Spinal infiltrations and biopsies using an advanced real-time MR guidance approach: preliminary clinical report

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Introduction: The multiplanar imaging capabilities of MR are of great advantage for real-time needle guidance compared to CT. However, manual initial imaging plane positioning for needle guidance is time consuming and precise alignment along the planned trajectory can be very difficult, in particular for complex trajectories. In addition, when working with a single-slice sequence one needs to switch between imaging planes of different orientations to accurately monitor needle advancement. The focus of this work is to clinically evaluate an advanced MR guidance approach for percutaneous needle interventions consisting of an interactive, real-time multi-slice pulse sequence in combination with an interventional MRI software package.

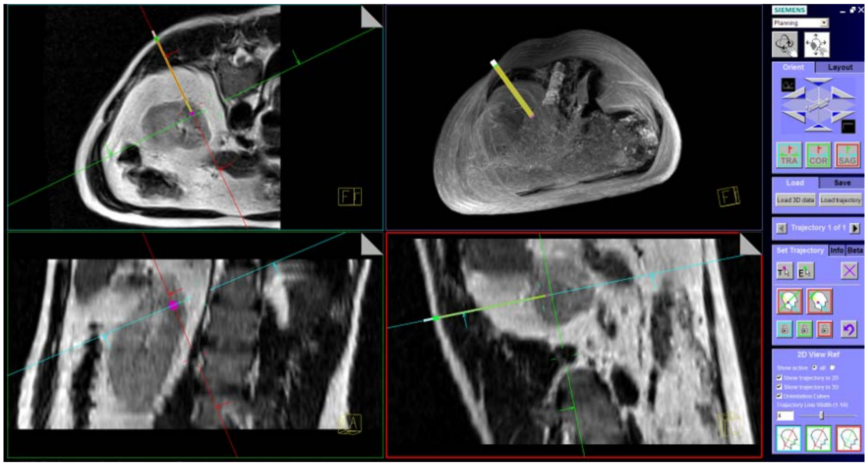

Fig. 1*: Planning of a double-oblique path for a kidney biopsy using a 3D BLADE dataset in Planning@IFE. The trajectory (yellow line) is defined by selecting the entry and target points in any MPR plane. The MPRs can be automatically aligned along the planned path for trajectory review (as shown here) and automatic real-time slice positioning.*

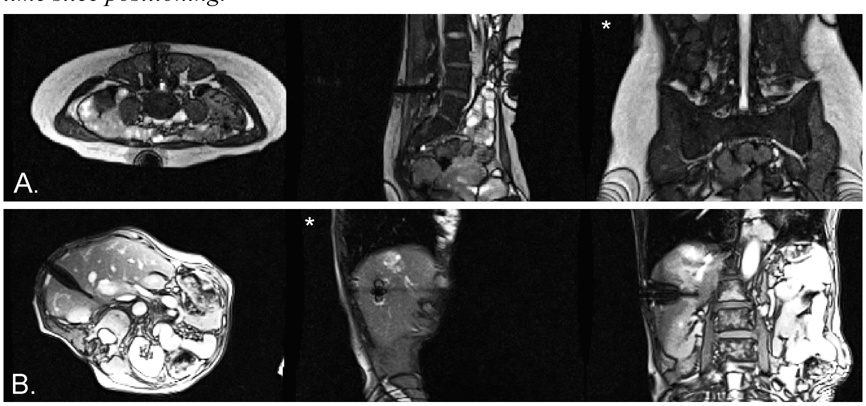

Fig. 2*: Real-time pseudo-axial, -sagittal and -coronal slices during a spinal infiltration (A) and a liver biopsy (B, patient placed on a cushion for entry point accessibility). Slices were automatically aligned along the planned needle path.*

Method: All procedures were performed on a 1.5T open bore MR scanner (Siemens MAGNETOM Espree, Erlangen, Germany) with local anesthesia (xylocain). Body matrix and spine matrix coils were used when feasible; otherwise the body coil was used. For needle guidance an interactive real-time, multi-slice balanced SSFP works-in-progress pulse sequence (BEAT_IRTTT, Siemens Corporate Research, USA) [1,2] was used together with an extended version of the Interactive Front End (IFE, Siemens Corporate Research, USA) [3] providing advanced planning capabilities (Planning@IFE, Fig. 1) and automatic real-time image plane alignment along the planned path. For planning, a T2-weighted 3D dataset (BLADE, 12 to 30 slices, field-of-view 380 mm, reconstructed in-plane resolution 1.5 mm, slice thickness 3 mm, total acquisition time 40 to 100 s) was used. Needles were placed under continuous imaging with patient free-breathing. Relevant imaging parameters for the BEAT_IRTTT sequence were: matrix 224×202, field-of-view 350 to 450 mm, in-plane resolution 1.56 to 2 mm, slice thickness 4 mm, TE/TR 2.2/4.1ms, flip angle 50°, bandwidth 302 Hz/Px, temporal resolution 819 ms. Patient inclusion criteria for MR-guidance were: young patients under the age of 50 (to limit X-ray exposure); patients with tumor not visible with CT; patients with tumor location requiring pseudo-axial needle path (e.g. liver Couinaud segment 8). Other patients referred for CT guided spinal infiltration (cortivazol, 4.75 mg) or biopsy were randomly included for MR guided procedure.

Results and Discussion: BEAT-IRTTT and IFE were successfully used in 9 spinal infiltrations and in 6 abdominal biopsies (Figs. 1 and 2). Procedures were performed by three experienced interventional radiologists. A total of 19 needle paths were defined. The automatic slice alignment in Planning@IFE produces an initial imaging plane positioning with respect to the planned trajectory and the patient principal axes. The slice positions can be further interactively adapted during the intervention. This allows even a less experienced technologist to run the scan. In addition, radiologists reported that using two orthogonal real-time imaging planes facilitates continuous 3D visualization of the needle, target, and surrounding structures (Fig. 2). This was particularly useful for abdominal biopsies which often require a double-oblique path. To further speed up procedure time, the imaging plane at the needle tip (marked by an asterisk in Fig. 2) was only switched on once the needle was close to the target to control final needle depth. Total procedure time (planning and needle guidance) ranged from 3 (spinal infiltration) to 30 min (complex kidney biopsy, 3 samples).

Conclusion: In this preliminary work, an advanced MR guidance approach was used for spinal and abdominal punctures in 15 patients. To our experience, automatic real-time slice alignment greatly simplifies the workflow and is an important step towards decreased MR guided procedure time. The proposed slice layout with three slices along the planned trajectory orthogonal to each other further allows for efficient and safe needle placement also into difficult target locations.

References: [1] Pan et al., Proc. ISMRM, p. 195, 2011. [2] Stafford et al., 8th IMRI Symposium, p. 111, 2010. [3] Lorenz et al., Proc. ISMRM, p. 2170, 2005.