High-resolution silicon photomultiplier time-of-flight dedicated head PET system for clinical brain studies

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Running title: Silicon photomultiplier TOF dedicated head PET

Key Words: High resolution, silicon photomultiplier, time of flight (TOF), dedicated head PET, brain
Disclosure statement

Kazunari Ishii received a research grant from Shimadzu Corporation.
Kazunari Ishii reports the provision of the dhPET scanner from Shimadzu Corporation.
Yoshiyuki Yamakawa, Suzuka Minagawa, Shiho Takenouchi, Atsushi Ohtani, Tetsuro Mizuta are employees of Shimadzu Corporation.

No other potential conflicts of interest relevant to this article exist.

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ABSTRACT

We acquired brain positron emission tomography (PET) images of fluorodeoxyglucose (FDG) and flutemetamol PET using a time-of-flight-PET system dedicated for the head (dhPET) and a conventional whole-body PET/computed tomography (wbPET) system and evaluated the clinical superiority of dhPET over wbPET. **Methods:** There were 18 subjects for the FDG-PET study and 17 subjects for the flutemetamol PET study. FDG-PET images were first obtained using wbPET, followed by dhPET. Flutemetamol PET images were first obtained using wbPET, followed by dhPET. Images acquired using dhPET and wbPET were compared by visual inspection, voxel-wise analysis, and standard uptake value ratio (SUVR). **Results:** All FDG and flutemetamol images acquired using dhPET were judged as better by visual inspection than those acquired using wbPET. The voxel-wise analysis demonstrated that accumulations in the cerebellum, lateral occipital cortices, and around the central sulcus area in dhPET FDG images were lower than those in wbPET FDG images, whereas accumulations around the ventricle systems were higher in dhPET FDG images than those in wbPET FDG images. Accumulations in the cerebellar dentate nucleus, midbrain, lateral occipital cortices, and around the central sulcus area in dhPET images were lower than those in wbPET images, whereas accumulations around the ventricle systems were higher in dhPET flutemetamol images than those in wbPET flutemetamol images. Mean cortical SUVRs of FDG and flutemetamol dhPET images were significantly higher than those of FDG and flutemetamol wbPET images, respectively. **Conclusion:** The dhPET images had better image quality by visual inspection and higher SUVRs than wbPET images. Although there were several regional accumulation differences between dhPET and wbPET images, understanding this phenomenon will enable full use of the features of this dhPET system in clinical practice.
INTRODUCTION

The field of brain positron emission tomography (PET) has recognized the importance of fluorodeoxyglucose (FDG)-PET, amyloid PET, and tau PET scans for diagnosing dementia. This reflects the increase in the number of dementia patients due to an aging society, with the number of scans expected to increase(1-4). Whole-body PET (wbPET) /computed tomography (CT) scanners are not optimal for imaging small structures such as the brain; conventional wbPET scanners are large and expensive, and their spatial resolution is not always sufficient for brain examinations. Ideally, the spatial resolution should be sufficient to enable delineation of the thickness of the gray matter and small brain structures without partial volume effects. There are several head-only designed PET scanners, such as HRRT(5), NeuroPET/CT(6), Hammatsu brain PET(7), and brain-dedicated helmet type PET(8). They have been reported to have better spatial resolution than conventional wbPET scanners. Catana reviewed the developments of these dedicated head PET imaging devices and expects further improvements to be made: improvements in imaging smaller structures, such as hippocampal subfields and thalamic and brain stem nuclei; improving sensitivity without sacrificing spatial resolution; improving portability, mobility, and wearability of the device; and reducing the cost of the scanner(9). Thus, our collaborators modified a dedicated breast PET scanner: a silicon photomultiplier time-of-flight (TOF)-PET scanner (SET-5002, Shimadzu Corporation, Kyoto, Japan) dedicated for the head PET (dhPET) to enable its use not only for breast imaging but also for brain imaging. Detailed basic specifications of the dhPET system are described elsewhere(10). This TOF-PET system for the head and breast is designed to be less expensive than the conventional wbPET system but with higher sensitivity and spatial resolution. Although previous dedicated head PET
systems have been recognized for their high spatial resolution of FDG-PET images, there have been no reports of cases in which diagnoses were clinically overturned. Moreover, there have been no reports of their implementation in amyloid PET studies. We acquired FDG and amyloid PET data using a conventional wbPET system and our novel brain TOF-PET system in the same individuals and compared clinical interpretations and PET tracer uptake values between the two scanners.

