High-resolution in vivo imaging of inguinal lymph nodes using 7 Tesla MRI: a feasibility study.

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Introduction

Clinical imaging of inguinal lymph nodes plays a vital role in many cancer diseases such as lymphoma, skin cancer, gynecologic and urologic tumors. However, conventional imaging approaches lack sufficient sensitivity to detect micrometastasis in lymph nodes [1]. This difficulty can be attributed to the small size of lymph nodes which may contain sub-centimeter tumor clusters in the early stages, and the lack of spatial resolution. Therefore, the correct nodal staging remains a central radiologic challenge.

To date, the imaging of lymph nodes at 7 Tesla is unexplored *in vivo* but has been performed *ex vivo* for healthy lymph nodes of post mortem specimens without cancer [2] and dissected lymph nodes of breast cancer patients [3,4].

Against this background, the first step of the current pilot study was to develop a feasible *in vivo* approach to visualize inguinal lymph nodes at 7 Tesla using a T_1w sequence and a loop coil at highest feasible resolution with regard to measurement time and adequate image quality. The second aim of the current study was to qualitatively evaluate the visible anatomical details, the reproducibility, and overall workup of the procedure. To test the clinical feasibility, we additionally examined one patient with malignant melanoma and known macro-metastasis.

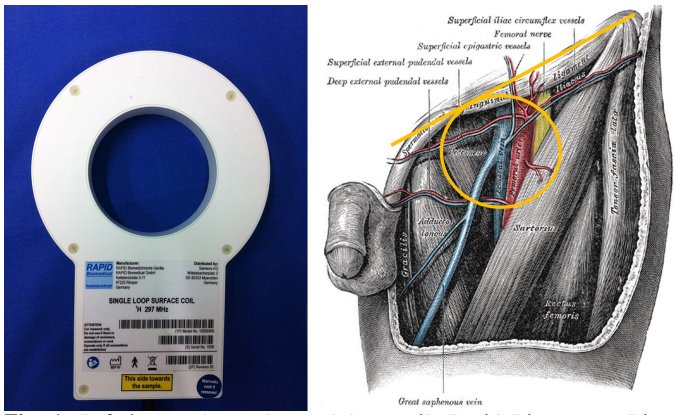

Fig. 1: Left image shows the used loop coil (Rapid Biosystems, Rimpar, Germany). Right image [5] demonstrates the positioning of the loop coil. The orange line represents the inguinal ligament and the coil (orange circle) is positioned tangentially and medio-caudal of that line.

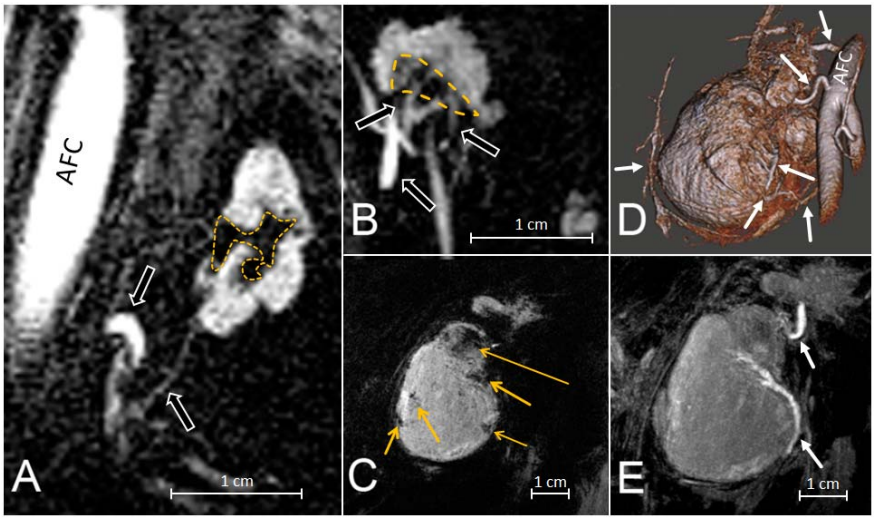

Fig. 2: Visualization of inguinal lymph nodes using the T1w sequence as described in the materials and methods (A, B and C). A-B: lymph nodes of healthy volunteers. Black arrows show vessel supply to the healthy lymph node. The dashed orange line marks the fat hilus region, AFC = Arteria femoralis communis. C-E: Lymph node macrometastasis of a patient with melanoma. Orange arrows indicate randomly scattered hypointense regions among the metastastic lymph node corresponding to displaced fat tissue or tumor necrosis. White arrows demonstrate pathological vessel infiltration. D: 3D-reconstruction using Fovia (Palo Alto, California, USA) demonstrating the vessel infiltration with origin from the femoral artery. E: Maximum intensity projection to visualize vessel infiltration.

Materials and Methods

The examinations were performed in accordance to the declaration of Helsinki and were approved by the local ethics committee. All measurements were performed on a 7T whole-body scanner (MAGNETOM 7T, Siemens, Erlangen, Germany) with a single-channel surface loop coil (Rapid Biosystems, Rimpar, Germany). We established the examination procedure on 6 healthy volunteers and tested its clinical feasibility on 1 patient with malignant melanoma and known inguinal lymph node macrometastasis. Best image quality was achieved by a T_1w, flow-compensated, fat-saturated Gradient-Echo sequence (imaging parameters: TR/TE 21/6.8 ms, 15° nominal flip angle, 0.38×0.38×0.38 mm³ isotropic resolution, 1 average). The acquisition time strongly depended on the weight/height of the individual due to SAR limits and was (10.0 ± 5.7) min. in average, minimum 3.30 min., maximum 20 min.. For coil positioning, see Fig. 1. The loop coil was fixed with a small sand bag and strapped to the patient table. In the patient case, the lymph node position was determined by ultrasound-imaging prior to the MRI examination to improve later coil positioning.

Results and Discussion

Imaging results for one healthy volunteer is shown in Fig. 2A, B. In healthy subjects, on average (7.5 ± 1.6) lymph nodes were detectable. A fat hilus sign was seen in (61.3 ± 19.9) % of the detected nodes. Flow-compensation reduced flow and pulsation artifacts beyond visibility, breathing artifacts were not present. The examination procedure was comfortable and stable for all tested participants (n=7). With this technique, microscopic details of the lymph node such as fat hilus sign, afferent and efferent vessels can be visualized in normal lymph nodes (Fig. 2 A, B). In case of the patient with lymph node macrometastasis, pathological vessel infiltration and the connection of these vessels to the surrounding arteries were visible at 0.38mm isotropic resolution (Fig. 2 C, D and E). The existence of peripheral vascularization is considered to be a characteristic sign for metastasis in angiogenetic tumors [6] and shown in Fig. 2 D, E. Moreover, the presence of a homogeneous fat hilus is considered to be a sign of benignity [6] as growing tumor clusters in the node may result in destruction of the fat hilus as demonstrated in Fig. 2C. The described approach presents a proof of principle for high resolution imaging of superficial inguinal lymph nodes *in vivo* and could be clinically valuable for any cancer disease that affects this region. Future patient studies are now mandatory to evaluate the clinical significance of high resolution superficial lymph node imaging at 7T MRI.

References

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