In October 2015, Michael Soussan, MD, began evaluating a newly installed SIGNA™ PET/MR system at CEA Service Hospitalier Frédéric Joliot (SHFJ) in Orsay, France. Dr. Soussan compared sensitivity, specificity and clinical confidence between the new PET/MR and an existing prior generation PET/CT in order to better understand the role that PET/MR should play in patient management.

Oncology staging is currently the primary utilization of PET/CT, accounting for approximately 80% of patient scans at CEA-SHFJ. PET/CT is also used for brain exams.

According to Dr. Soussan, a major challenge is to demonstrate the ability of PET/MR to enhance the confidence associated with the interpretation of PET and MR imaging data. The hospital’s clinicians currently rely on the interpretation of PET/CT images. He believes demonstrating that PET/MR increases the certainty with which the physician comes to a conclusion based on the PET and MR images would certainly contribute to a large acceptance of the new system for patient management.

The PET component on the SIGNA PET/MR features a digital Silicon PhotoMultiplier (SiPM) detector that is up to three times more sensitive than conventional PET technology. It also features ultra-fast coincidence timing resolution enabling Time-of-Flight (TOF) reconstruction. With TOF reconstruction, the arrival times of each coincident pair of photons are more precisely detected, and the time difference between them is used to localize the PET signal accurately. TOF leads to improved PET image quality with higher structural detail and improved signal-to-noise ratio.

Results
Nuclear physicians were asked to provide their assessment regarding the overall PET image quality (image contrast and resolution) and the ease of interpretation. They compared the
PET/MR scans to the PET/CT scans. For this assessment, 150 patients underwent both a PET/CT and PET/MR. “Many of the differences we observed in the images are due to the different PET technology between our PET/CT and PET/MR scanners. This demonstrates the huge progress made in PET detector technology over the years, by taking advantage of TOF, enhanced reconstruction including point spread function modeling and scatter recovery,” Dr. Soussan says. “The PET/MR clearly demonstrated better contrast, resolution and image quality over the prior generation PET/CT scanner.”

The PET/MR is a big advancement in technology, he adds, with this new combination of modalities providing improved lesion detectability and more accurate interpretation of the signal. Motion correction using Q.Static was also evaluated on every patient undergoing a PET/MR exam at CEA-SHFJ. “We could already see the difference in quantitation and lesion appearance but the most important point is that we can use it routinely, which will help us make a comprehensive assessment of the clinical benefit of motion compensation. Using PET/MR, motion correction can now enter the clinical practice, and it is possible to use it for every patient. With the high PET sensitivity, we can perform a shorter acquisition with Q.Static retaining about half the signal and still have images perfectly suitable for interpretation,” he says.

“Improving the spatial resolution and image quality of PET is very important—it helps make the technique more precise and efficient than with prior generation technology,” Dr. Soussan adds. He is hopeful that a higher PET sensitivity can help clinicians address the issue of false positives and false negative lesions when these situations occur in clinical practice.

**Case 1**

A 75-year-old patient with colorectal cancer, treated six months earlier with adjuvant chemotherapy, referred to PET/CT (non-TOF PET/CT system: 371 MBq, 75 min post IV, 4 min/bed position, no PSF modeling in reconstruction) followed by PET/MR (100 min post IV, 4 min/bed position, TOF and PSF modeling reconstruction).

The improvement in sensitivity leads to homogenous liver and better contrast recovery of small lesions. This case shows that PET/MR enables a precise staging of liver metastasis, improving the therapeutic strategy.
Case 2
A 76-year-old patient with initial diagnosis of well-differentiated, midgut neuroendocrine tumor with lymph nodes and liver metastasis. The patient was scanned with F18-DOPA PET/MR (245 MBq, 94 min post IV, 6 min/bed, 4 beds, TOF and PSF modeling reconstruction). Q_Static was employed for respiratory gating.

Figure 3. The impact of respiratory gating with [B] Q_Static can be clearly seen. In the (A) static images, two right liver lesions are blurred (black and red arrows) and the upper lesion almost appears as two lesions (black arrow, SUVpeak 1.9, metabolic volume [42% threshold]: 3 cm³). With (B) Q_Static reconstruction, the images are clearer with an increase in lesion conspicuity for a diagnosis of two lesions (B, black arrows). The quantitation of the upper lesion is improved (SUVpeak 2.2, metabolic volume [42% threshold] 0.8 cm³). Furthermore, in the Q_Static image, a third lesion previously poorly visible was also identified (blue arrow).