MATERIALS AND METHODS

Outline of the New dhPET Scanner

FIGURE 1 shows the appearance of the scanner for the brain scan mode. The scanner consisted of three detector rings with a diameter of 300 mm, with each ring comprising 16 detector modules, which offer a sufficient axial field of view (FOV) of 162 mm to allow whole-brain scanning. A three-dimensional image was reconstructed at an isotropic voxel size of 1.1 mm with a matrix of $240 \times 240 \times 148$ using the list-mode dynamic row-action maximum-likelihood algorithm. In the brain mode, attenuation correction was performed using the maximum-likelihood attenuation correction factor (ML-ACF) method combined with the quantification process, which compensates for non-uniformity in the head using the TOF information without CT. First, a non-quantitative $\mu$-map was reconstructed from the attenuation correction factor (ACF) obtained using the ML-ACF method. Next, the maximum area of the head in the $\mu$-map was quantified, taking into account the fact that the human head consists primarily of soft tissue, and combined with the structural information of the headrest. Finally, an attenuation-corrected diagnostic image was reconstructed using the $\mu$-map. The dhPET has high
spatial resolution and achieves 2.5 mm full-width at half maximum (FWHM), 10 mm from the center of the FOV in NEMA NU 2-2012 (10). In addition, an image of the Mini-Derenzo phantom showed that 1.6-mm diameter hot rods could be clearly separated, which visually confirmed the high spatial resolution of dhPET

**Subjects**

The subjects of this study were those who underwent conventional wbPET imaging for clinical examination, free medical treatment, or as part of the Japan Agency for Medical Research and Development (AMED) study (jRCTsO31180219), who agreed to undergo additional imaging with the dhPET system and allow the use of their wbPET imaging data for this study.

There were 18 subjects for the FDG study (eight males and 10 females): seven had mild cognitive impairment, four had Alzheimer’s disease, one had dementia with Lewy bodies, one had frontotemporal dementia, one had subjective cognitive impairment, two had epilepsy, one had lymphoma, and one had skull bone metastasis. The mean age of participants was $67.7 \pm 16.0$ years.

For the flutemetamol study, we included 17 subjects (eight males and nine females): seven with mild cognitive impairment, four with Alzheimer’s disease, three healthy older adult subjects, one with dementia with Lewy bodies, one with frontotemporal dementia, and one with subjective cognitive impairment. The mean age of participants was $73.1 \pm 7.6$ years. Fourteen subjects participated in both the FDG and flutemetamol PET studies.
The study protocol was submitted and approved by the Certified Review Board of Hyogo College of Medicine (jRCTs052200055). Our institutional review board also approved this study, and written informed consent was obtained from all participants.

**Image Acquisition and Reconstruction**

For the FDG-PET scan, subjects fasted for 4 h before being administered FDG. The mean dose of $^{18}$F-FDG administered to patients was $192.0 \pm 18.7$ MBq (range: 150.5–213.4 MBq). FDG-PET imaging of the brain was performed using the Discovery PET/CT 710 scanner (GE Healthcare, Milwaukee, USA) for wbPET. The Discovery PET/CT 710 is a combination of a lutetium-based scintillator with a photomultiplier tube-PET and a 16-slice CT scanner. This scanner enables a 150.42-mm axial FOV and a 700-mm transaxial FOV with 47 image planes spaced at 3.27-mm intervals. The spatial resolution was 5.27 mm at FWHM according to a NEMA NU 2-2007.

The scanning protocol was performed using the Japanese Alzheimer's Disease Neuroimaging Initiative (J-ADNI) FDG-PET protocol (11) for cognitive disorders. A 30-min list-mode emission scan was acquired on a wbPET scanner, which started 30 min after the intravenous injection of FDG. Subjects were instructed to lie quietly in a dimly lit room with their eyes open under minimal sensory stimulation. Subsequently, dhPET scanning was performed for 30 min with list mode (average scanning time after injection: $71 \pm 5$ min). Oncology subjects underwent 2 min of wbPET scanning 60 min after the intravenous injection, followed by 5 min of dhPET scanning (average scanning time after injection: $90 \pm 1$ min). Epilepsy subjects underwent 20 min of
wbPET scanning 60 min after the intravenous injection, followed by 20 min of dhPET scanning (average scanning time after injection: 86 ± 1 min).

