Cactus spines as fiducials for MRI and pathology correlation of ex-vivo human lymph nodes

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Introduction

Technological advancements in medical imaging have taken great strides towards non-invasive diagnosis of disease. However in many cases pathologic examination is considered the gold standard and invasive procedures still remain necessary to confirm the diagnosis; at least until the imaging method is reliably validated. In order to achieve this validation, radiological-pathological correlation has to be established. This requires a common frame of reference for which anatomical landmarks can be used or, if no suitable intrinsic features exist, an extrinsic fiduciary marker can be applied. As part of a 7T MR study correlating intranodal features of ex vivo human lymph nodes to histopathology, we used cactus spines as an extrinsic marker. This abstract describes the properties and suitability of cactus spines used as fiduciary markers in the correlation of MR imaging to histopathology.

Materials and Methods

We included 15 consecutive patients with histologically proven breast cancer with a diameter of at least 2 centimeters, determined on mammography and ultrasound, who were about to undergo a sentinel lymph node biopsy (SLNB). Following the SLNB, the nodes were stitched onto a plastic rack, in order to maintain a consistent shape, and were conserved in formalin for 24 hours. A cactus spine was inserted in each node as a fiducial. During 7T MRI scanning (Philips Health Care, Cleveland, USA), using a Transmit/Receive head coil with a 16 channel receive coil (Nova Medical Systems), the nodes were submersed in fomblin to provide susceptibility matching. A 3D T1 weighted fat suppressed fast field echo (fsFFE) data set was acquired [TR/TE 158/5.59ms, flip angle 35°, FOV 23.6 x 110 x110 mm, resolution 180µm isotropic]. Pathologic processing and examination were performed by an experienced pathologist. To maintain an accurate correlation of MRI with pathology, the nodes were mapped and numbered. Also the superior and one lateral side of each node was dyed black and blue respectively. The nodes were sliced in 4mm sections and numbered again. They were paraffin embedded and cut into 3µm thick slices which were stained with Haematoxylin & Eosin (H&E) and, in case of suspicion of metastases, were also immunohistochemically stained. MRI identification of the fiducials was checked for all nodes. Fiducial induced distortion of nodal geometry at MR imaging and the presence of susceptibility artifacts was scored. Also fiducially induced distortion of pathologic anatomical detail and the presence of cutting artifacts were noted. H&E and immunohistochemical stains were assessed for possible interference.

Results

42 nodes were harvested during the SLNB procedures and subsequently scanned and examined pathologically. On the MR images the cactus spine in the lymph node could be readily identified in all nodes (figures 1-5). Nodal geometry was not affected by the cactus spine in any node and no susceptibility artifacts were noted. On histopathology images the gross nodal geometry remained intact as well. Small deformations were noted parallel to the needle in 8/42 nodes (figure 5). These deformations can be explained by differences in rigidity between the nodal tissue and the cactus spine. Technically, the deformations did not interfere with microscopic analysis. Also the presence of the cactus spine did not interfere with H&E and immunohistochemical staining. Visual correlation between MRI and histopathology is shown in figures 1-5: with the use of the cactus spine as a fiduciary, pathologic-anatomic architectural features of the cortex and medulla, such as small blood vessels and intranodal capillaries, could be correlated to MRI features.

Conclusion

Cactus spines are suitable fiducials for the correlation of MR imaging to histopathology in ex-vivo human lymph nodes. Cactus spines can readily be identified on both MR and histopathologic imaging and do not interfere with (immuno-) histopathologic analysis. As a fiduciary marker cactus needles are inexpensive, simple to use, and aid in the accurate intranodal correlation of imaged features.

Figures (Fig.) 1-5: Correlation of T1-weighted fsFFE 7T MR images (0.18mm thick slices) to histopathological H&E stained slices (1.5x magnification).
Fig. 1. A lymph node with a cactus spine (circle) inserted in the cortex. **Fig. 1c.** Phase-contrast microscopy showing the different refractive index of the cactus spine. **Fig. 2**. A lymph node with metastases: the low signal-intensity cactus spine (in cross-section, black circle) allows for correlation of the MR image with the histopathologic image, despite the lack of contrast between metastatic and non-metastatic tissue in the T1W-MRI data. On the histopathology slide metastatic (thin black arrow) and non-metastatic tissue (thin white arrow) can be identified. **Fig. 3 and 4** shows a cactus spine inserted through the lymph node cortex (circle). From the volumetric MRI data set, the corresponding 2D image plane could be visually selected using the cactus spine as an anchor point. Cortical detail (black arrows), which on MRI could either be fatty tissue or blood vessels, was shown to correlate with small blood vessels using the cactus spine as a reference. The blood vessels are filled with erythrocytes, causing a susceptibility difference, which explains the low signal intensity. Also in **fig. 4** cortical fatty areas could be identified (white solid arrows) **Fig. 5** Parallel to the cactus spine (black circle) a microtomy artifact is seen on the pathology image. This is induced by refractive index differences between nodal tissue and cactus spine. Gross nodal morphology however remains intact. Intranodal capillaries (black arrows) can also be accurately identified.