Preliminary clinical experience with a navigation system for biopsies in a diagnostic 1.5T closed-bore MR scanner

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Introduction/Purpose

Minimally-invasive MR-guided interventions are becoming increasingly important due to a number of well-known advantages of MRI over other imaging modalities. Over the last years, different concepts for interventional assistance and instrument navigation have been described for practically all regions of the body [1]. In the standard MRI environment around a closed-bore (cylindrical) scanner, however, the manipulation options inside the bore are very limited. Therefore, we are pursueing a concept where the patient is moved out of the bore and the navigation system uses instrument positions that are properly registered to the MR coordinates of 3D anatomical roadmap data. The purpose of this work was to report on our preliminary clinical experience from four navigated biopsies in different regions of the body.

Materials and Methods

The basic setup of the navigation system (Localite GmbH, St. Augustin, Germany) has been described previously [2]. MR navigation is based on 3D roadmap data acquired immediately before the intervention. An additional MR scan captures the position of three MR-visible markers on a flexible holder that is placed next to the interventional entry. The holder also features a set of three optical reference markers in a fixed geometry to the MR markers. A second set of reflective markers is attached to the instrument (biopsy needle) via a sterilizable MR tracker. A tracking camera (Polaris Spectra, NDI, Waterloo, Ontario) continuously determines the relative position between instrument and reference markers. After automatic 3D localization of the MR marker positions [3], the coordinate transformation between the instrument position/orientation and the MR coordinates is known. The navigation system then calculates the virtual position of the instrument and displays the reformatted slices onto a 35"×27" large in-room screen in realtime (Fig. 1 top). Needle guidance is accomplished by a flexible custom-made (Leipzig University/Invivo Germany) holder with a detachable ball at its end (Fig. 1 bottom). A flexible loop (Ø=19 cm) and the integrated spine array coil (1.5T Siemens Symphony) were used for imaging. Biopsies were taken with coaxial 16G true cut systems (Invivo, Würzburg, Germany and Somatex, Teltow, Germany). The study was approved by the institutional ethic committee, and written informed consent was obtained from all patients prior to biopsy.

Results

Four biopsies, 2x kidney, 1x liver, and 1x lower extremity (medial vastus muscle), were guided by the Localite system without major complications. Both T1- and T2-weighted sequences (VIBE, TSE and HASTE) were used to plan the intervention and control the actual needle position (Figs. 2 and 3). All biopsy samples were diagnostic (clear-cell carcinoma of the kidney parenchyma, focus with chronic fibrous interstitial nephritis, liver metastasis of a poorly differentiated adenocarcinoma, and focal fibrosis in the thigh).

To achieve the same level of inspiration for the liver biopsy during breathhold, a short respiration training was performed. In addition, adequate local and systemic analgesia was provided in all cases. Patients with a BMI up to 35.4 kg/m^2 could be biopsied successfully. Proper line-of-sight between optical markers and camera could be established by adjusting the camera position accordingly. In all cases, the trajectory was double oblique. Maximum intervention time was 1:28 h.

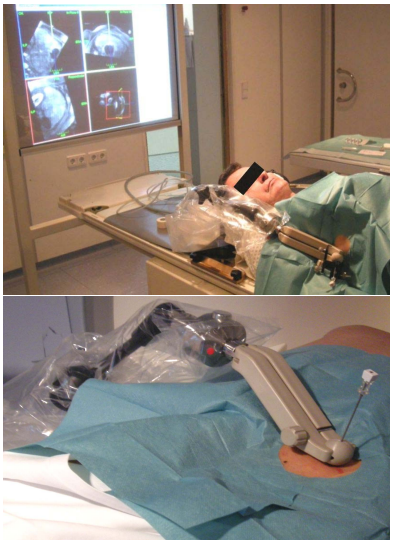

Fig. 1: Clinical setup for biopsy. **Top:** Liver biopsy with navigation scene on in-room screen showing position of inserted needle. **Bottom:** Kidney biopsy with partially inserted needle held by custom-made bracket holder illustrating the various degrees of freedom.

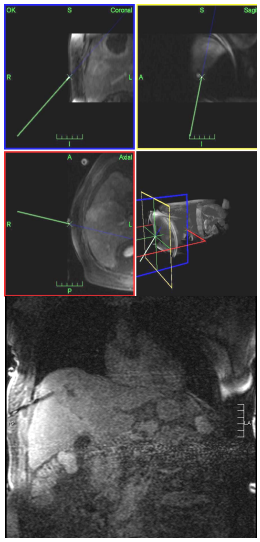

Fig. 2: Biopsy in the right liver lobe. **Top:** Screenshot of the corresponding navigation scene showing three standard views and 3D rendering. **Bottom:** Intra-operative control image (CE T1w VIBE, TA=17 s) with needle artifact.

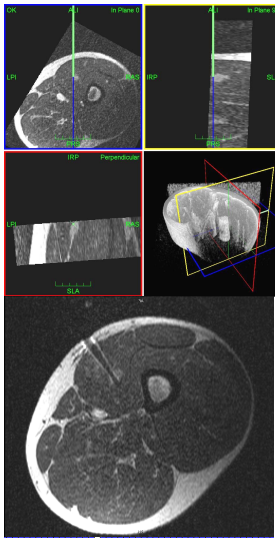

Fig. 3: Biopsy in the right medial vastus muscle. **Top:** Screenshot of the navigation scene showing three instrument-related views. **Bottom:** Intraoperative control image (CE T1w TSE) with needle inside lesion.

Discussion and Conclusion

Our preliminary results show that the presented navigation technique could be reliably put to clinical use in various regions of the body. By following a specific breathhold protocol, punctures could even be performed in organ regions affected by respiratory motion (liver and kidney). Due to the realtime image reformatting in three planes and good hand-eye coordination, double oblique biopsy trajectories could easily be realized. In addition, the relative referencing technique warrants a valid registration at arbitrary MR table and camera positions. Care must be taken with the positioning of the MR markers with respect to the isocenter because the applied gradient correction is less reliable at larger distances. To ensure sterility at smaller distances, a sterilizable reference holder will be used. In comparison with other assistance devices for closed-bore scanners (e.g. [4]), the presented setup is more compact and also allows interventions in more obese patients.

In conclusion, the navigation system could be integrated into the standard environment of a primarily diagnostic (closed-bore) scanner with only little modification. It allowed flexible and reliable MR-guided punctures in various regions of the torso and extremities.

References [1] M. Moche et al., JMRI 2008;27:276, [2] H. Busse et al., Proc. ISMRM 2008:#1214, [3] H. Busse et al., JMRI 2007;26:1087, [4] M. Moche et al., Proc. ISMRM 2007:#486.