The amyloid PET scanning methods with flutemetamol have been described previously(12). The mean dose of $^{18}$F-flutemetamol was 199.5 ± 9.1 MBq (range: 180.6–210.1 MBq), which was injected intravenously into an antecubital vein. A 20-min list-mode PET scan was acquired from 90 min using the wbPET scanner following the protocol of the AMED study (jRCTsO31180219). Subsequently, a 20-min list-mode scan was performed using the dhPET system (average scanning time after injection: 117 ± 2 min).

For the wbPET reconstruction conditions, FDG PET images were reconstructed using the following algorithms and conditions: a block sequential regularized expectation-maximization algorithm; $\beta = 100$; 256 × 256 matrix; transaxial FOV, 300 mm; 1.2 mm/pixel. Flutemetamol PET data were reconstructed using the following algorithms and conditions: three-dimensional (3D)-Ordered Subsets Expectation Maximization (OSEM) with TOF; four iterations; 16 subsets; 128 × 128 matrix; transaxial FOV, 256 mm; 2.0 mm/pixel; Gaussian filter, 4.0 mm (FWHM).

For the dhPET reconstruction conditions, FDG PET images were reconstructed using the following algorithms and conditions: list-mode dynamic row action maximum-likelihood algorithm (DRAMA); subset = 200, $\beta = 200$, iteration = 1; 240 × 240 matrix; transaxial FOV, 264 mm; 1.1 mm/pixel. Flutemetamol PET data were reconstructed using the following algorithms and conditions: list-mode DRAMA; subset = 150, $\beta = 100$, iteration = 1; 240 × 240 matrix; transaxial FOV, 264 mm; 1.1 mm/pixel.

These parameters met the criteria for phantom testing based on the PET imaging site qualification program of the Japanese Society of Nuclear Medicine (specifically, the % contrast in the
Hoffman 3D brain phantom was greater than 55%, and the coefficient of variation in the cylindrical phantom was less than 15%.

**Data Analysis**

The comparison of spatial resolution between wbPET and dhPET images was evaluated visually. The advantage of dhPET over wbPET was scored as follows:

1 (inferior): spatial resolution was lower, or there was low contrast between the lesioned and normal area

2 (intermediate): spatial resolution was almost equal, and the contrast was equal between the lesioned and normal area

3 (superior): spatial resolution was higher, or there was high contrast between the lesioned and normal area.

Additionally, we examined whether interpretation of dhPET image changed the clinical diagnosis by interpretation of wbPET image.

First, two nuclear medicine physicians independently scored the images to determine interobserver variability. If the two physicians disagreed, they discussed their interpretations and determined a final score.

For the voxel-based comparison we used Statistical Parametric Mapping (SPM) 12 (https://www.fil.ion.ucl.ac.uk/spm/software/spm12/). The FDG and flutemetamol images were each co-registered to individual magnetic resonance imaging (MRI) images, which were segmented into gray matter (GM), white matter, and cerebrospinal fluid using the SPM12 segmentation program. Individual GM images were then spatially normalized to the template
image using the Diffeomorphic Anatomical Registration Through Exponentiated Lie Algebra algorithm (13), and the normalized parameters were applied to the co-registered PET image. PET images were then spatially normalized to Montreal Neurological Institute space. All images were smoothed using an 8-mm Gaussian filter. We then performed a voxel-based comparison using a paired t-test between the wbPET and dhPET images. The significance threshold was set at $p < 0.05$ using family-wise error (FWE) correction.

Mean cortical standard uptake value ratios (SUVRs) of each subject for both dhPET and wbPET images were calculated using Centiloid volumes of interest (VOI): the voi_CerebGry_2mm and voi_ctx_2mm (http://www.gaain.org/centiloid-project). For regional SUVR, we used four VOIs of the major regions specific to Alzheimer’s disease (frontal, temporal, posterior cingulate, and parietal cortices), which were produced for a previous study (14). A paired t-test was used to compare the mean cortical SUVRs of the FDG and flutemetamol images between dhPET and wbPET acquisitions. The Shapiro-Wilk test revealed that the distribution was not normal in any of the regional SUVRs. Comparisons of regional SUVRs between the two scanners for the FDG and flutemetamol images were performed using the non-parametric repeated-measures Friedman test, and post hoc tests were corrected using Bonferroni correction.

