Precise Co-registration of SPECT and MRI for Small Animal Imaging using a Common Animal Bed with External References:Visualization of Macrophage Distribution within Inflammatory Lymph Nodes

M. Yamaguchi[1], D. Suzuki[1,2], R. Shimizu[1,2], R. Nakagami[1,3], K. Tsuda[1], I. O. Umeda[1], Y. Okuyama[2], K. Yoshikawa[2], and H. Fujii[1,4]

[1]Functional Imaging Division, National Cancer Center Hospital East, Kashiwa, Chiba, Japan, [2]Faculty of Health Sciences, Komazawa University, Setagaya, Tokyo, Japan, [3]Graduate School of Human Health Sciences, Tokyo Metropolitan University, Arakawa, Tokyo, Japan, [4]Institute for Bioinformatics Research and Development-Japan Science and Technology Agency, Chiyoda, Tokyo, Japan

Introduction: Nuclear medicine (NM) can provide unique information about sentinel lymph nodes, although it shows poor anatomical information; therefore, the superimposition of NM images on MR images would enhance the excellent features of MRI in spatial resolution and tissue contrast. A high magnetic field, however, makes it difficult to develop a combined scanner, especially in combination with a single photon emission computed tomography (SPECT) that requires metallic collimators [1]. The software-based post-processing precise fusion of images obtained by separate scanners would be therefore practical. We have shown the feasibility of the MRI-SPECT co-registration technique to detect mouse lymph nodes using an in-house built animal bed for both MRI and SPECT scans ("a common animal bed") and post-processing software in combination [2]. In this study, we tried to demonstrate the feasibility of this technique to diagnose lymph nodes under inflammatory conditions. The inflammatory condition was induced by local administration of Freund complete adjuvant (FCA), which contained dead tubercle bacilli in oil [3]. The aim of this study was to investigate: 1. how well MRI and SPECT images of the swollen lymph nodes were co-registered; and 2. the significance of MRI-SPECT fusion imaging for lymph nodes involved in inflammation.

Materials and methods: All animal experiments were conducted according to the protocol approved by the institutional animal experimental committee. Male ddY mice (n=4) were administered 0.05 mL FCA to the foot pad. Two or three weeks after FCA administration, these mice were examined by MRI-SPECT according to the following procedures; approximately half an hour before SPECT acquisition, 0.05 mL ^{99m}Tc phytate (3.7 MBq) was injected into the ipsilateral foot pad, and the foot was massaged. The mouse was placed on a common animal bed constructed with an acrylic tube which has 3 small containers filled with radioisotope fluid as external markers for image co-registration. MR images were acquired with a 3 T whole body scanner (Signa HDx; GE, Milwaukee, WI) equipped with a dedicated receiver coil for small animal use (solenoid type, three turns, 3.5cm in diameter). Transverse and sagittal T_2-weighted images of the hind limb of the mouse and external markers were obtained using a fast spin echo sequence with fat suppression (TR/TEeff = 4000/60 ms, FOV = 40mm, slice thickness = 1mm, matrix = 256 x 192 (ZIP512), and 2 NEX). SPECT images were acquired with a small animal scanner equipped with 4 detectors each of which has 9 pinhole collimators (NanoSPECT/CT; Bioscan, Washington DC). The scan parameters were as follows; 24 projections, 300 sec/projection, and OSEM reconstruction. SPECT and MRI data sets, which were in the DICOM format, were manually merged using commercially available software (In Vivo Scope ver1.37, BioScan, Washington DC) to ensure that the positions of the three external markers were matched on MRI-SPECT fusion images.

Results and discussion: The location of the swollen lymph nodes and external markers were precisely matched on MRI-SPECT fusion images in all cases. MRI clearly demonstrated the swollen lymph nodes as a high signal nodule. On SPECT, the uptake of ^{99m}Tc was shown only in the periphery of the swollen lymph nodes. The distribution of ^{99m}Tc was also confirmed on autoradiography. Our results show that ^{99m}Tc phytate SPECT can indicate the location of regional lymph nodes after local injection of a tracer in the lymphatic basin. In addition it can demonstrate functional differences within lymph nodes; the paucity of macrophages at the central part of the lymph nodes presumably caused the negative uptake. On the other hand, MRI demonstrated the whole volume of the swollen lymph node and the anatomical relationship between the lymph nodes and the surrounding structures; therefore, these two image modalities play complementary roles in the diagnosis of swollen lymph nodes under inflammatory conditions.

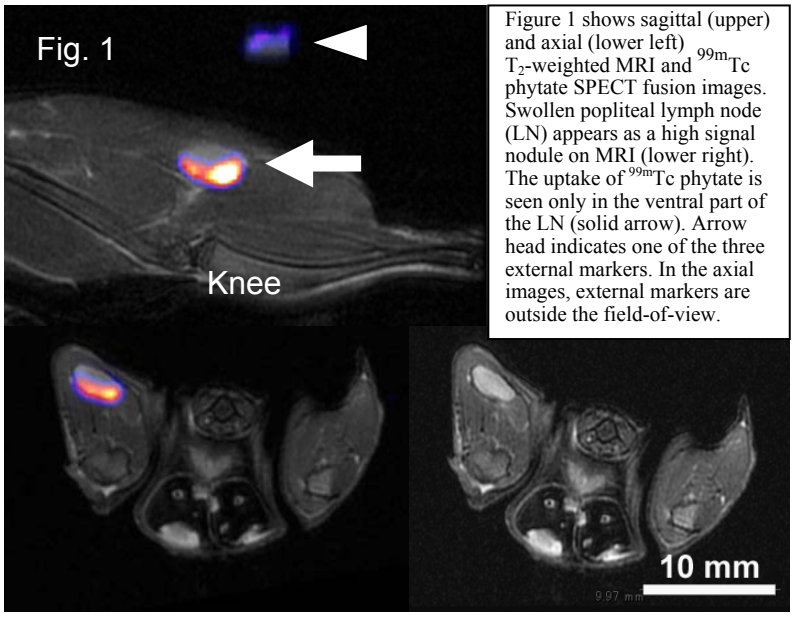

Figure 1 shows sagittal (upper) and axial (lower left) T_2-weighted MRI and ^{99m}Tc phytate SPECT fusion images. Swollen popliteal lymph node (LN) appears as a high signal nodule on MRI (lower right). The uptake of ^{99m}Tc phytate is seen only in the ventral part of the LN (solid arrow). Arrow head indicates one of the three external markers. In the axial images, external markers are outside the field-of-view.

Conclusion: **A post-processing fusion technique of high-resolution SPECT and MRI is feasible for simultaneous functional and anatomical evaluation of swollen lymph nodes *in vivo*. This preliminary result warrants further study in MRI-SPECT co-registration for sentinel lymph node metastasis.**

References: [1] Nalcloglu O, et al. Proc. ISMRM 2007 ; 15 :920 [2]Yamaguchi M, Fujii H, et al. Proc. ISMRM 2009; 17:3091 [3] Herborn CU, et al. JMRI 2003; 18: 328 – 335

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