

Carotid Plaque Imaging with an Eight-Channel Transmit/Receive RF Array at 7 Tesla: First Results in Patients with Atherosclerosis.

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Introduction: Atherosclerosis is one leading cause of morbidity and mortality worldwide. For optimal risk stratification measurement solely of the luminal stenosis might not be sufficient. Dedicated MR plaque imaging allows accurate characterization and quantification of intraplaque components to identify high-risk patients^{1,2}. 3T MRI, with its ability to increase spatial resolution, has already improved plaque imaging compared to 1.5T MRI³. A dedicated eight-channel transmit/receive RF array for carotid imaging at 7T has been developed and previously presented⁴. In the present study, we implemented and adapted a plaque imaging protocol from 1.5 to 7 Tesla and evaluated plaque imaging with the 7T carotid RF coil in healthy volunteers as well as patients with clinically relevant atherosclerosis of the carotid bifurcation.

Methods: Two healthy volunteers and three patients with hemodynamically relevant atherosclerotic plaques of the carotid bifurcation were investigated after giving informed consent. An eight-channel (2x4 channels) transmit/receive RF surface array was used as presented previously⁴. Measurements were performed on a whole-body 7 Tesla MR scanner (Siemens Magnetom 7T). Images were obtained with a T1-weighted 3D spoiled gradient echo sequence (FLASH-3D; TR/TE = 5.5/1.8 ms, 15° flip angle, resolution 0.75 mm isotropic, GRAPPA factor 2, TA = 3:11 min.) for high-resolution non-contrast-enhanced MR angiography. Additionally, a pulse-triggered PD- and T2-weighted turbo spin echo (TSE; TR = 550 ms, TE = 27/81 ms, 150° flip angle, resolution 0.4 x 0.4 x 2 mm³, GRAPPA factor 2, TA = 1 min.) sequence was used for detailed classification of the vessel wall and lumen. No iv contrast material was administered. Total measurement time per volunteer was between 20-30 min. including all adjustments and repetitions.

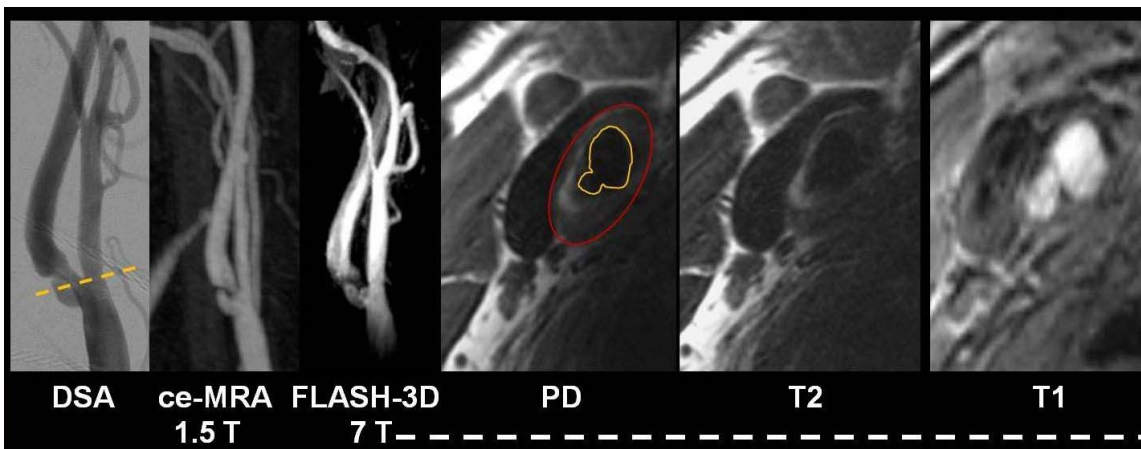


Figure 1: Angiography and plaque imaging of an ulcerated plaque of the internal carotid artery: Maximum intensity projection (MIP) reconstructions of a FLASH-3D sequence at 7 Tesla and a contrast-enhanced MR-angiography at 1.5 Tesla, both compared to DSA reference of the same patient (dotted line indicates axial slice orientation). Axial PD-, T2- and T1-weighted (corresponding axial MPR of T1w-FLASH-3D) images demonstrating the carotid artery outline (red) and inner vessel lumen (yellow), interposed with the different signals of various plaque components.

Results: In patients as well as healthy volunteers the images revealed good RF signal excitation of both sides and a high vessel-to-background image contrast for the non-contrast-enhanced FLASH-3D high-resolution MR angiography (MRA) without need for administration of iv contrast material. Maximum-intensity-projections (MIPs) of these MRA were qualitatively comparable to contrast-enhanced MRA at lower field strengths (Figure 1). Even in the presence of severely calcified plaques, the perfused remnant vessel lumen was clearly visible and even different focal areas of calcifications could be distinguished. Although the signal intensity was lower for the pulse-triggered TSE compared to the FLASH-3D, regional vessel wall thickening, various intraplaque components as well as ulcerations of the plaque surface and flow voids were well visualized in all patients, although in our series, no histological correlation could be obtained (Figure 1).

Discussion: This initial study in human patients with relevant atherosclerosis of the carotid bifurcation demonstrates that the concept of plaque imaging can be transferred to 7 Tesla ultra-high-field MR imaging using a custom-built eight-channel transmit/receive RF array. Although typical plaque imaging techniques at lower field strengths such as dark blood sequences as well as inversion recovery preparation pulses could not be used due to SAR restrictions at 7T, the presented imaging protocol allows for high-resolution MR angiographic imaging as well as detailed plaque characterization in patients. Even in the presence of severely calcified carotid plaques, the differentiation of blood flow in the remnant vessel lumen as well as differentiation of distinct intraplaque components and surface ulcerations was possible without the administration of iv contrast material. This is of particular importance since especially patients with relevant atherosclerosis commonly have relative or absolute contraindications against the administration of gadolinium contrast material. Further and larger scale studies are needed to address the correlation between imaging findings and histology of plaque components at 7 Tesla and to demonstrate the impact on clinical treatment of atherosclerosis.

References:

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