**RESULTS**

Interobserver agreement of the visual inspection scores was 100% for both FDG and flutemetamol images. The two observers scored 3 (superior) for all FDG and flutemetamol images. FIGURES 2 and 3 show representative FDG and flutemetamol images from both
scanners. As shown in FIGURE 2, the red nucleus was clearly depicted in the dhPET image. For the FDG-PET images, the pattern of abnormal uptake in dementia patients was similar across both dhPET and wbPET images. However, the contrast between the decreased and preserved areas was clearer in the dhPET images. In both cases of epilepsy, medial temporal metabolic reduction was observed in both the wbPET and dhPET images, although the detection of findings was slightly easier on the dhPET images owing to the higher resolution. In the malignant tumor cases, the lesions were similarly identifiable, although the dhPET images showed a finer distribution of accumulation than the wbPET images. For the flutemetamol-PET images, the detection of amyloid deposition was similar across both PET systems, except for one of the 17 cases, in whom the dhPET image showed a more detailed amyloid distribution. This amyloid PET image of this equivocal case is shown in FIGURE 4: amyloid accumulation was suspected in the right lateral temporal cortices on the flutemetamol PET image scanned using the wbPET scanner. However, the flutemetamol PET image scanned using the dhPET system showed no cortical accumulations, which indicated an amyloid-negative case.

Mean SUVRs of the dhPET FDG and flutemetamol images were significantly higher than those of the wbPET FDG and flutemetamol images (TABLE 1). The regional SUVRs of the dhPET FDG and flutemetamol images were also significantly higher than those of the wbPET FDG and flutemetamol images, except for the parietal SUVR of the FDG images (TABLE 2).

Voxel-based analysis revealed that accumulations in the cerebellum, lateral occipital cortices, and around the central sulcus area were lower and accumulations around the ventricle systems were higher in dhPET FDG images than in wbPET FDG images (FIGURE 5). Accumulations in the cerebellar dentate nucleus, midbrain, lateral occipital cortices, and around the central sulcus
area were higher in wbPET flutemetamol images than in dhPET flutemetamol images, whereas accumulations around the ventricle systems were higher in dhPET flutemetamol images than in wbPET flutemetamol images (FIGURE 6).

DISCUSSION

This is the first clinical report on the application of a silicon photomultiplier TOF dhPET. The high spatial resolution and low scatter noise of the scanner enable better detection of detailed cortical accumulations of FDG or flutemetamol. Clinically, this TOF-dhPET scanner with a silicon photomultiplier offers better resolution and contrast within the cortical distributions of PET tracers than those of conventional PET scanners. This may be because of the higher spatial resolution and lower scatter noise of dhPET than those of wbPET, rather than higher statistical noise. One study highlighted that the ability to depict the red nuclei in brain FDG-PET images is an indicator of high resolution (15). As shown in FIGURE 2, the red nucleus could be clearly visualized by the dhPET system, which may indicate its high resolution.

As shown in FIGURE 4, the high-resolution amyloid PET image provided accurate accumulations in the cortices, which demonstrates the clinical impact of the method. Because of the spatial resolution and spill-over of white matter uptake to the cortical ribbon limitations of wbPET, the increased uptake observed in the right temporal cortices appeared equivocal, which could lead to a misdiagnosis of positive accumulation. In contrast, dhPET imaging demonstrated the true accumulation (i.e., not increased accumulation). In the amyloid PET images, some cases may show ambiguous accumulation, as observed in our case, although this is not common.
Therefore, a resolution equivalent to that of our PET system may be required to make an accurate diagnosis.

One of the advantageous features of the dhPET system is not needing to acquire a transmission scan for attenuation correction using an external radiation source, which avoids external radiation exposure of the patient. Even in cases where additional imaging is required or multiple PET tracer images are repeatedly acquired in the same subject, frequent PET examinations are possible because of the lower radiation exposure using the dhPET system. However, as shown in FIGURES 5 and 6, we detected significant regional differences in accumulation distributions between wbPET and dhPET images. Following FWE correction, the occipital lobe and cerebellar accumulation counts of the dhPET images were lower than those of the wbPET images. Therefore, as long as this phenomenon is considered, the dhPET system may be used for routine clinical examination without the need for CT attenuation correction. However, to take advantage of the high resolution of the dhPET system and eliminate differences in accumulation distribution due to attenuation correction among different PET scanners, it will be necessary to create a database of normal controls using this system.

