

## Coronary Artery Plaque Visualization and Differentiation using contrast enhanced MRI

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**Purpose:** While coronary catheter angiography remains the gold standard for the detection of significant coronary artery stenoses, this luminographic technique fails to detect early-stage atherosclerotic changes and is not suitable to differentiate plaques according to their architecture and composition. Contrast enhanced magnetic resonance imaging has been shown to be useful for plaque visualization and characterization in aortic and carotid plaques (1,2), but has not been utilized in human coronary arteries so far. Therefore, the purpose of our study was to evaluate contrast enhanced black blood coronary MRI for selective visualization and non-invasive differentiation of atherosclerotic coronary plaque in humans.

**Material and Method:** Eight patients with coronary artery disease (CAD) as confirmed by previous x-ray angiography were studied. MR scans were performed on a 1.5 Tesla Scanner (Philips Medical Systems) with a 5-element cardiac coil. The MR protocol consisted of a ECG triggered, free-breathing navigator-gated 3D balanced Fast Field Echo (FFE) sequence for coronary luminography (voxel size 1x1x3mm, TR/TE 5.7/2.8ms, flip angle 110°) and a T1-weighted black blood inversion recovery (IR) sequences before (N-IR) and after administration of 0.3 mmol/kg Gd-DTPA (Magnevist®) (CE-IR) for plaque imaging. The inversion time of the IR sequences were calculated based on dose and timing after contrast injection (IR-N ca. 450 ms, IR-CE ca. 280 ms). Other scan parameters were: TR/TE 6.1/1.9ms, flip angle 30°.

Coronary CT-Angiography (16-slice multi-detector CT, Sensation 16, Siemens Medical Systems; scan parameters: detector collimation 16 x 0.75 mm, table feed 3.4 mm/rotation, rotation time 420 ms, tube current 370 mAs, tube voltage 120 kV) served as the standard of reference for the detection of coronary artery plaques. Plaques were categorized as calcified, non-calcified, and mixed based on their Hounsfield number derived from MDCT.

**Results:** With MDCT, a total of 27 plaques could be identified, 6 of whom were calcified (calcified nodules were not evaluated), 5 non-calcified and 16 mixed calcified/non-calcified. On N-IR MRI, 6/6 (100%) calcified plaques appeared dark, 3/5 (60%) non-calcified plaques were dark and the remaining 2/5 (40%) were bright. Two of 16 (13%) mixed plaques were bright and 14/16 (87%) were dark. On CE-IR MRI, all calcified plaques appeared dark, 2/5 (40%) non-calcified plaques were dark and 3/5 (60%) were bright, 10/16 (63%) mixed plaques were bright and 5/16 (31%) were dark. Of the 16 non-calcified and mixed plaques that appeared dark on N-IR MRI, 1 non-calcified and 10 mixed plaques appeared bright on CE-IR MRI (contrast uptake). There were no plaques with bright appearance on N-IR and dark appearance on CE-IR MRI.

**Conclusion:** This study yielded two important findings: (1) The use of black blood CE-IR coronary MRI for the detection of selective contrast uptake in non-calcified and mixed coronary plaque in patients with CAD has been demonstrated. The observed contrast uptake may be associated with neovascularization, inflammation, and/or endothelial dysfunction, markers for plaque vulnerability. (2) The different signal intensities of plaques in N-IR scans in combination with different signal intensities after contrast application facilitates differentiation of three different plaque types: 1. Plaques that are hypointense on N-IR and CE-IR, 2. Plaques that are hyperintense on N-IR and CE-IR and 3. Plaques that are hypointense on N-IR and hyperintense on CE-IR. While further studies are required to investigate the pathologic changes underlying our observations, we conclude that this method may have potential for noninvasive characterization of coronary plaque in patients with CAD.

### References:

1. Yuan, C., et al., *Contrast-enhanced high resolution MRI for atherosclerotic carotid artery tissue characterization*. J Magn Reson Imaging, 2002. **15**(1): p. 62-7.
2. Kramer, C.M., et al., *Magnetic resonance imaging identifies the fibrous cap in atherosclerotic abdominal aortic aneurysm*. Circulation, 2004. **109**(8): p. 1016-21.

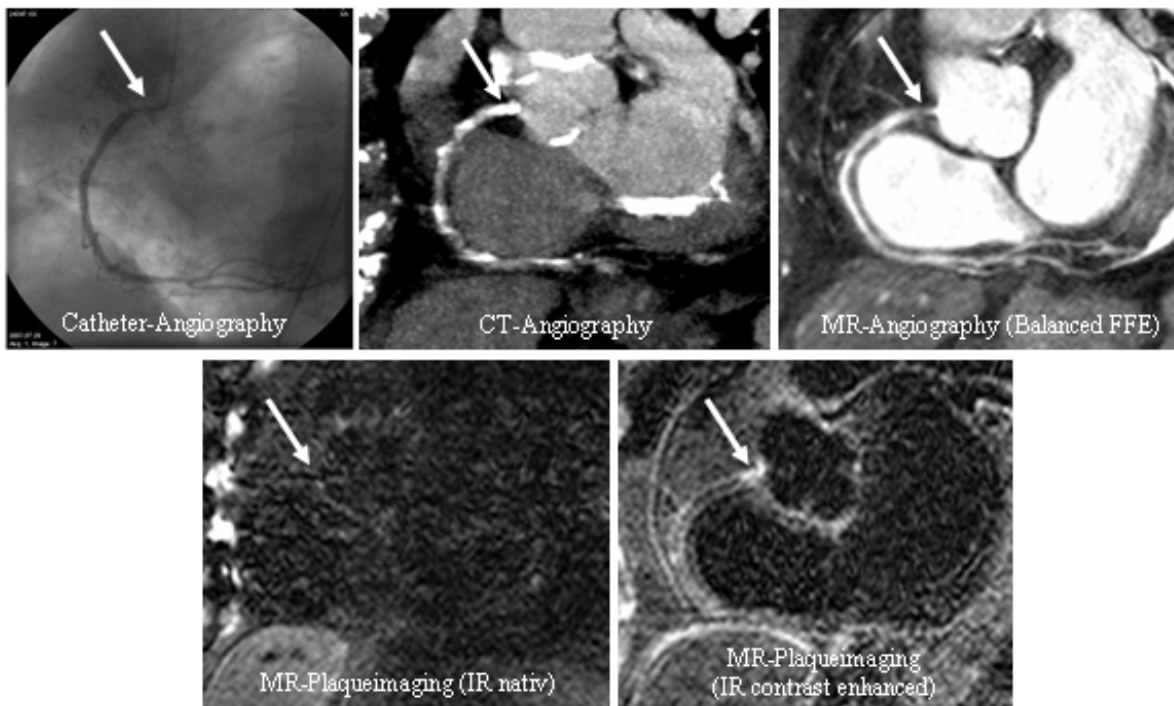


Figure 1: Patient with high-grade stenosis of the proximal right coronary artery (RCA) as identified by catheter-angiography. CT-angiography shows large, mainly calcified plaque in the proximal RCA superimposing the lumen. MR-angiography depicts the stenosis in good correlation to catheter-angiography. Inversion-Recovery MR-plaqueimaging before (IR native) and after contrast media application shows marked enhancement of the proximal RCA plaque.