Tracking system for real-time MR-guided percutaneous interventions at 1.5T

R. J. Stafford[1], B. Fetics[2], A. Roth[2], C. Lorenz[3], A. J. Krafft[4], M. Bock[4], and K. Ahrar[5]

[1]Imaging Physics, The University of Texas M. D. Anderson Cancer Center, Houston, TX, United States, [2]Robin Medical, Inc., Baltimore, MD, United States, [3]Siemens Medical Solutions, Inc., Baltimore, MD, [4]Division of Medical Physics in Radiology, German Cancer Research Center (DKFZ), Heidelberg, Germany, [5]Diagnostic Radiology, The University of Texas M. D. Anderson Cancer Center, Houston, TX, United States

Introduction

MRI provides excuisite soft tissue contrast for localization and guidance of percutaneous interventional procedures without using ionizing radiation. Recently, higher field MR scanners with patient access more akin to CT and compatible/safe equipment have entered the marketplace (Stattaus , et al, JMRI 2008;27:1181–1187). One problem associated with efficiency of workflow in performing these procedures is the ability to quickly plan out the procedures and observe the needle trajectory in real-time prior to placement in tissue. In this report we describe our initial experience with an FDA approved active tracking system for MRI that can be used in a cylindrical bore to help plan and target needle/applicator placement in real time. The procedures are carried out in a dedicated interventional MR suite featuring a 1.5T short bore MRI with wide aperture for ease of access to the patient. We show preliminary results in a phantom demonstrating the ease of use for targeting.

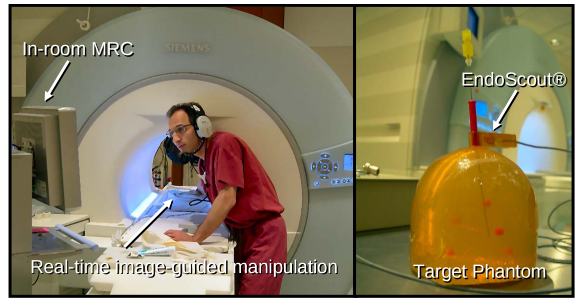

Fig 1: Interventional radiologist uses a live overlay of needle trajectory from EndoScout® on planning images in coordination with a live gradient echo image of the target to guide needle through a sterilizable guide into a biopsy phantom.

Materials

All procedures were performed in an outpatient interventional facility featuring a short bore (125 cm) 1.5T clinical MRI scanner (MAGNETOM Espree, Siemens Medical Solutions, Inc.) with a wide aperture (70 cm). The system is equipped with an 18 channel receiver and high performance gradients (DZ-Engine, 33 mT/m amplitude; 170 T/m/s slew rate) for rapid, high resolution imaging. A breast biopsy phantom (Invivo Corp.) and tri-modality abdominal phantom (CIRS, Inc) provided targets. A single loop coil (Siemens Medical Solutions, Inc.) was placed atop the phantoms and the spine array provided signal from underneath. A table side, in-room monitor (MRC) was used to visualize procedure progress from either side of the bore or patient table. Communication between technologist and radiologist was facilitated using an MR compatible communication system with digital noise reduction (IMROC, OptoAcoustics).

An FDA approved, commercially available needle tracking system for MRI (EndoScout®, Robin Medical, Inc.) was integrated into the gradient cabinet in the control room. EndoScout® software provides real-time projected needle trajectory overlays on planning images (with coordinates) using a gradient echo imaging sequences which had been designed for real-time needle tracking (and imaging) with the EndoScout® (the latter are non-FDA cleared, investigational features).

For static planning images, orthogonal SSFP images (TR/TE/FA=3.6ms/1.4ms/72º, 256x192, 5mm thick slices, 0.7s per acquired plane) through the target lesion were collected. Then a 2D gradient echo single slice transverse acquisition (TR/TE/FA=15ms/2.8ms/15, 160x160, 10mm thick slice, 2.4s/img) in the plane of the lesion was prescribed to activate the gradient tracking and provide real-time feedback images of the target slice to visualize in coordination with the projected trajectories on the planning images.