When measuring regional cortical SUVRs of glucose metabolism and amyloid deposition (16), high-resolution images obtained using the dhPET system will provide more accurate SUVRs and enable correct diagnoses. The mean cortical SUVRs calculated from the dhPET images were consistently higher than those calculated from the wbPET images. One reason may be that SUVR is obtained by dividing the cortical counts by the cerebellar counts, and the cerebellar counts of the dhPET images tended to be lower than those of the wbPET images (FIGURES 5 and 6). The regional SUVRs of the FDG and flutemetamol on the dhPET images were also significantly
higher than those of the FDG and flutemetamol on the wbPET images, except for the parietal SUVR of the FDG images. In patients with dementia, atrophy and hypometabolism in the parietal region are greater than in other regions; therefore, we speculate that this impacted the counts of enlarged sulci, which are fewer on high-resolution dhPET images. Moreover, a large metabolism decrease would have further weakened the differences. The dhPET images had a lower partial volume effect because of the high spatial resolution. The voxel-based analysis revealed lower accumulations in the FDG dhPET images than in the FDG wbPET images in the cerebellum, lateral occipital cortices, and around the central sulcus regions. This observation in the cerebellar and occipital regions is likely due to the attenuation correction method, whereas that around the central sulcus region is likely due to the high spatial resolution of the dhPET because the central sulci are wide in older adults. The accumulation differences near the ventricles may be related to partial volume differences; however, this could not be verified in our study. Additionally, differences in scanning time points may be a significant factor. Because dhPET scanning was always performed approximately 30 min after the wbPET scanning, this time difference may have affected the differences in FDG and flutemetamol accumulation and washout in the brain structures.

In an aging society, measures to combat dementia are crucial, and early diagnosis has the potential to delay or suppress the onset of dementia. Our findings will facilitate the widespread use of dhPET systems for scanning the brain to enable individuals to benefit from early diagnoses of dementia(17), epilepsy, and brain tumors.

There are several limitations to this study. Because the wbPET scanner used in this study was not a silicon photomultiplier PET system, it may be argued that it would have high spatial
resolution. However, the resolutions of the silicon photomultiplier PET/CT Discovery MI, Digital Biograph Vision PET/CT System, and the Philips Vereos PET/CT System are also approximately 4 mm FWHM (18-21). Moreover, even if the resolution of the silicon photomultiplier PET scanner is compared with that of the wbPET scanner, there will not be a significant impact on the results of this study because the resolution of the dhPET system is less than 3 mm FWHM(10). Furthermore, even if the silicon photomultiplier is compared with previous or current head-only designed PET scanners (e.g., HRRT and helmet type PET scanners) or approaches that correct for partial volume errors or improve segmentation using PET/MRI(22), the results are unlikely to change significantly.

The dhPET scan was always acquired after the standard system scan. This may introduce bias related to the timing window of the acquired PET images after the injection. We suspect that the SUVR differences between the systems are not simply due to differences in scan timing, but rather, due to a combination of differences in scan time and attenuation correction methods. Moreover, it is worth highlighting that an increase in SUVR using the dhPET does not represent clinical/technical superiority over wbPET.

Statistical image analysis with a database of healthy controls using this system would help with clinical diagnoses in routine practice. However, interpreting data acquired using this system would remain challenging if there are major differences in attenuation correction relative to PET/CT.

To take advantage of the high spatial resolution of the dhPET system, it is necessary to reduce the effects of head motion that may occur during the 20–30 min of scanning. To address this issue, optimization of the conditions for generating high-quality images in a short period and the
development of image reconstruction methods that detect or account for head motion will be crucial.

CONCLUSION

Our novel dhPET scanner can provide high-resolution and high-sensitivity images for FDG and amyloid PET that are superior to those offered by conventional wbPET. This new technology will enable more accurate diagnoses of brain diseases in the future.
Ethical Approval

All procedures involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Certified Review Board of Hyogo College of Medicine (jRCTs052200055).

