Multisequence Whole-Brain Intracranial Vessel Wall Imaging at 7.0 Tesla MRI

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Introduction

For imaging of intracranial arterial pathology, visualization of the lumen is not enough due to arterial remodeling. Therefore, an imaging method directly depicting the arterial vessel wall is of great value. It was previously shown that imaging of healthy and diseased intracranial vessel wall at 7.0 Tesla (7T) MRI is possible with the 3D $T_1$-weighted MIPR-TSE sequence, with high resolution and sufficient contrast. However, due to its limited coverage (13mm), more extensive assessment of the whole cerebral arterial tree is not possible. Furthermore, a multisequence MRI protocol, including – besides $T_1$-weighting – proton density (PD)- and $T_2$-weighting, may better characterize vessel wall pathology. The aim of this study was to develop a multisequence high-resolution intracranial vessel wall protocol with whole-brain coverage.

Methods

This study was approved by the institutional review board of our institution; all subjects 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 modified MIPR-TSE sequence with non-selective short RF pulses and SENSE in two directions was used to obtain a sequence with whole-brain coverage (Figure 1). The parameters were adapted to obtain the three different contrast weightings (Table 1). All sequences had the same variable refocusing flip angle scheme, with low refocusing angles ranging between 12° and 40°, optimized to yield a constant signal response for tissue with a $T_1/T_2$ of 2000/55ms for at least half the train length. This allows a long readout with limited blurring. Five healthy volunteers (mean age 26 years, range 22-34 years) were scanned with both the limited-coverage MIPR-TSE sequence, and the three whole-brain sequences. For two patients who were scanned for clinical purposes, individually relevant vessel wall sequences were performed. Three observers independently compared conspicuity and image contrast of all four vessel wall sequences in the healthy volunteers. Furthermore, in all scans, multiple signal profiles of a predefined area including vessel wall and background were used to calculate mean highest (vessel wall) and lowest (background signal) signals calculated. The ratio of vessel wall and background signal was used as a measure of image contrast / vessel wall conspicuousness.

Results

Whole-brain coverage for the PD-, $T_1$- and $T_2$-weighted vessel wall sequences was successfully obtained in all subjects. Vessel walls of the large vessels of the Circle of Willis, as well as their smaller branches were clearly visible in all whole-brain scans. All three whole-brain sequences had similar ratings regarding visibility of the vessel wall, artifacts and overall image quality, though slightly less than the limited-coverage MIPR-TSE sequence, which was judged to give the best conspicuity of the vessel walls in most cases. The signal ratios for all three whole-brain sequences were similar, with approximately a factor of two more signal in the vessel walls compared to their surroundings. For the limited-coverage scan, this signal ratio between vessel wall and surroundings was 2.6. For the two patients both the whole-brain-coverage MIPR-TSE sequences and the limited-coverage sequence gave similar diagnostic information. In the vasculitis patient (Figure 2), enhancing small arterial branches were found, that could not be appreciated on the limited-coverage MIPR-TSE sequence.

![Figure 1.](image1.png) Comparison of coverage between the limited-coverage MIPR-TSE sequence (a) and the whole-brain MIPR-TSE sequence (b). On both sequences, vessel wall of the distal internal carotid artery (ICA) can be observed (arrows in a and b), more clearly illustrated on the zoomed-in images (arrows in c and d). Note that the vessel lies at the inferior border of the field of view (FOV) of the limited-coverage sequence (a), which illustrates the sensitivity of this sequence to malpositioning of the FOV or patient motion between the scan at which FOV planning is performed and the actual vessel wall sequence.

![Figure 2.](image2.png) 7.0 Tesla limited-coverage 3D MIPR-TSE (a), and whole-brain $T_1$-weighted MIPR-TSE images before (b) and after (c-h) contrast administration of patient with vasculitis. Diffuse thickening of all intracranial vessel walls, like the MCA (dashed white arrow in a-h, can be seen. After contrast administration, there is diffuse enhancement of most of the intracranial arteries (white and black arrows in c-g).