Hybrid Tracking and Visualization of Therapeutic Devices under MRI Guidance

O. Unal[1,2], E. K. Brodsky[1], and K. N. Kurpad[2]

[1]Department of Medical Physics, University of Wisconsin, Madison, WI, United States, [2]Department of Radiology, University of Wisconsin, Madison, WI, United States

INTRODUCTION

Despite recognition and study of various problems associated with MRI-guided tracking and visualization of therapeutic endovascular devices such as catheters and guidewires, it remains a challenge to consistently track and visualize a broad range of such devices under any circumstances. Active and passive methods can be used to track and visualize the placement of such devices under MR guidance. Each method separately has both advantages and disadvantages. However, when these active and passive methods are combined, they can complement each other. The objective of this study was to perform *in vitro* and *in vivo* evaluation of catheters incorporating MRI-visible coatings [**1**] for passive visualization of the entire device length, miniature RF-coils for active tip-tracking, and inductively-coupled self-resonators (wireless markers) to further improve passive visualization of such therapeutic devices.

MATERIALS AND METHODS

A 15-turn tuned / untuned solenoid of 36AWG magnet wire for tip tracking and 5 cm long inductively-coupled self-resonator was incorporated onto a 6 F catheter with coated MRI-visible coatings [1] or filled with dilute Gd-DTPA. A real-time version of 3D PR (VIPR-ME) technique [2] was implemented and used for simultaneous active tip-tracking and passive visualization of these catheters employing these hybrid tracking and visualization methods. In tip tracking mode, the solenoid part was utilized. The sequence acquires time frames with sets of radial lines are sampled in each interleaved subframe so that a more fully sampled representation of *k*-space can be assembled when multiple adjacent interleaves are combined. To determine the catheter tip position, three nearly orthogonal projections from each subframe were selected, regridded individually, and Fourier transformed to generate 1D profiles representing its position on orthogonal planes. Due to the localized spatial sensitivity of the coil, this gives rise to a sharp peak in the Fourier-transformed signal. Passive device tracking and visualization of wireless marker and Gd-filled catheter were simultaneously acquired using an external coil. All experiments were performed on a 1.5 T scanner using 6 F catheters filled with dilute Gd-DTPA. The images were reconstructed using temporal Tornado filter [3] and HYPR-based techniques [**4**].

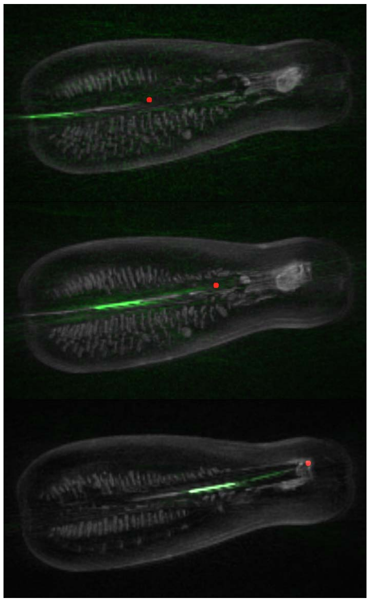

Figure 1: Temporal superimposed snapshot images of 6F catheter employing hybrid (active and passive) tracking and visualization methods. Red overlay points to the catheter tip location obtained using the active tip-tracking coil and green overlay shows the location of the wireless marker obtained with the external coil by passive visualization of the catheter that is filled with dilute catheter Gd (white).

RESULTS AND DISCUSSION

Figure 1 depicts snapshots from a time-resolved volume image depicting a moving catheter embedded with a tip-tracking coil, wireless marker, and filled with dilute Gd in a phantom. The anatomical/roadmap image (white) has 1.2 mm isotropic resolution and was generated using data from an external coil over the full 60 s scan dataset. Catheter tip position (red dot), is calculated at 8 fps using three orthogonal projections of data from the internal coil. The passive marker is imaged (green overlay) with 2.5 mm resolution, based on 4-8 s of data [3] from the external coil.

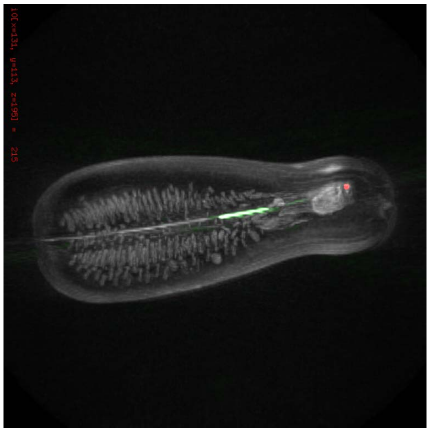

Figure 2: A 1-cm thick MIP snapshot image of the 6F catheter shows a longer portion of the catheter lumen filled with dilute Gd. Red overlay points to the tip location obtained with the active tracking coil and green overlay shows the location of the passively obtained wireless marker.

Figure 2 depicts a 1-cm thick MIP snapshot image of the 6F catheter showing a longer portion of the catheter lumen filled with dilute Gd. The red overlay points to the tip location obtained with the active tracking coil and the green overlay shows the location of the passively obtained wireless marker. The use of HYPR-based techniques [4] may further improve the temporal resolution while maintaining good image quality.

CONCLUSIONS

Our preliminary results suggest that simultaneous active tip tracking passive visualization of coated or filled catheters with Gd-DTPA and embedded with inductively coupled resonators is feasible and may offer advantages over other passive and active tracking techniques using 3D PR techniques. These devices, when used in combination with radial or hybrid radial/Cartesian acquisition and HYPR reconstruction techniques may pave the way for MR fluoroscopy and consistent tracking and visualization of a broad range of therapeutic devices under any circumstances.

REFERENCES

1. Unal O, *et al.*, JMRI, 23, 763, 2006. **2.** Brodsky *et al.*,ISMRM, 322 2003. **3.** Barger AV, *et al*., MRM, **48**, 297, 2002. **4.** Mistretta CA, *et al.*, MRM, 55, 30, 2006.

ACKNOWLEGMENTS

This work was supported in part by NIH grant R01 HL086975.