^{19}F MR-Visualization of Fluoropolymers Using Ultrashort TE Imaging

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Introduction

^{19}F ultrashort echo-time (UTE) imaging for the first time allows MR visualization of fluoropolymers such as PTFE (polytetrafluoroethylene, Teflon) on standard clinical MRI scanners. Due to their short T_2 relaxation time, these materials are invisible to conventional ^{19}F MR sequences. Fully fluorinated materials furthermore do not exhibit ^{1}H MR signal. Since fluoropolymers are used in a number of implants (e.g. stents) and catheters, we propose to use ^{19}F UTE MRI for visualization of implants and tracking of catheters. As the human body naturally does not contain MRI-visible fluorine, ^{19}F images have no background signal and allow easy localization of the polymers in the body. In this work, Teflon imaging is demonstrated using a 2D UTE sequence without slice selection.

Methods

Three small fluoropolymer rods (PTFE) were placed in phantom fluid and were imaged at 3.0 T. The rods had diameters between 2 and 4 mm and lengths between 4 and 8 cm. Three orthogonal projections were acquired on the ^{19}F channel, using a 2D UTE readout [1] in combination with non-selective block pulse excitation. Experiments were performed on a modified clinical 3.0T whole body scanner (Achieva, Philips Healthcare, The Netherlands) capable of ^{19}F imaging using a dual-tuned ^{19}F/^{1}H solenoid RF coil (∅ 7 cm) [2].
Scan parameters were: FOV = 160 mm, isotropic matrix size 64^2, 16384 radial projections, TE = 40 µs, repetition time TR = 3.4 ms, flip angle 10°, total scan duration 56 seconds.

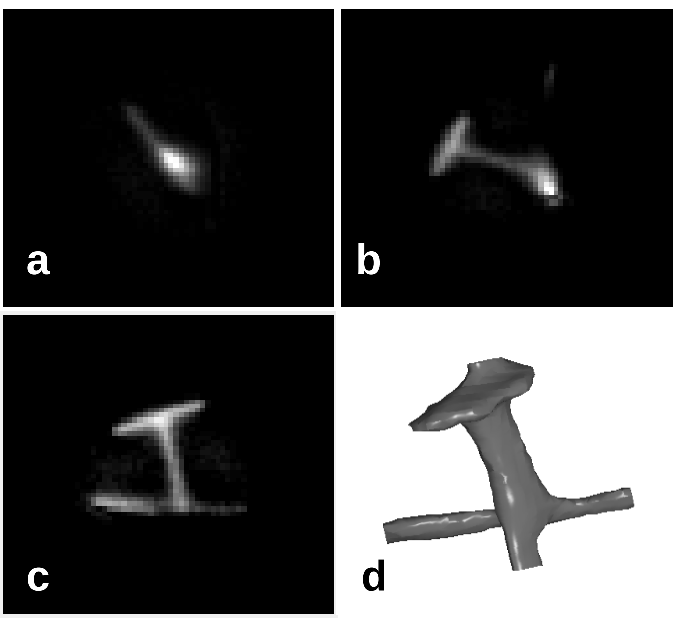

Figure 1: (a-c) ^{19}F signal in three orthogonal projections of the Teflon phantom, acquired at ultrashort TE = 40 µs.
(d) Reconstructed 3D structure obtained from the projections.

Results and Discussion

Figure 1 shows three orthogonal projections of the phantom, acquired on the ^{19}F channel at TE = 40 µs (a-c). At later echo times of several hundred µs, no ^{19}F signal is picked up due to the short T_2 of PTFE, which is estimated to be on the order of a few hundred µs. By solving the regularized inverse problem, the 3D structure can be derived from the projections (d) [3]. This technique can be used for localizing fluoropolymers like implants or catheters in the human body. For tracking of catheters, the demonstrated scan time of almost one minute is too long. Fluoropolymers other than PTFE may have longer T_2 and/or higher fluorine content leading to an increased signal level, which would allow faster imaging. The dual-tuned ^{19}F/^{1}H coil used in this experiment allows either an interleaved or simultaneous scanning on the ^{19}F channel. Simultaneous ^{19}F/^{1}H MRI can be used to register ^{19}F information to the human anatomy. While ^{19}F imaging has been suggested for tracking of catheters filled with ^{19}F-containing fluids [4], fluoropolymers can be integrated much easier into the catheter than fluids.

Conclusion

UTE imaging on the ^{19}F resonance allows the visualization of fluoropolymers such as PTFE (Teflon). This opens the door for MR visualization of fluoropolymer-based biocompatible implants or catheters. As a passive marker, polymer materials can be integrated easily into catheters, allowing localization and possibly tracking of the devices.

References

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