

Real-time MR-Guided Percutaneous Interventions in a Dedicated 1.5T Clinical Suite

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Introduction

MRI is a non-invasive, non-ionizing imaging modality which provides unparalleled soft tissue contrast for localization of anatomy and disease for guidance of percutaneous interventional procedures such as biopsy and ablation. Low field (≤ 1.0) magnets have traditionally been the systems of choice due to patient access, but at the cost of performance and SNR. 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). In this report we describe our initial experience with a dedicated interventional MR suite featuring a 1.5T short bore MRI with wide aperture. We describe our techniques, equipment, protocols and results with a focus on our approach to MR-guidance to percutaneous procedures using real-time imaging or intermittent scanning.

Materials

All patients were enrolled in a prospective study approved by our Institutional Review Board. All procedures were performed in an outpatient interventional facility (with full anesthesia support) featuring a short bore (120 cm) 1.5T clinical MRI scanner (Magnetom Espree Siemens vB13, Medical Solutions) 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. Surface coils (8-channel body matrix or single loop coil) were placed on top of the patient while the built in spine array provided signal underneath. Two table side, in-room monitors were used to visualize procedure progress from either side of the bore or patient table. Communication between technologist and radiologist was facilitated using MR compatible communication system with digital noise reduction (IMROC, OptoAcoustics).

Non-contrast enhanced T2-W single and multi-plane trueFISP or HASTE sequences, with and without fat saturation, were primarily used for real-time image guided MR compatible biopsy needle placement or intermittent imaging while T1-W imaging was performed only sparingly. Bandwidths were generally kept high (≥ 500 Hz/pixel), and were increased with increasing field of view to minimize artifacts. Acquisitions times were on the order of about 0.6s per image (real-time BEAT_IROTT) to 4s-7s (5-plane trueFISP or HASTE for intermittent imaging).

Results

A total of 183 MRI-guided biopsies were performed during from 10/2007-8/2008. Real-time MRI guidance was used in 59 cases (33%). The biopsy sites were soft tissue (57%), bone (23%), kidney (9%), or liver (11%). Trajectories included axial, sagittal and double oblique approaches non-axial approaches often being employed in kidney or liver. A fluid filled dilator [1:50 Gd] was used as a reference marker during planning. Axial planning was landmarked to the axial alignment laser while non-axial approaches required use of both lasers and coordinates of the entry point from the planning images. Laser accuracy on both sides of the bore (accuracy was better than 2mm after initial calibration) and dilator signal levels were added to daily scanner quality assurance scanning. The pre-market trueFISP sequence designed for real-time interventional procedures (BEAT_IROTT), standard trueFISP, and HASTE real-time sequences were used in 44%, 49%, and 7% of cases, respectively with BEAT-IROTT providing either single or multiplanar images (Figure 2).

Conclusions

Clinical real-time MRI-guided manipulation of biopsy needles at 1.5 T is technically feasible in compact length magnets with expanded bore diameters. The bore dimensions facilitated better access to the patient than conventional cylindrical bore designs often enabling real-time MR guided manipulation of equipment without robotic assistance. However, the ergonomics of patient access are still somewhat limited and mechanical devices which assist in positioning/holding equipment would be valuable additions as well as easy-to-use software/hardware for real-time passive or active needle tracking to increase workflow. We found that the combination of high-field (1.5T) with a high performance gradients and a multi-channel system facilitated rapid acquisition of high resolution images at a rate of approximately 1 image per second provided adequate tissue and needle contrast for real-time MRI-guidance of percutaneous biopsies without need for contrast agent. Additionally, the use of a fast multiple planar T2-W acquisition (BEAT_IROTT) and display for real-time monitoring proved an extremely useful aid for needle navigation.

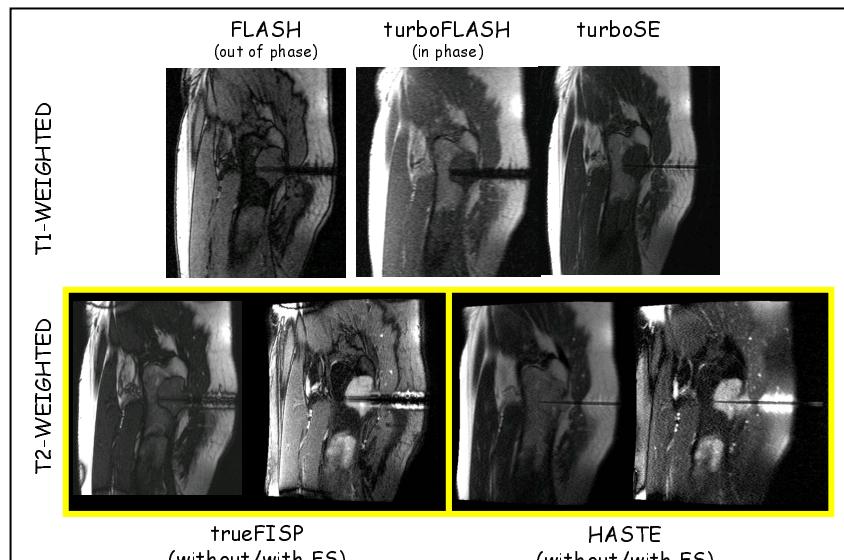


Figure 1: MR-guided biopsy of metastatic sarcoma in left femur. Non-contrast enhanced T2-W trueFISP and HASTE sequences were usually chosen over T1-W sequences for planning, real-time needle guidance, and intermittent imaging.

(Figure 1). FOV ranged from 22cm–30cm with acquisition matrices of 256 x 192.

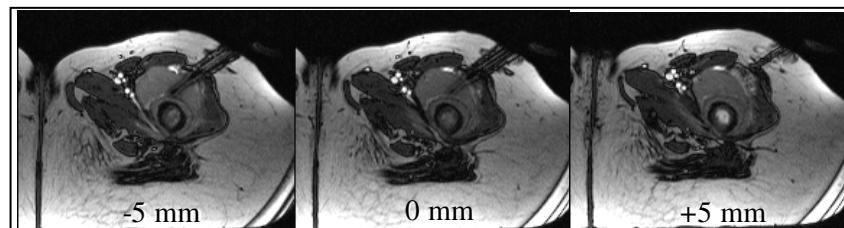


Figure 2: High resolution real-time multi-planar trueFISP (BEAT_IROTT) was useful for biopsy guidance and facilitated the ability to more easily guide the needle to multiple targets than single slice approaches with frame rates on the order of <2s.