# MR-Guidance Method for Needle Procedures Using a Dedicated Interventional MRI Suite and Device-independent Active Tracking Markers

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**Purpose:** MR-guided needle procedures are becoming more frequent with the availability of open and wide-bore MR systems. Feasibility was shown for different applications such as breast-, liver- or prostate-biopsies in patient studies [1]. Different techniques were proposed, using real-time image guidance, special passive needle guides or biopsy devices with integrated active MR markers [2]. In this work, we propose small active MR markers that can be applied for most needle applicators in combination with a dedicated software package for MR interventions. This setup may provide shortened procedures using already commercially available biopsy devices. Basic feasibility of the new combination was shown in a phantom experiment.

**Methods**: Mock-up biopsy experiments in a pomelo were performed using a real-time image guidance platform (Interventional MRI Suite, "iSuite", Philips Healthcare, Philips Research) [3] connected to a standard clinical 1.5T scanner (Achieva, Philips Healthcare) with a 30' in-room display (eSys, Philips Invivo). The iSuite visualizes 3D MR images (roadmaps) as well as real-time 2D images and models for all kind of tracking devices. The scan-geometry can be manipulated interactively during real-time imaging. It is possible to switch instantaneously between arbitrary imaging and tracking sequences. Both, 2D real-time images and reformats of a 3D roadmap, can be aligned with the direction of a tracked device.

Miniature active markers were designed using a two turn PCB-based receive coil fitted to the size of commercially available torus-shaped fiducial signal sources (PinPoint, Beekley Medical, Bristol, CT). A tune and match to 50Ω as well as a detune circuit including a PIN-diode is located on the PCB. The full assembly has an overall size of 27x15mm. The bias voltage for the PIN-diode is supplied via the micro-coax cable, which is also used for transmitting the RF-receive signal. The fiducial is bonded on top of the double layer PCB coil in such a way that the center hole of the marker superposes the center of the coil loop (Fig. 1a). Each marker is attached to a separate receive channel of the MR system. In order to determine the location of a marker center in the 3D space, a pulse sequence similar to [4] is applied (Tip angle: 20°, TR: 5.1ms, in plane resolution: 0.8mm). Since the markers are located outside of the subject under examination and since the coils have a localized sensitivity profile, the received signal originates from the fiducials only. The strong signal dropdown at the edges of the fiducials can be easily detected within the acquired three projections. Due to the symmetry of the torus-shaped fiducials, the center of each marker can easily be determined from the detected edges of each fiducial, independent of the direction of the projection relative to the coil orientation. Two of these markers are placed on the needle shaft in order to acquire the position and the orientation of the device (Fig. 1b). It is assumed that the needle is rigid in the first instance. The first marker is fixed to the proximal end of the needle shaft. The second one is placed on the subject under intervention, guiding the needle during initial puncturing. When the needle tip is placed on this second marker, the initial tracking cycles are used to automatically calibrate the length of the needle. This allows displaying the needle tip relative to the two markers, while pushing the needle through the second maker. A needle model, including the marker positions, is displayed overlaid on a 3D roadmap (Fig. 2a). The tracking sequence allows a position update rate of up to 30Hz, enabling fast optical feedback to the operator. The actual needle orientation is used to display three reformatted, orthogonal views of a 3D roadmap. In this way, the optimal insertion angle can be found intuitively. Roadmaps are typically acquired at the beginning of the intervention, e.g. to show optimal contrast for the targeted lesion or risk structures. Immediate switching between available roadmaps is possible. 2D images can be quickly acquired to verify the needle position on the basis of its artifact intermittently and finally when the needle is placed in the desired position.

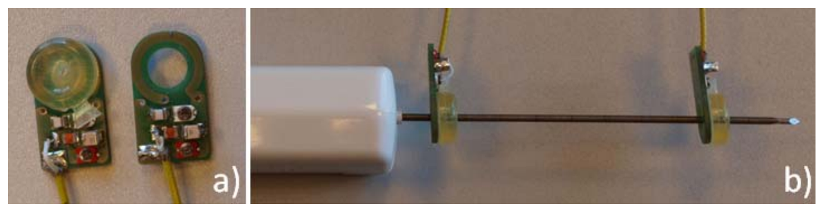


**Fig. 1: a)** Miniature active marker with and without mounted fiducial. **b)** Two active markers placed on a MR compatible biopsy needle.

**Results:** The setup enabled targeted advancement of the needle under free-hand guidance for an inexperienced operator, easily hitting the planned target. The display of the needle model relative to three orthogonal reformatted slices of the 3D roadmap aligned with the needle allowed intuitive navigation. The needle position and orientation as derived from the marker tracking was well aligned with the passive visualization by 2D gradient echo images (Fig. 2b).

**Discussion:** The high tracking rate allows for fast, intuitive and accurate needle placement in phantom experiments. For control, 2D images in automatically determined slice orientations can be acquired immediately. The method thus allows frequent imaging-based guidance control to enable applicability in organs moving e.g. due to respiratory motion.

**Conclusion:** The proposed setup supports fast and reliable MR guided needle procedures, taking advantage of the excellent soft-tissue contrast of MRI. The combination with almost any needle device should be possible. As a next step, after sterilizability has been implemented, the procedure has to be tested in a clinical setup.

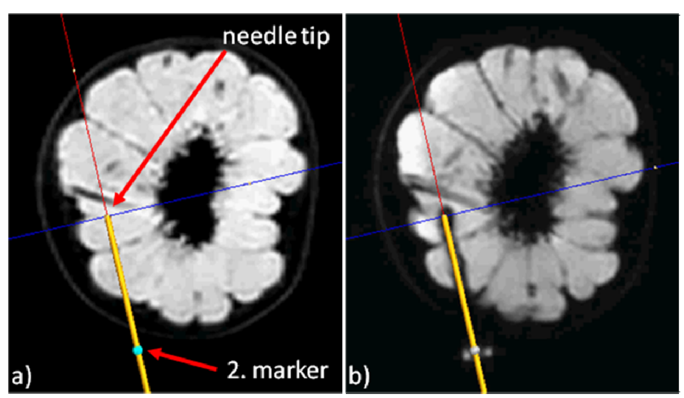


**Fig. 2: a)** Snapshot of one viewport of the iSuite, showing a multi-planar reformat of a 3D roadmap, overlaid by the needle model (orange). **b)** 2D gradient echo image of the same geometry as a), showing the needle is correctly placed. The red and blue lines depict the orientation of the image slices shown in the two other viewports.

**References:**

**[1]** Fischbach F et al. Radiology 2012; Nov;265(2):359-70. **[2]** Coutts GA et al. Magn Reson Med 1998; 40:908-913 **[3]** Fischbach F et al. Proc 9th International Interventional MRI Symposium 2012; V13 **[4]** Dumoulin CL et al. Magn Reson Med 1993; 29:411-415