19F MR-Visualization of Fluoropolymers Using Ultrashort TE Imaging

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Introduction
19F 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 T2 relaxation time, these materials are invisible to conventional 19F MR sequences. Fully fluorinated materials furthermore do not exhibit 1H MR signal. Since fluoropolymers are used in a number of implants (e.g. stents) and catheters, we propose to use 19F UTE MRI for visualization of implants and tracking of catheters. As the human body naturally does not contain MRI-visible fluorine, 19F 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 19F 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 19F imaging using a dual-tuned 19F/1H solenoid RF coil (Ø 7 cm) [2]. Scan parameters were: FOV = 160 mm, isotropic matrix size 64², 16384 radial projections, TE = 40 µs, repetition time TR = 3.4 ms, flip angle 10°, total scan duration 56 seconds.

Results and Discussion
Figure 1 shows three orthogonal projections of the phantom, acquired on the 19F channel at TE = 40 µs (a-c). At later echo times of several hundred µs, no 19F signal is picked up due to the short T2 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 T2 and/or higher fluorine content leading to an increased signal level, which would allow faster imaging. The dual-tuned 19F/1H coil used in this experiment allows either an interleaved or simultaneous scanning on the 19F channel. Simultaneous 19F/1H MRI can be used to register 19F information to the human anatomy. While 19F imaging has been suggested for tracking of catheters filled with 19F-containing fluids [4], fluoropolymers can be integrated much easier into the catheter than fluids.

Conclusion
UTE imaging on the 19F 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