Preclinical Evaluation of a Novel Fiber Compound MR Guide Wire

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Objective:

For interventional Magnetic Resonance Imaging (iMRI) dedicated and MR-conditional or even MR-safe instruments are required. The guide wire is a key item for intravascular interventions. Mechanical stability and stiffness are required for navigation, while good visibility during real-time imaging is needed for optimal guidance. In addition to these demands, RF-safety is mandatory for any clinical use. We examined a passively MR-visualized guide wire (GW) consisting of fiber glass compound with hydrophilic coating. Mechanical properties of the GW, handling and the operability in different interventional scenarios were evaluated in a swine model.

Methods:

As previously described the GW consists of a fiber glass compound, produced using a micro-pultrusion technique [1]. The tip of the GW consists of a 100mm cone-shaped Nitinol extension. For passive MR-visualization, the core material has been doped with iron powder. Additionally, several iron splints are attached at regular distances in the distal section of the GW. A polyurethane jacket covers the core material and a hydrophilic biocompatible layer ("Lubriteq", Hemoteq GmbH, Germany) improves the gliding properties. The jacket additionally contains wolfram powder to render the guide wire visible using X-ray fluoroscopy. The overall diameter of the GW is 0.032'' with a length of 200 cm.

Different interventions were conducted in 5 pigs at a 1.5 Tesla whole body scanner (Achieva, Philips Medical Systems, Best, The Netherlands) using a 5 element surface coil. All interventional procedures were monitored using a real-time balanced-SSFP sequence (TR=2.8, TE=1.41, flip-angle=40°, Matrix 112, Field of View 320 mm, sliding window-technique 5 images per second). Arterial approach was established via an inguinal artery sheath (8 F). The GW was repeatedly placed in the renal (n=30), carotid (n=10) arteries, in the left cardiac ventricle and with the aid of an ACN1 angiography catheter (Cook Inc., USA) in the contra lateral inguinal artery (n=20). Time required for each vessel catheterization was assessed and the induced artifacts of the GW were determined on the MR-images.

From inguinal approach, a selfexpanding Nitinol stent (Jostent SelfX, Abbott Vascular Devices, The Netherlands; 8 mm diameter, 32 mm length) was deployed an iliac artery. Catheters were inserted over the wire into both renal arteries. Subsequently, the guide wire removed and a small amount of contrast medium was injected trough the catheter (Magnevist, Schering, Germany ; 0.25 mmol in 5 ml saline). In addition, a balloon catheter was advanced into the right renal artery and filled with a MR contrast medium. By GW navigation, a 6F Cobra angiographic catheter (Terumo, Japan) was placed in a renal segment artery. Via a coaxially introduced 3F micro catheter 0.5 ml butylcyanoacrylate (Histoacryl, B. Braun, Germany) were applied for embolization of the segment. To verify successful embolization, intravenously contrast enhanced MR-angiography was performed. Two experienced interventionalists conducted the iMRI procedures and evaluated the GW-handling subjectively.

Results:

Real time MRI enabled distinct visualization of the GW by susceptibility artifacts. The induced artifacts by the iron markers (Fig. 1, arrowheads) as well as the doped core material (Fig. 1d, arrows) of the GW could clearly be differentiated. On real time MR images, the artifacts measured approximately 2 and 5 mm. This was sufficient for depiction of the GW without precluding the orientation within the vessels and allowed accurate maneuvering of the GW. The GW was placed in the renal arteries within averagely 16 sec, in the carotid arteries within 5 sec, in the contra lateral inguinal artery within 46 sec and was successfully introduced into the left ventricle. GW navigation permitted fast positioning of a catheter in the renal artery. After injecting CM arterially, a broad loss of signal within the kidney on real time MR images proofed the location of the catheter. After inserting the balloon catheter and expanding the balloon with a contrast agent a signal void was visible in the renal artery. GW navigation permitted deploying the stent precisely at the pre-selected position in the inguinal artery. Embolization of segment arteries was successfully performed after catheterization of the renal artery with the guide-wire and a cobra catheter and coaxial introduction of a 3F catheter into a segment artery. The subsequent MR angiograms showed the accurate outcome of this treatment.

All interventionalists assessed handling of the GW to be nearly equal in terms of stiffness, flexibility and guidance compared with a standard Nitinol guide wire (Radiofocus 0.032'', Terumo, Japan).

Conclusion:

The introduced guide wire proved to be maneuverable and allowed for catheterization of the target vessels in all described interventions. The GW was clearly visible on real-time MRI. Moreover, it permits excellent handling characteristics that facilitate a precise and safe MR guided positioning of the GW.

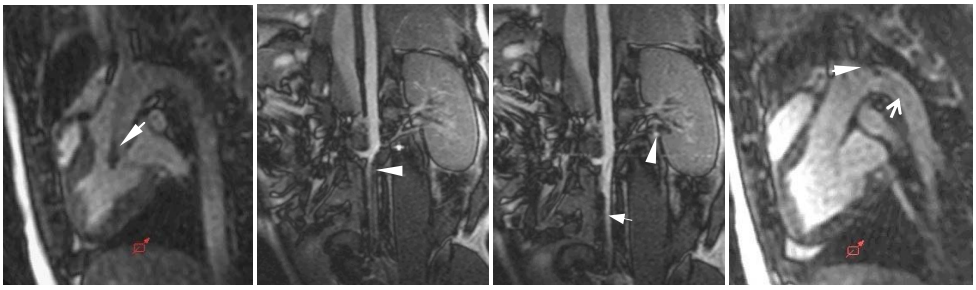

Figure 1: On Real-time MRI, the artifacts induced by the iron markings (arrowheads) are clearly depictable in the left ventricle (a), within the aorta (b), the renal (c) and carotid (d) arteries. Additionally, the artifacts induced by the iron doped core material (arrow in sub-picture (d)) can be delineated.

[1] Krueger S. et al; Evaluation of an MR-Compatible Guidewire Made in a Novel Micro-Pultrusion Process; Proc. Intl. Soc. Mag. Reson. Med., (15), p291; 2007.