A Gd-DTPA based insoluble polymer coating technique for endovascular device visualization

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INTRODUCTION

In MR-guided endovascular procedures, a passive visualization technique for the devices such as guidewires and catheters based on MR-visible coating with polymers including T_1 contrast agents like Gd-DTPA (Gd-diethylenetriaminepentaacetic acid) has been attracting attentions [1]. In addition to the relative simplicity and safety compared with the techniques using electronic circuits, such coating techniques have a capability of depicting the entire length of the device. The most challenging issues in these techniques are to obtain an image quality to allow the visualization of guidewires having a metal core producing a susceptibility artifact.

The purpose of this study is to evaluate the fundamental feasibility of *in vitro* visualization of guidewires and catheters coating with Gd-DTPA based block copolymer which was designed to obtain insolubility and visibility sufficient under the MRI for MR-guided endovascular interventions.

MATERIALS AND METHODS

A block copolymer (**I**) comprised of hydrophilic and hydrophobic subunits which linked Gd-DTPA complex was synthesized. The content ratio of Gd-DTPA to the polymer was 0.4 %. The guidewire (ϕ: 0.035 inch) with a Ni-Ti core and urethane tube (ϕ: 1.55 mm) as a catheter were coated by a dipping process using polymer **I** (Sample 1). The analogue containing no Gd-DTPA was also used as coating polymer (Sample 2). The sample without coating was used as a negative control (Sample 3). These samples were soaked into saline for swelling (Figure 1). The thickness of the coatings was 100-150 μm in a moist state. The long axis of the devices was set in the same direction of static magnetic field to decrease the effect of susceptibility artifact from a metal core. Imaging was performed using a 1.5 Tesla MRI (Signa EXCITE TwinSpeed Ver.11, GE Healthcare, Milwaukee, WI, USA) using a birdcage head coil. The imaging parameters were as follows: effective TR/TE/TI, 1493 ms / 5.5 ms / 684 ms ; TI, 684 ms; slice thickness, 5 mm; slice spacing, 0.5 mm; FOV, 300 x 300 mm^2; phase FOV, 0.6; acquisition matrix, 256 x 256; reconstruction matrix, 512 x 512; RBW, 250 kHz; ETL, 10; NEX, 8 for T_1-FLAIR optimized for saline suppression. TR/TE/FA, 34 ms / 1.6 ms / 45 degree; slice thickness, 5 mm; slice spacing, 0.5 mm; FOV, 300 x 180 mm^2; acquisition matrix, 256 x 256; reconstruction matrix, 512 x 512; RBW, 250 kHz; NEX, 4 for FSPGR.

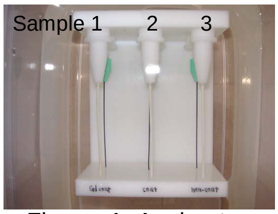

Figure 1 A phantom for imaging.

RESULTS AND DISCUSSION

Figure 2 and 3 show typical coronal and axial images of the guidewires imaged by (a) T_1-FLAIR and (b) FSPGR. Sample 1 having polymer **I** was visible with a high signal intensity. The contrast to noise ratio (CNR) between the guidewire and saline in the T_1-FLAIR case was 3.6. Sample 2 gave no visible signal. No susceptibility artifact was observed with Sample 3. Therefore, the observed signal enhancement was caused by T_1 shortening effect of Gd-DTPA confined in the coating polymer **I**. The signal enhancement was observed in a few minutes after swelling and was stable during the experiment for several hours, even if tested it repeatedly. IR-FIESTA was considered as one of the suitable sequences to visualize our samples.

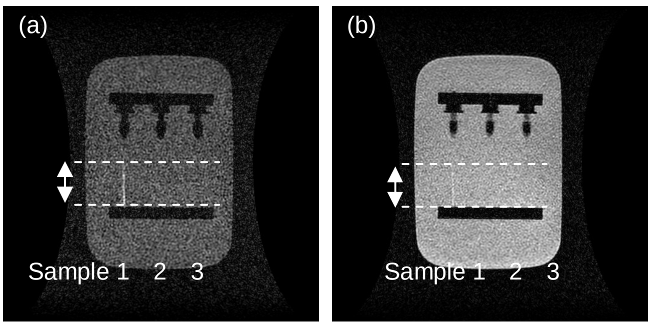

Figure 2 Coronal MR images of the guidewires. (a) T_1-FLAIR. (b) FSPGR. The arrow indicates the coated part.

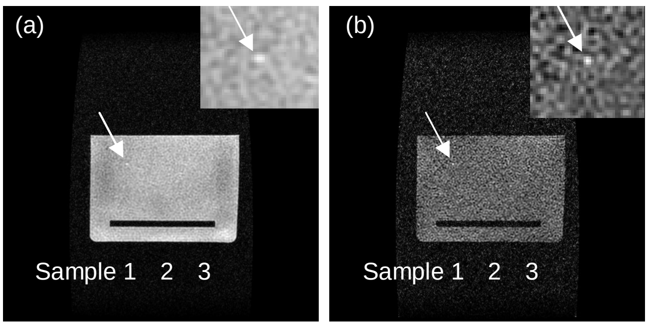

Figure 3 Axial MR images of the guidewires. (a) T_1-FLAIR. (b) FSPGR. The arrow indicates the sample 1.

CONCLUSION

This study shows that the MR-visible catheters and guidewires coated with the Gd-DTPA based polymer will contribute to the development of MR-guided endovascular procedures. The further study will involve optimization of a Gd-DTPA content in the polymer to adapt for clinical imaging techniques such as a tracking and a fast imaging.

REFERENCES

[1] O. Unal, et. al., J Mag Reson Imaging, **23**, 763, 2006.