Intravascular 3.0T MRI Using an MR imaging-Guidewire

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Introduction: Atherosclerotic cardiovascular disease remains the leading cause of death in developed countries. MRI is a useful imaging tool for characterizing atherosclerotic plaques with multiple planes. However, this advantage of MR technology is limited to the imaging of superficially-seated arteries when using a surface coil, due to decrease of signal-to-noise ratio (SNR). Previous efforts have been made to place a MR imaging-guidewire (MRIG) into deep-seated arteries, which thereby creates high SNR next to the target vessel walls and plaques with 1.5T MR scanners [1]. The aim of this study was to evaluate the possibility of generating MRIG-mediated intravascular MRI by using a 3.0T MR scanner.

Materials and Methods: A 0.032-in MRIG was fabricated based on a coaxial cable with an 8-cm extension of its inner conductor (Fig. 1). We first confirmed the functionality of the MRIG in 3T by performing an in vitro experiment using a phantom. The phantom consisted of a saline-filled, 315×125×130mm plastic box, which contained a plastic tube to imitate a vessel in the body (Fig. 2). The tube, 8-mm in outer diameter and 5-mm in inner diameter, was filled with saline. The MRIG was inserted into the tube, and then connected, via a tuning circuit box, to a 3T MR scanner (GE Healthcare, Milwaukee, WI) to obtain axial and coronal T2-weighted imaging (WI). The axial T2WI parameters were 2100/102.2-ms TR/TE, 8-cm FOV, 256×192 matrix, and 3-mm slice thickness. The coronal T2WI parameters included 2100/91.1-ms TR/TE, 12-cm FOV, 192×160 matrix, and 3-mm slice thickness.

To validate the feasibility of intravascular MRI with a 3.0T MR scanner, we then performed in vivo experiments by using two white rabbits, approximately 3 kg in weight. Through a surgical cutdown, we placed a 3F introducer into the right femoral artery and then positioned the 0.032-in MRIG into the abdominal aorta under X-ray fluoroscopy guidance. We then transferred the animals to the 3T MR scanner and acquired intravascular axial MRI of the aortic walls using (a) T1WI with FSE sequence, 500/7.7-ms TR/TE, 10×10-cm FOV, 192×160 matrix, and 3-mm slice thickness; (b)T2WI with FSE, 3000/83.5-ms TR/TE, 10-cm FOV, 384×320 matrix, and 3-mm slice thickness; (c) proton-WI with 3000/16.7-ms TR/TE, 10-cm FOV, 384×320 matrix, and 3-mm slice thickness; and (d) spoiled gradient echo (SPGR) imaging with 21/4.8-ms TR/TE, 30º flip angle, 8-cm FOV, 192×168 matrix, and 3-mm slice thickness.

Results: In vitro 3T MRI with the phantom demonstrated clearly the wall of the phantom tube, “vessel,” with high MR signals near the MRIG. At the center of the tube, the MRIG was shown as a dark dot or line on the axial and coronal images, respectively (Fig. 3). The in vivo intravascular 3T MRI showed clearly the aortic walls of the rabbits on T1-, T2-, and proton-WI (Fig.4a-c). With SPGR sequence, we could see the high-intense aorta lumen and the low-intense MRIG as well (Fig. 4d).

Conclusions: It is feasible to use a 0.032-inch MRIG to generate high-SNR, intravascular MRI, which may enable MRIG-guided intervention in the 3T environment.

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Fig. 1. A 0.032 Intravascular MRIG, connected to the 3T MR scanner through a tuning/matching circuit.

Fig. 2. In vitro experimental set-up, showing a tube, imitating a “vessel”, is placed within the saline-filled plastic box.

Fig. 3. In vitro 3T MRI of the phantom using the MRIG, showing the hypointense wall of the tube (arrowheads) on both axial (a) and coronal (b) images. The MRIG appears as a dark dot (a) or a dark line (b) located at the center of the hyperintense saline within the tube.

Fig. 4. In vivo 3T MRI of the aorta showing the MRIG-guided intervention: a) T1WI showing the aorta walls; b) T2WI showing clear MRIG and aorta walls; c) proton-WI showing clear MRIG and aorta walls; d) SPGR imaging showing high-intense aorta lumen and low-intense MRIG.