Initial clinical experience with a robotic assistance system for liver biopsies in a diagnostic 1.5T MR scanner

M. Moche[1], D. Zajonz[1], T. Kahn[1], and H. Busse[1]

[1]Dept. of Diagnostic and Interventional Radiology, Leipzig University Hospital, Leipzig, Germany

Introduction/Purpose

Freehand MR-guided biopsies in a closed-bore MRI scanner are typically performed by iterative cycles of visual targeting, manual instrument feed (outside the bore) and verification of the actual position with MR imaging (inside the bore) [1]. Based on the potential needle offset seen on the MR image, the physician uses a mental representation of the 3D geometry to reposition the instrument. Image guidance may be improved by providing the physician with geometrically aligned image information during instrument feed (navigation). An alternative solution is to attach the instrument to a device which allows to realize a trajectory according to an MR image-defined trajectory. The aim of this work is to report about our initial clinical experience of using a commercial robotic assistance system to perform percutaneous liver biopsies in a diagnostic MR scanner.

Materials and Methods

The MR-compatible assistance system Innomotion (Innomedic GmbH, Herxheim, Germany) fits into the 60-cm bore of a standard 1.5T MRI scanner [2]. Coarse positioning of the main unit is achieved manually by arresting the arm in five distinct positions along the supporting C-arm. Fine positioning with six degrees of freedom occurs via servo-pneumatic actuators which are controlled remotely. The application module (AMO, Fig. 1 top) at the end of the unit is equipped with a sleeve holder for the respective instrument and features four MRI-visible reference markers for additional position verification. Imaging was performed with a flexible loop coil (Ø=19 cm) in combination with the spine coil. T1- and T2-weighted breathhold sequences (VIBE, TrueFISP and HASTE) were used to plan and control the intervention. Entry and target points of the biopsy were defined on a dedicated workstation in the MR control room. After a short calibration step, the system moved the guiding sleeve into the planned trajectory. Outside the magnet and in breathhold, the needle is manually inserted by the physician. Immediately after needle placement, the guiding sleeve was disconnected from the system to avoid motion-induced liver injury (Fig. 1, bottom). The actual needle position was then controlled by appropriate MR scans. Biopsies were taken with coaxial 16G true cut systems (Invivo, Würzburg, Germany and Somatex, Teltow, Germany) with a length of 100 to 200 mm.

Results

Twelve liver lesions were biopsied (4 left and 8 right lobe) without any major complications or technical failures. All samples were suitable for histology yielding 5 hepatocellular carcinomas (HCC), 2 focal nodular hyperplasias (FNH), 2 metastases of an adenocarcinoma, 1 hemangioma, and 2 regenerating nodules. Most lesions (but two) could not be sufficiently discerned on native CT. With MRI, 10 of 12 lesions could be visualized without contrast enhancement (CE).

To achieve the same level of inspiration during breathhold, a short respiration training was performed. In addition, adequate local and systemic analgesia was provided. Patients with a body mass index (BMI, in kg/m^2) of up to 29.4 fitted into the bore reduced by the device. In one case, the integrated spine coil was removed to gain further space. One procedure on a patient with a BMI of 36.6 had to be finished in freehand technique. On average, 1.7 needle repositionings were necessary to reach the target. In 9 of 12 cases, the trajectory was double oblique. The median time between first and final MR scans was 1:17 h (0:52-3:25 h range).

Fig. 1: Clinical setup for liver biopsy. **Top:** Patient positioning for lateral access. **Bottom:** After insertion of the coaxial needle, the sleeve holder was disconnected and the device withdrawn from the intervention site.

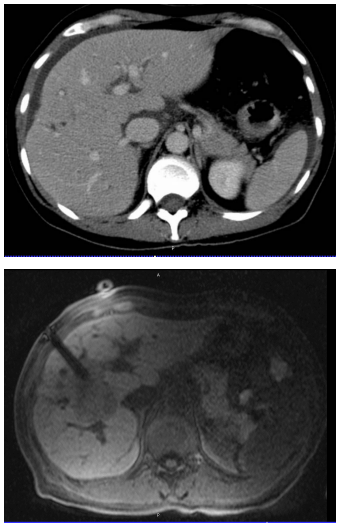

Fig. 2: Biopsy of a lesion in the right liver lobe (HCC, Ø=3 cm). **Top:** On native CT, the lesion was not visible. **Bottom:** Intraoperative control image (CE T1w VIBE, TA=17 s) after needle placement with good tumor visualization.

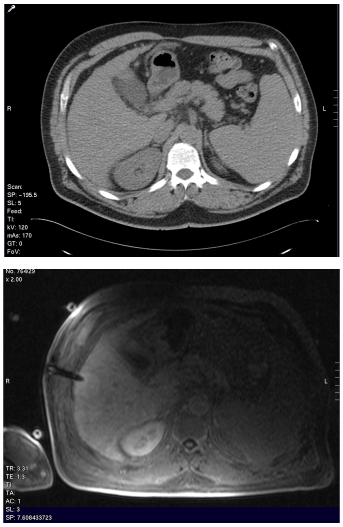

Fig. 3: Biopsy of a central lesion (FNH). **Top:** On CE CT (portal venous phase), the lesion was not visible. **Bottom:** Good tumor delineation on native MRI (T1w VIBE). The coaxial needle was inserted between two larger vessels.

Discussion and Conclusion

Adequate breathhold training with the patient is considered essential for liver biopsies. Patients with a BMI of up to 30 could be biopsied despite the spatial confinement. Most of the interventions could be performed without contrast media and the learning curve suggests a mean intervention time of less than one hour. The realization of double oblique access paths is considered to be improved by the device. In conclusion, our initial clinical results suggest that liver biopsies in a closed-bore MRI can be largely assisted with the presented robotic device. The main indication for such an approach is expected for lesions that are visible on MRI only.

References

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[2] S. Zangos et al., Eur Radiol 2007;17:1118.