Biopsy needle with markers – Design of an MR compatible needle for high-precision needle tip positioning

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Introduction

A major problem of magnetic resonance (MR) imaging in using metallic instruments are artifacts induced by the susceptibility of instruments and implants brought into the field of view of the scanner. Ferromagnetic materials cause artifacts which are not acceptable and, furthermore, experience torque and forces. Instruments, for example, MR compatible biopsy needles are made of less magnetic materials, such as titanium, titanium alloy or carbon fiber[1]. Since the invention of interventional MR, biopsy needles made of paramagnetic material have been developed.

We investigated one needle geometry for various fast imaging sequences (FLASH, FISP, TSE) at 0.2 T and at 1.5 T. Results reported in the present work demonstrate that it is possible to design a biopsy needle by proper use of diamagnetic material so that well-defined artifacts appear dictating the exact position of the needle tip under MR control.

Methods

Based on the preliminary numerical results[2], a special biopsy needle was equipped with negative diamagnetic markers: The needle was a puncture needle (Pencil Tip,16 G, Somatex, Schwerin, Germany) which was supplied with a diamagnetic coating resulting in rings being left out. The needle consists of a hollow titanium tube in which a stylet is guided and can be drawn back inside by means of a handle. The geometry of the manufactured needle is shown in Fig. 1. Both stylet and guiding tube are composed of titanium. The tube has been coated mechanically with a bismuth coating. The thickness of the bismuth coating has been chosen so that the artifact is, theoretically, fully compensated for the stylet being drawn back.

For imaging, we have selected FLASH, FISP and a TSE sequences on an open 0.2 T scanner (Magnetom Concerto, Siemens Medical Systems, Erlangen, Germany) and on a 1.5 T scanner (Magnetom Sonata, Siemens Medical Systems). The needle was mounted on a plastic ring and set into a Gd-DTPA doped water bath (0.5 Vol% Magnevist, Schering, Germany). Sequence parameters are listed in Table 1. Parameters have been optimized individually for both field strengths. We found that there is a large range of possible parameters allowing also for faster imaging with reduced spatial resolution. For the TSE sequence, artifacts are shown for needle orientation parallel to the readout-direction.

Results

The artifacts of the MR compatible biopsy needle are shown for needle orientation perpendicular to the exterior field in Fig. 2. The inner stylet was pulled back inside the hollow needle. The measurement parameters are listed in Table 1. At 1.5 T especially, the bismuth coating leads to a clear depiction of the needle tip geometry. The location of the needle tip can be estimated from the artifacts. Imaging is superior at 1.5 T as compared to at 0.2 T.

For TSE imaging, the needle was oriented in readout-direction perpendicular to the exterior field. In all cases, three dark equidistant point-shaped artifacts remain, indicating the position of the spared out bismuth-rings. From the artifacts in the MR image, the position of the tip can be estimated with a precision of ca.1 mm.

Discussion

As conclusion, instruments have to be well depicted in the MR image without obscuring or distorting the underlying anatomy. Optimization of needle and image parameters should be performed so as not to minimize the artifacts but to render the markers as visible as possible. In case of FLASH and FISP imaging, these artifacts are based on intra-voxel dephasing. In case of TSE imaging, these artifacts are based on misregistration of the signal along the readout direction. FLASH, FISP and TSE sequences were suitable for interventional use at 0.2 T, and at 1.5 T. With regards to the short measurement time, FLASH and FISP might especially be used with reduced spatial resolution for interventions. The imaging contrast has to be maintained together with a high spatial resolution.

We conclude that using diamagnetic markers is a step towards MR compatible needles which can be well depicted, epecially at the tip. Using a fast spin echo (FSE) sequence, a 3-point artifact was obtained with a prototype biopsy needle at both a high-field and at a low-field MR scanner. The 3 point-artifact is a satisfying guide for taking biopsies from well defined target regions, for example, from small tumors or small metastases in the liver in an interventional MR unit.

References

[1] J.R. Reichenbach, S. Wurdinger, S.O. Pfleiderer, W.A. Kaiser, J. Magn. Reson. Imaging. 11(1) Jan, 69-74, (2000)

[2] B. Müller-Bierl, H. Graf, P. Pereira, F. Schick, ICMP/ BMT Conference Proc, 368, (2005)

Fig. 1

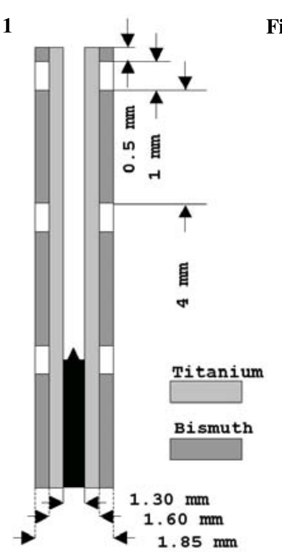

Fig. 2

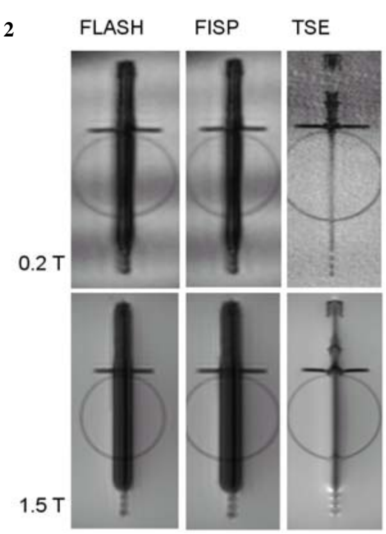

Table 1: Measurement Parameters

Field strength Tesla	Seq. Type	Meas. Time sec	TE/TR/BW ms-ms-Hz/pxl	Flip-Angle deg	Voxel Size mm³
0.2	FLASH	7.5	16/48/30	30	1.8 x 1.4 x 6.0
0.2	FISP	7.5	16/48/30	30	1.8 x 1.4 x 6.0
0.2	TSE	20	28/500/130	180	1.0 x 1.0 x 5.0
1.5	FLASH	10	3.8/48/176	30	1.8 x 1.4 x 6.0
1.5	FISP	10	3.8/49/176	30	1.8 x 1.4 x 6.0
1.5	TSE	20	24/500/130	180	1.0 x 1.0 x 5.0

Fig. 1: Needle prototype with negative markers. The spared-out rings are kept a distance of 5 mm apart from center to center. The distance of the artifacts equals the distance from the top artifact to the needle tip with the stylet being pushed forward to the limit.

Fig. 2: Top row: needle artifacts at 0.2 T (Magnetom Concerto). Bottom row: needle artifacts at 1.5 T (Magnetom Sonata). Artifacts are shown for FLASH, FISP and TSE sequences. For the parameters, cf. Table 1 above.