Rubber Materials for Active Device Tracking

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Introduction

For device tracking in MR image guided interventions active tracking coils can be used that acquire MR signal from their immediate vicinity only. If the coils are integrated into an endovascular catheter, the MR signal from the surrounding blood is utilized. When the coils are applied in air-filled spaces (e.g., the airways of the lung) or when they are integrated into a larger device (e.g., an MR-compatible robot) they require an additional MR signal reservoir close to or within the coil that is filled with an MR signal source. For this purpose aqueous solutions provide the highest MR signals, however, they often leak out of the reservoirs and thus require frequent re-filling. Recently, also semisolid and solid organic compounds of varying water content (agar, agarose gels, polyacrylate gel, vinyl plastisol, PVA, etc) have been proposed, but even with these compounds ageing and drying was observed, which compromised the long term reliability and shortened the shelf life [1]. Inspired by artifacts from RF coil housings and cable coatings in MR sequences with very short echo times (TE < 1 ms), in this work different rubber materials were investigated as possible signal reservoirs in tracking catheters, as they are expected to show nearly no degradation due to ageing.

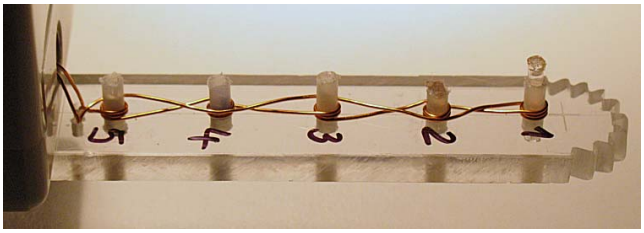

Fig 1: Dedicated test coil for sample characterization and tracking experiments. Signals of the 4 rubber materials (samples 2-5) were compared to a contrast agent solution (sample 1).

Materials and Methods

Four different rubbers were evaluated as semisolid signal materials for device tracking. To characterize the materials, a dedicated test coil with 5 imaging regions was formed out of coated copper wire (Fig. 1). The first imaging region contained a reference sample of physiologic saline solution with 1% Magnevist (Bayer Schering Pharma, Berlin, Germany). In the other four regions the following rubber materials were placed: (2) rubber cement (Marabu FIXOGUM, Tamm, Germany), (3) a cylindrical piece of PVC (razor gum, Pelikan, Germany), (4) dental duplicating silicone material (DEGUFORM, DEGUSSA, Hanau, Germany), and (5) UHU TAC patafix (UHU, Bühl, Germany).

The materials were imaged in a clinical 1.5 T whole body MR system (Avanto, Siemens, Erlangen, Germany) with a FLASH pulse sequence with 8 echoes to measure the relaxation time T_2*.The following parameters were used: TR = 50 ms, TE = 1.54-17.8 ms in 16 steps, 32 acquisitions, pixel size: 1.1×1.1 mm². From the image data the T_2* time and the signal at TE = 0 were calculated.

To assess whether the materials are suitable as signal reservoirs for device tracking, a dedicated tracking pulse sequence with a very short TE of 150 µs was designed that consisted of a short non-selective rf pulse (duration: 60 µs) followed by a highly asymmetric gradient echo. Additionally, in the two orthogonal gradient directions so-called z-dephaser gradients were applied to suppress background signal from static tissue. The other sequence parameters were: TR = 3 ms, α = 10°, 256 data points/projection. The test coil was moved manually, and the position was extracted from the signal projections.

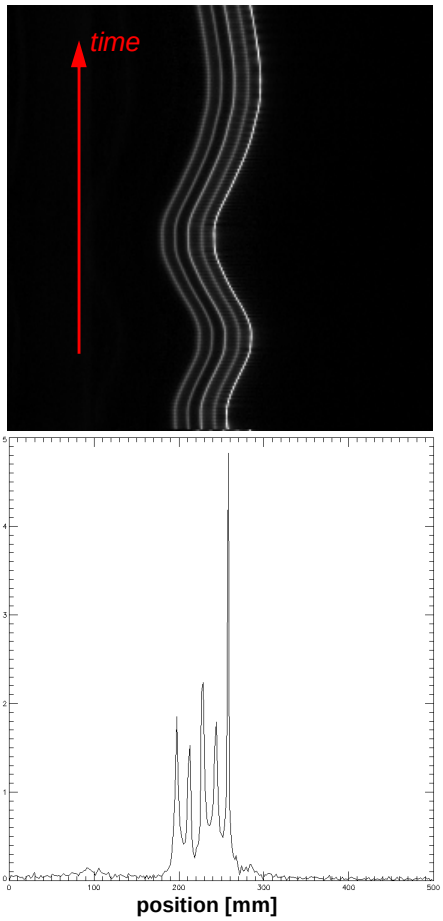

Fig. 2: Time series of tracking experiments (top) and a single projection (bottom) of the short-TE tracking sequence. The reference substance showed the highest signal amplitude; however, all rubber materials could also be used for device tracking.

Results and Discussion

The T_2* relaxation times of the materials 1 / 2 / 3 / 4 / 5 were 5.5 / 0.7 / 2.0 / 1.5 / 0.5 ms. The spin density (i.e., S(TE=0)) of all materials was found to be of the same order of magnitude as that of the reference solution. As expected, the reference solution had the highest SNR in the tracking experiment, but all rubber materials also exhibited an SNR of more than 10 in the projection peaks, which is required for stable device tracking (cf. Fig. 2). The current experiments demonstrate that long-term stable rubber materials can be utilized as reservoir material in active device tracking coils, if special pulse sequences with very short echo times are used.

References

[1] Sandhu GS, et al. Proc. Intl. Soc. Mag. Reson. Med. **15** (2007) 3385.