Passive tracking device with a controllable susceptibility effect: demonstration with catheter in vivo.

William Dominguez-Viqueira[1], Hirad Karimi[1,2], Jennifer Barry[1], and Charles H Cunningham[1,2]

[1]*Imaging Research, Sunnybrook Research Institute, Toronto, Ontario, Canada,* [2]*Medical Biophysics, University of Toronto, Toronto, Ontario, Canada*

Introduction

Due to the rich anatomic information available, MRI is an attractive tool for guiding endovascular interventions. Susceptibility artifact–based tracking using paramagnetic markers [1] is a simple and economical approach, but has been used with limited enthusiasm partly because of the image degradation that results from such devices. In this work, a susceptibility-based tracking device which can be mechanically turned ON and OFF [2] is implemented in a catheter tip and demonstrated *in vivo.*

Materials and Methods

The susceptibility device consisted of three concentric cylinders of titanium and graphite giving an outer diameter of 3mm and length of 15mm as previously described [2] (Fig.1.a). The device was designed to create a minimum susceptibility artifact in MRI when all the cylinders are aligned (OFF position); and a large artifact when the cylinders are miss-aligned (ON position) to facilitate tracking [2]. The catheter was built by attaching the device to biocompatible PTFE tubing with heat-shrink and gluing the titanium parts at the distal end. A nylon wire was glued the graphite piece on the opposite end of the device to push and pull this piece in and out relative to the titanium parts (Fig.1.a and b). A side guide-wire (mono-rail) can be also be used with this catheter as shown in Fig 1 a.

A Yorkshire pig (25 kg) was sedated with Ketamine (15mg/kg) and Atropine (2mls, 0.04mg/kg) IM and intubated under a protocol approved by the institutional animal care and use committee. Under isoflurane, inhaled anesthesia, a 10F sheath was placed in the femoral artery and the catheter was inserted and advanced to the carotid bifurcation using a guidewire under fluoroscopy. Once at the bifurcation an angiogram was performed to advance the catheter into the carotid artery (a chronic total occlusion will be induced in this area in future experiments). MR images were performed using a 3T MR scanner (MR750, GE Healthcare, Waukesha, WI), with a 5 inch diameter receive-only surface coil using a fast gradient-recalled echo sequence. Images were taken with the tracking device in ON and OFF positions to quantify the susceptibility artifacts in both positions. Volume projection images with positive contrast using a frequency selective spin echo sequence were also acquired to find and track the catheter.

Results and Discussion

Fluoroscopy images of the carotid showing the tracking device using the guide-wire and iodine contrast are shown in Fig.2. The ability to use the device with conventional guide-wires under fluoroscopy was useful to guide the catheter through the bifurcation in to the carotid. *In vivo* images of the neck area of a pig with the catheter in ON(a) and OFF(b) positions are shown in Fig.3. As shown in Fig.3.a and b the image distortions are minimized when the device is in the OFF position (Fig.3.b). Positive contrast images are shown in Fig.3.c and d, where only the tip of the device can be seen. This facilitates locating the device in projection images which can be helpful *in vivo* to automatically track the device.

Conclusions

A passive tracking catheter with a susceptibility effect that can be enabled and disabled by sliding one of the components was designed, fabricated and demonstrated *in vivo*. The difference between the aligned and miss-aligned configurations was large in the acquired MR images, showing the feasibility of tracking the device by periodically moving the graphite layer. Even though the device was demonstrated in a catheter, it can also be designed for different tools or devices for interventional MR procedures. In future work, faster imaging sequences will be implemented for real-time tracking.

Acknowledgements

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References

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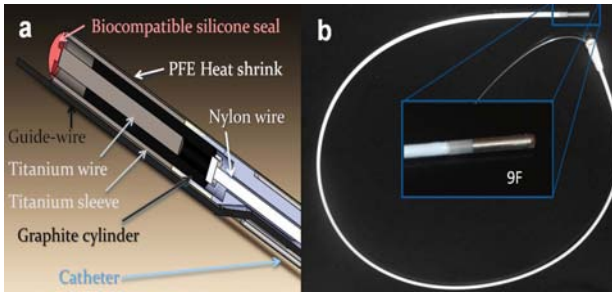

Figure 1. Catheter assembly with the susceptibility device. **a**: 3D model of the assembly. **b**: actual catheter picture.

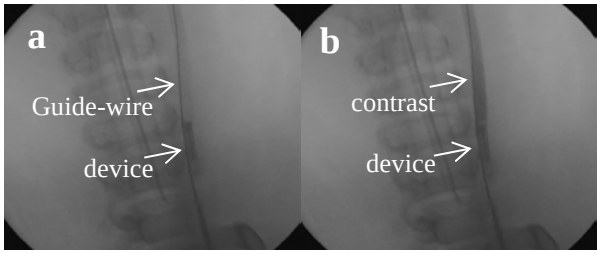

Figure 2. In vivo fluoroscopy images of the device in the carotid. **a**: device with guide-wire. **b**: device with contrast.

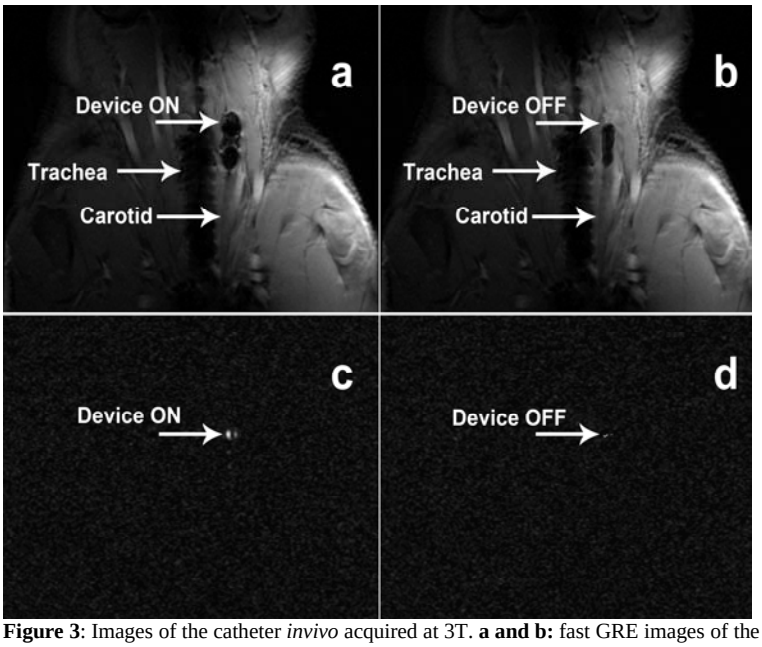

Figure 3: Images of the catheter *invivo* acquired at 3T. **a and b:** fast GRE images of the neck area of a pig with the device in ON and OFF position respectively. **c and d:** positive contrast images of the same area with the device in ON and OFF position respectively.