Assessment of Carotid Atherosclerotic Disease Using 3D Fast Black Blood MR Imaging: Comparison with DSAØ

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Introduction: Currently, digital subtraction angiography (DSA) remains the current clinical standard for evaluating carotid atherosclerosis disease. Its known limitations include using ionizing radiation and being unable to visualize the vessel wall. Black-blood (BB) MR imaging techniques have been developed to accurately visualize and quantify both the lumen and the outer wall boundaries of large arteries.[1,2] By selectively suppressing the signals coming from the artery lumen, BB-MR imaging can better delineate the structure of the arterial wall. Recent developments in motion-sensitized dephasing preparations[3,4] have enabled 3D BB-MR image acquisition in arbitrary planes with robust blood suppression and large longitudinal coverage. Few studies in the literature have compared BB-MR imaging with the gold standard DSA in measuring carotid lumen stenosis.

Purpose: To determine the accuracy of 3D fast BB-MR imaging at quantifying carotid atherosclerosis disease compared to DSA.

Methods: Sixty-five carotid arteries from 52 patients (mean age 64.5 years, 43 males) with at least 50% stenosis identified by duplex ultrasound, underwent 3D BB-MR imaging and DSA within 3 days. Conventional intra-arterial DSA studies were performed using a trans-femoral artery approach and selective common carotid artery catheterization on a digital angiography unit (INNOVA 4100, GE, USA). 3D BB MR images were acquired using a whole body clinical scanner (Philips Achieva TX, Best, the Netherlands), a dedicated phased-array carotid coil and with the improved motion-sensitized driven-equilibrium (iMSDE)[4] prepared rapid gradient echo sequence (3D turbo field echo, TR/ TE 9.3/4.4 ms, flip angle 6°, FOV 250[FH] ×160[RL]×64[AP] mm^3, acquisition matrix 312×200×80, acquired resolution 0.8×0.8×0.8mm^3, Rec resolution 0.4×0.4×0.4mm^3, fat suppression selective partial inversion recovery [SPIR], acquisition time 2 minutes 42 seconds). Quantitative measurements including degree of stenosis according to the NASCET criteria, stenotic lesion length and the presence/absence of plaque ulceration were determined and compared between the two imaging techniques.

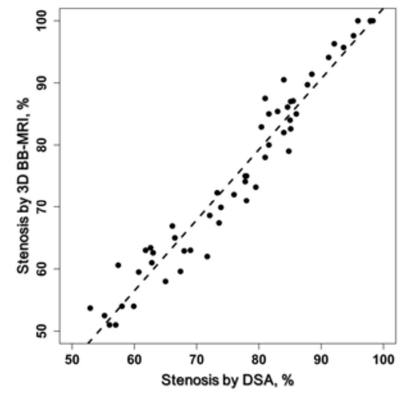

Fig 1. Stenosis by 3D BB-MRI versus DSA. The dashed line is the regression line.

Results: Very good agreement in measuring luminal stenosis was found between 3D BB-MR imaging and DSA (ICC 0.96; 95% CI: 0.93, 0.97) (Fig.1). The 3D BB-MR stenosis measurements were 1.26% smaller than DSA on average, with limits of agreement of ±7.66% (Fig.2A). 3D BB-MR imaging was also found to have high sensitivity (91.7%), specificity (96.2%) and agreement (Cohen's κ=0.85; 95% CI: 0.66, 0.99) with DSA for detection of ulcers. Good agreement was found between lesion length measured by 3D BB-MR imaging and DSA (ICC 0.75; 95% CI: 0.51, 0.84). However, stenotic lesion length measurements by 3D BB-MR imaging were on average 4 mm longer than those measured by DSA (P < 0.001) (Fig.2B).

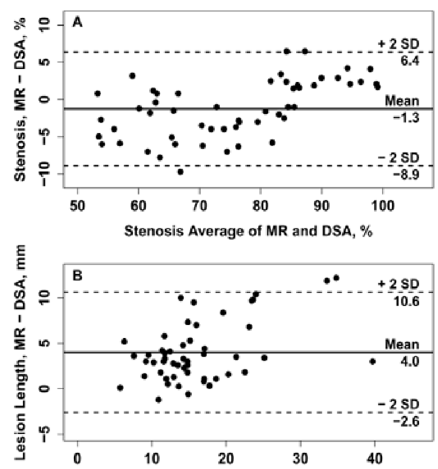

Fig 2. Bland-Altman plots of the difference in stenosis (A) and lesion length (B) measurements between 3D BB-MRI and DSA versus the means.

Discussion and conclusions: In the artery-by-artery analysis, compared with DSA, 3D BB-MRI successfully identified almost all carotid lesions in those with > 50% stenosis, with great similarity on morphology of the lesions and severity of stenosis (Fig.3, 4). With 3D BB-MR imaging, both the inner and outer wall of the artery is directly visualized, making it a potentially more accurate approach to visualize the distal extent of the plaque and more reliable measurement of the stenotic lesion length of the plaque compared to DSA. 3D BB-MR imaging was only found to over-identify ulceration on a small group of arteries when compared to DSA, which was presumably caused by the limited spatial resolution. In conlusion, this study shows the usefulness of 3D BB-MR imaging in noninvasive evaluation of the carotid artery stenosis measurements, lesion lengths and ulcer, using DSA as a reference. With fast acquisition and large coverage, 3D BB-MR imaging has the potential to become an alternative imaging approach in evaluating the severity of atherosclerosis.

References:

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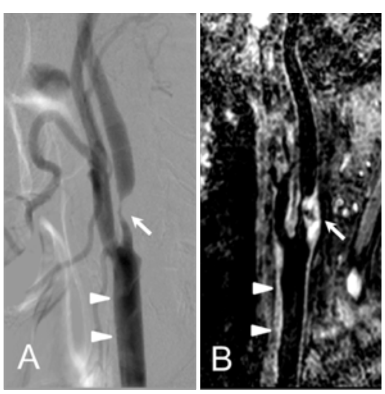

Fig. 3 Advanced atheroscleroitc disease caused severe internal carotid stenosis (arrow), detected on both the DSA (A) and 3D BB-MR imaging (B). The common carotid wall thickening (arrowheads) was visualized on the 3D BB-MR imaging (B) but presented as normal on DSA (A).

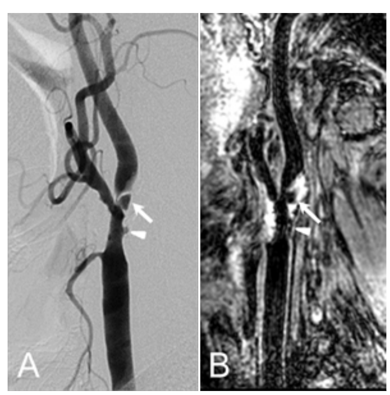

Fig. 4 The ulcers (arrow and arrowhead) of the carotid plaque surface at the bifurcation detected on both the DSA (A) and 3D BB-MR imaging (B).