Fast and Precise: Real Time MR-guided Prostate Biopsy at 3 Tesla in Animal Experiment.

P. Zamecnik[1], A. J. Krafft[2], F. Maier[3], J. Rauschenberg[2], and M. Bock[2]
[1]DKFZ German Cancer Research Center), Heidelberg, Baden-Württemberg, Germany, [2]DKFZ (German Cancer Research Center), [3]DKFZ (German Cancer Resaerch Center)

Introduction
Since MR-guided interventions require both high image quality and short acquisition times, in clinical routine such procedures are increasingly performed within closed-bore high field MR systems which offer only limited patient access. Safe and precise localization of the instruments is mandatory for any intervention. Recently, an automatic tracking technique has been presented, which uses a passive MR marker for real time needle guidance during prostate biopsies [1]. Diagnostic MRI of prostate at 3 Tesla showed better diagnostic values compared with 1,5 Tesla systems [2]. MR-guided prostate biopsies at 1,5T showed better results than the standard ultrasound guided procedures [3]. In this animal experiment the real time passive tracking approach using a manually steerable, highly flexible holder designed for instrument placement in 3 Tesla closed-bore systems was used to perform a fast MR-guided real-time prostate biopsy as an advanced minimally invasive technique.

Materials and Methods
In Fig. 1 and 2 the experimental setup with the highly flexible instrument holder is shown. The device can be directly connected to the MR patient table and allows flexible manual steering. Its distal end features a plastic connector with a ball joint for instrument attachment.
The automatic tracking technique [1] uses a plastic cylinder (Invivo GmbH, Schwerin, Germany) filled with contrast agent solution (Gd-DTPA/H_2O 1:100) as a passive marker. A phase-only cross correlation algorithm determines the marker position from two tracking FLASH images in real-time. Based on the information of the marker position, a trueFISP imaging slice is automatically aligned parallel to the instrument (e.g. puncture needle) which can be inserted through the central opening of the marker. The technique (TR/TE = 3,75/1,61 ms, FOV: 350x350 mm^2, partial Fourier: 4/8) was implemented on a 3 T clinical, whole body MR system (TrioTim, Siemens Medical Solutions, Erlangen, Germany).
In an *in vivo* (3-moth-old, domestic pig) biopsy experiment, it was investigated whether the combination of flexible arm and automatic tracking technique is suitable for safe and precise instrument guidance for prostate biopsy at 3T conditions.
At first, the passive marker was attached to the ball joint of the holder (Fig.1), inserted into the rectum (Fig.2) and moved manually under real-time guidance until aligned with the target. After alignment, the MR-compatible puncture needle was inserted into the prostate under real-time imaging (Fig 3,4,5). Next, the puncture needle mandrel was replaced by an MR-compatible biopsy device under automatic tracking guidance. After confirmation of the biopsy device position using common T2w sequences, the biopsy was performed.

Results
Alignment of the passive marker and insertion of the puncture needle into the prostate was possible under real-time guidance in less than 15 min. The corresponding slice orientation was automatically adjusted parallel to the passive marker, and thus parallel to the needle trajectory. Fig.4, 5 show the final position of the puncture needle successfully perforating the target. The subsequent needle replacement by the biopsy device had no effect on the position of the passive marker. Consequently, the imaging slice orientation was not affected.

Discussion
Safe and precise instrument guidance was demonstrated with the automatic tracking sequence during insertion of puncture needle and the biopsy device into the prostate at 3 Tesla conditions. The flexible holder allowed accurate placement of the instruments in the target volume. During the entire intervention, no manual and time consuming slice repositioning was needed, and the time needed to insert needle/biopsy device was less than 15 min. The image quality during the procedure was very good with only small artifacts caused by the biopsy devices. This technique might lead to shorter procedure times while preserving precise instrument monitoring and excellent anatomical imaging of the prostate during the procedure. In a next step, clinical study with patients with suspect PSA-levels will be initiated to perform the complete intervention under automatic real-time tracking guidance at 3 Tesla conditions.

References
[1] de Oliveira A, et al. Magn Reson Med. 2008; 59: 1043-1050
[2] Bloch BN, et al. Acad Radiol. 2004 Aug;11(8):863-7
[3] Anastasiadis AG et al. Eur Urol. 2006 Oct;50(4):738-48


Fig.1


Fig.2

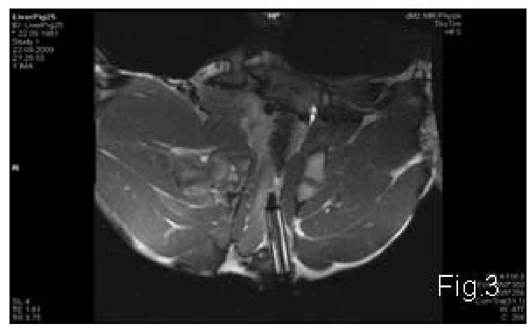
Fig.3

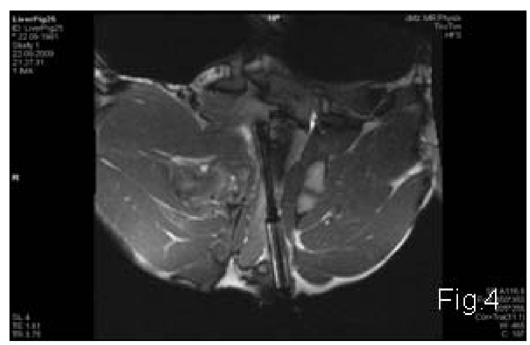
Fig.4

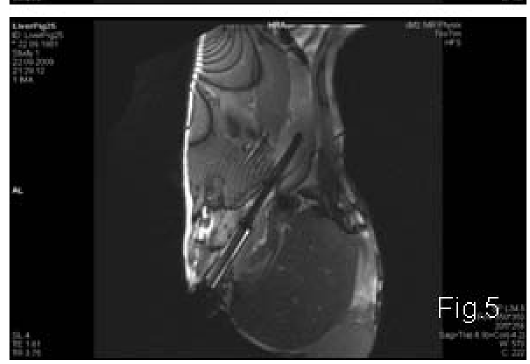
Fig.5