# AN ACTIVE TWO CHANNEL GUIDEWIRE FOR INTERVENTIONAL CARDIOVASCULAR MRI

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## INTRODUCTION

The success and safety of interventional magnetic resonance imaging (iMRI) procedures require conspicuous intravascular instruments that can be distinguished from surrounding tissues. iMRI guidewires must navigate diseased tortuous structures without damaging them and while retaining mechanical integrity. The device tip is most likely to injure, disrupt, or perforate diseased tissue and generally requires the most attention. The guidewire shaft should provide adequate support to deliver a range of interventional devices which may be rigid and bulky. Both tip and shaft need simultaneously to be visible to the operator to assure safe procedure conduct. Active visualization imparts a unique image "signature" for reliable tracking and display of devices under MRI [1,2]. We developed an active 0.035-inch vascular guidewire with enhanced visibility and favorable mechanical characteristics for MRI-guided interventions.

## METHODS

The 0.035-inch guidewire prototype was constructed in a Class 10,000 cleanroom, using all medical-grade components. An RF loop coil antenna embedded into the instrument tip imparts only localized spatial coverage for visualizing single points at the distal end. The guidewire shaft incorporates a loopless antenna with spatial coverage along its length and that provides whole shaft visibility. The guidewire was designed so the additional loop antenna channel would not compromise active instrument size and handling compared with common X-ray devices. The gold-plated rod used for the inner core of the guidewire and loopless antenna was grinded along the distal 3 inches to improve guidewire tip flexibility. Both antenna channels were insulated from each other using low durometer (less rigid) thermoplastic elastomer (Pebax) polymer tubing. Dedicated matching/detuning circuitry boxes were prepared for each antenna channel. *In vitro* phantom and *in vivo* swine scanning experiments were performed to test visibility of the guidewire tip and shaft profile and overall handling and performance. Animal protocols were approved by the institutional Animal Care and Use Committee. All imaging was performed with a 1.5 T Siemens Espree scanner using a TrueFISP sequence (TR 3.72 ms, TE 1.86 ms, flip angle 60, slice thickness 6 mm, matrix size 224x224, bandwidth 797 Hz/pixel). Custom-designed software was used to highlight each individual channel with a different color and display them on the anatomic imaging. Mechanical properties (torquability, tip flexibility, pushability) of the guidewire prototype were also compared in several bench-top evaluations with representative 0.035" commercially-available guidewires.

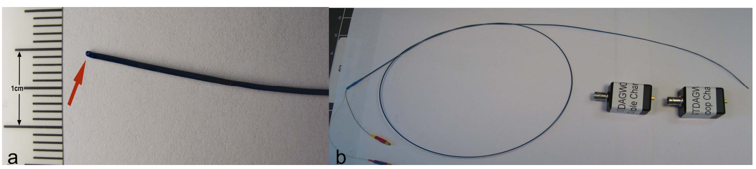


**Figure 1. (a)** Photograph of the distal tip of the active guidewire. The arrow shows the dome-shaped atraumatic tip of the guidewire. **(b)** The two channel 0.035" active guidewire prototype (1 meter long) with dedicated matching/detuning circuit box for each channel.

## RESULTS

During guidewire advancement inside the aortic arch model *in vitro* tests, the loop channel showed good axial homogeneity at the two ends of the solenoid coil. The longitudinal signal profile was homogenous over the entire length of the loopless antenna channel. Shaft strength lent to easier application of torque and advancement of the device in the animal during *in vivo* experiments. The two-channel active guidewire was visualized well along the entire shaft during the *in vivo* experiments. The loop antenna signal at the distal tip facilitated device navigation by providing distinct tip visualization and tip orientation. Guidewire tip position and shaft could easily be seen relative to background anatomy during advancement. The proximal bright signal received through loop channel is helpful to determine distal tip deflection. The guidewire was flexible and torquable enough to follow vasculature without much resistance. Mechanical testing comparisons with several commercially-available guidewires demonstrated that the two channel guidewire design provides similar distal tip flexibility, torquability, and pushability for vascular applications.

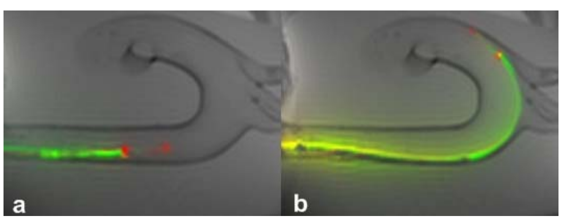


**Figure 2**. Phantom MR image acquired with two channel guidewire. **(a)** Tip (red color) and distal shaft (green color) of the guidewire could be seen easily during advancement. **(b)** The guidewire manipulated to advanced over the simulated aortic arch.

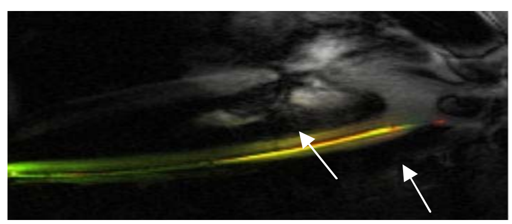

**Figure 3**. Guidewire in Porcine Aorta. The guidewire was inserted through femoral access up to the aortic arch. Both guidewire tip (arrow, red) and shaft (green) were reconstructed in different colors during real time MRI.

## CONCLUSION

We developed a guidewire for interventional cardiovascular MRI that combines a loop coil for enhanced tip visibility and a dipole antenna for whole-shaft visibility in a compact 0.035-inch guidewire package. This overcomes the limitations of each individual design. Moreover, we sought to preserve mechanical characteristics necessary to perform complex interventional procedures, including flexibility, pushability and torquability. We demonstrated that this prototype guidewire was comparable to commonly-used devices used under X-ray. The visibility and handling of this guidewire can help facilitate safer interventional MRI procedures.

## REFERENCES

1. Ladd ME, et al., *Active MR visualization of a vascular guidewire in vivo*. J Magn Reson Imaging 1998; **36** (1):220-225.
2. McKinnon GC, et al., *Towards active guidewire visualization in interventional magnetic resonance imaging.* Magma 1996; **4**(1):13-18.