

Intracoronary MR Imaging Using a Novel 0.014-inch MRIG: Toward MRI-Guided Coronary Interventions

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Introduction: Magnetic resonance imaging (MRI) has the unique ability to not only generate vessel wall images but also to evaluate organ anatomy and function as well as metabolism¹. It is expected that MRI may become a “one-stop-shop” imaging modality for coronary artery interventions, such as MRI-guided PTCA and stent placement as well as gene therapy². In this study, we attempted to validate the feasibility of using a newly-designed and clinical-sized 0.014-inch MR imaging-guidewire (MRIG), to catheterize the coronary arteries and thereby to generate intracoronary MR imaging.

Materials and Methods: The custom 0.014-inch MRIG was first manufactured by plating/cladding highly electrically conductive materials, silver or gold, over the inside and outside of coaxial conductors, which were made of the superelastic and nonmagnetic materials, Nitinol and NP35N. This newly-designed 0.014-inch MRIG reduced MR signal attenuation and increased the signal-to-noise ratio³. Through a carotid artery cutdown, a 7F introducer was placed. Then, to test the mechanical property of the new 0.014-inch MRIG, we used it to catheterize the left coronary arteries of three dogs. To validate the feasibility of using the MRIG to generate intracoronary MR imaging, we positioned the MRIG, using a 2.5mm dilation-perfusion balloon catheter (Remedy, Boston Scientific, MN), into the left coronary arteries and then generated intracoronary MR images of the left anterior descending artery or circumflex artery branches in an additional three dogs. Once MRIGs were placed in the coronary arteries, the animals were transferred to a 1.5T MR scanner (GE Healthcare, WI). With cardiac trigger and breath-hold, longitudinal and four-chamber views of cine cardiac MR images were obtained using FGRE (TR/TR/FA=5.2ms/1.6ms/20°, FOV=32x32cm, thickness=5mm, space=2mm, matrix=256x160, and NEX=0.5). Then, 3D MR coronary angiography of the LAD or circumflex artery branches using a FIESTA sequence was obtained. Based on the MR coronary angiography, we subsequently inflated the balloon and operated the 0.014-inch MRIG, at a receive-only mode, to generate longitudinal and axial intracoronary MR images using FGRE (TR/TR/FA=7.2ms/3.5ms/20°, FOV=18x18cm, thickness=3mm, space=0.5mm, matrix=256x256, NEX=0.5, and BW=32 kHz).

Results: In all six animals, the left main coronary arteries were successfully catheterized and the MRIG was accurately positioned into the left coronary artery branches, either LAD or circumflex (Figure 1). 3D FIESTA MR imaging showed the course of the LAD or circumflex arteries (Figure 2). Intracoronary MR imaging demonstrated the coronary artery walls as a “train track” on longitudinal views and the inflated balloon as a bright thick ring on axial views (Figure 3).

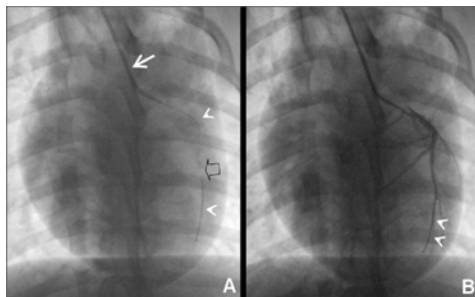


Fig.1. X-ray fluoroscopic imaging of a dog heart. (A) Via the guiding catheter (arrow), the 0.014-inch MRIG (arrowheads) is positioned in the left anterior descending (LAD) branch of the coronary artery. The open arrow indicates the inner-outer junction of the MRIG. (B) Coronary angiography confirms the location of the MRIG (arrowhead) in the LAD.

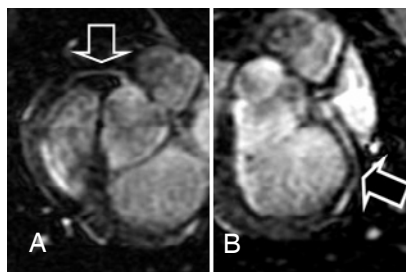


Fig.2. 3D MRCA, demonstrating courses of the right circumflex artery branch (arrow on A) and the left anterior descending artery (arrow on B).

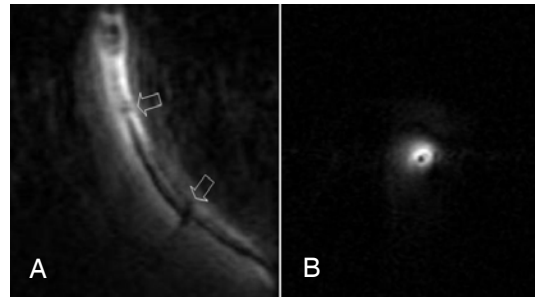


Fig.3. Intracoronary MR imaging using the 0.014-inch MRIG. (A) The longitudinal-view image, showing the coronary artery wall as a “train-track,” with two balloon metal marks (arrows). (B) The axial-view image, showing the inflated balloon as a bright thick ring and the MRIG as a dark point within the balloon.

Conclusion: The preliminary results of this study demonstrate the potential of using this new, clinical-sized, gold/silver/Nitinol-based, 0.014-inch MRIG to catheterize the coronary arteries, to position the balloon catheter into the coronary arteries, and thus, to generate intracoronary MR imaging of the coronary artery branches. With continuous refinement, the new 0.014-inch MRIG-based imaging technique may facilitate MRI-guided interventions, such as PTCA and stent placement, as well as gene/drug therapy of atherosclerotic coronary diseases in an MRI environment.

Reference:

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