) with sufficient spatial and contrast resolution.

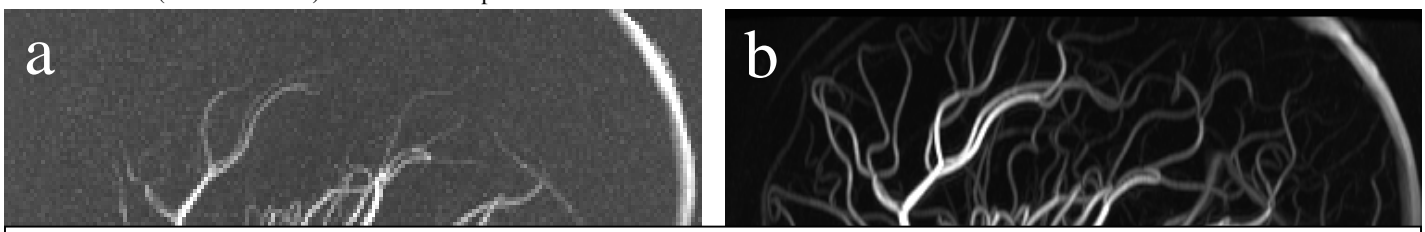

Figure 2: MIPs of 1.5T (a) and 7T (b) PC MRA of the vasculature superior to the circle of Willis of a 39 year old, male volunteer. The acquisitions times for both sequences were about 5 minutes. Axial images were acquired with slices thickness of 0.75 mm. The 7T images depict third order branches of the circle of Willis, e.g. the paracentral artery.

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References:

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