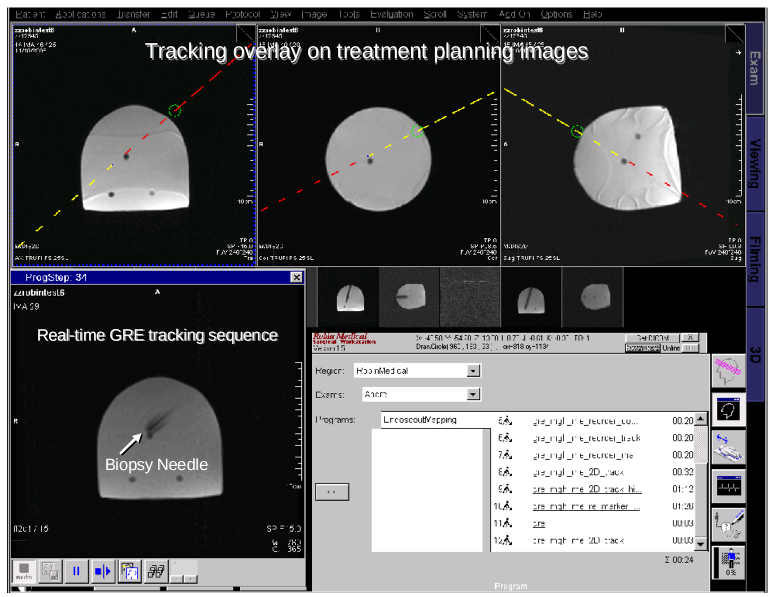

Fig 2: EndoScout® software overlays trajectories on static planning images of a 5-mm target. Live single slice gradient echo images in the plane of the target provide verification. Difference between EndoScout® trajectory and needle location at target is <3mm.

Results

Given the Espree bore dimensions, the radiologist was able to reach into the scanner to manipulate the needle in real-time while observing the projected needle trajectories on the in-room MRC (Fig. 1). Real-time guidance was performed on four targets (3 in breast phantom and 1 in the abdomen phantom) and the perpendicular deviation from the planned trajectory versus the measured trajectory or actual needle was <3 mm in each case. Examples of two procedures are illustrated in Fig. 2 & 3. In cases where the needle was oblique to the real-time plane, after initial placement was completed, the trajectory coordinates could be used to quickly prescribe oblique and double oblique planes to catch the needle and proceed with real-time guidance or intermittent imaging as needed.

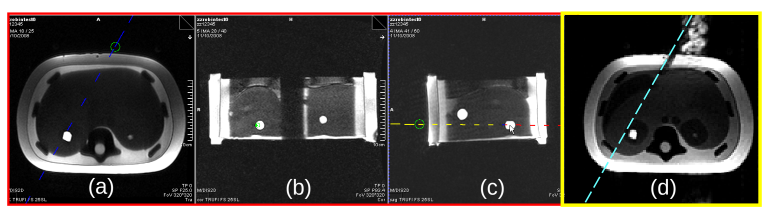

Fig 3: Active tracking of the needle trajectory on orthogonal trueFISP planning images (a-c) of a tri-modality liver biopsy phantom. The projected needle trajectory from a post-placement trueFISP image is shown in (d). At lesion depth, perpendicular distance between EndoScout® trajectory in (a) and projected needle trajectory in (d) is <3mm.

Discussion

Here we present our initial evaluation in phantom of an FDA approved tracking device for the interventional MRI environment. We investigated the feasibility for aiding needle placement in real-time guidance of percutaneous procedures. We found that the device is easily integrated into our interventional MRI suite and can be manipulated by the radiologist in real-time for targeting lesions. The predicted trajectories agreed well with observed trajectories on images. Without further modification, the device would be useful for both initial needle placement or real-time guidance of the needle to target in conjunction with a live image. Currently, we are working to expand the functionality of the system for real-time guidance. Integrating the system with Siemens commercially available SSFP based interactive real-time sequence (BEAT_IRT) for real-time manual or automated feedback based manipulation of the imaging plane to match the trajectory would be useful. Further efforts to integrate the system with multiplanar real time acquisition (pre-market BEAT_IRTTT) in conjunction with the navigation/visualization too Interactive Front End (IFE) has potential for making real-time manipulations easier in a cylindrical bore magnet.