Author Contributions

KI and KH generated the research idea and concept. KH, SW, DMI, TY, YY, SM, ST, and TM acquired the basic imaging data. KI, KH, SW, DMI, and TY acquired the clinical imaging data. KI and HK visually interpreted the PET images. KI, KH, TY, and TM performed the quantitative analysis. KI, KH, and TM drafted the work. KI wrote the manuscript. All authors contributed to the article and approved the submitted version.

ACKNOWLEDGMENTS

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KEY POINTS

QUESTION: Do FDG and amyloid PET images obtained with a time-of-flight-PET system dedicated for the head (dhPET) have clinical superiority to those with a conventional whole-body PET/CT (wbPET) system?

PERTINENT FINDINGS: FDG and amyloid images acquired using dhPET are superior to those acquired using wbPET in spatial resolution and provide accurate diagnosis. Mean SUVRs of FDG and amyloid dhPET images are significantly higher than those of FDG and amyloid wbPET images, respectively.

IMPLICATIONS FOR PATIENT CARE: FDG and amyloid images acquired using dhPET provide useful information and support accurate diagnosis for individual patients.
REFERENCES


TABLE 1. Mean standard uptake value ratios of fluorodeoxyglucose (FDG) and flutemetamol images acquired using the dedicated head positron emission tomography (PET) and conventional whole-body PET scanners

<table>
<thead>
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<th>Dedicated head PET</th>
<th>Whole body PET</th>
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<tbody>
<tr>
<td>FDG</td>
<td>1.17 ± 0.18</td>
<td>1.04 ± 0.14</td>
</tr>
<tr>
<td>flutemetamol</td>
<td>2.09 ± 0.47</td>
<td>1.79 ± 0.46</td>
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TABLE 2. Regional standard uptake value ratios of fluorodeoxyglucose (FDG) and flutemetamol images acquired using the dedicated head positron emission tomography (PET) and conventional whole-body PET scanners

<table>
<thead>
<tr>
<th></th>
<th>Frontal</th>
<th>Temporal</th>
<th>Posterior cingulate</th>
<th>Parietal</th>
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<tbody>
<tr>
<td><strong>FDG</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dedicated head PET</td>
<td>1.25 ± 0.16*</td>
<td>1.10 ± 0.19*</td>
<td>1.23 ± 0.23*</td>
<td>1.00 ± 0.20</td>
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<td>Whole-body PET</td>
<td>1.11 ± 0.14</td>
<td>1.02 ± 0.17</td>
<td>1.16 ± 0.22</td>
<td>1.04 ± 0.20</td>
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<tr>
<td><strong>Flutemetamol</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dedicated head PET</td>
<td>2.03 ± 0.49*</td>
<td>1.86 ± 0.48*</td>
<td>2.08 ± 0.55*</td>
<td>1.78 ± 0.42*</td>
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<tr>
<td>Whole-body PET</td>
<td>1.69 ± 0.47</td>
<td>1.63 ± 0.45</td>
<td>1.83 ± 0.53</td>
<td>1.66 ± 0.43</td>
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*significantly higher than whole-body PET (p < 0.05, Bonferroni correction)
FIGURE 1. The appearance of the dedicated head positron emission tomography (dhPET) scanner
FIGURE 2. Representative fluorodeoxyglucose (FDG)-positron emission tomography (PET) image acquired on the dedicated head PET (dhPET) scanner (upper row) and conventional whole-body PET/computed tomography (wbPET) scanner (lower row)
An 85-year-old male patients with mild cognitive impairment due to Alzheimer’s disease. Bilateral posterior cingulate gyri, precuneus, and temporal hypometabolism are shown.
FIGURE 3. Representative flutemetamol-positron emission tomography (PET) image acquired using the dedicated head PET (dhPET) scanner and conventional whole-body PET/computed tomography (wbPET) scanner
A: Amyloid-negative image (72-year-old healthy male subject) acquired using the dhPET scanner (upper row) and the wbPET scanner (lower row).
B: Amyloid-positive image (70-year-old male Alzheimer’s disease patient) acquired using the dhPET scanner (upper row) and the wbPET scanner (upper row).
FIGURE 4. Equivocal case of amyloid accumulation using the dedicated head positron emission tomography (dhPET) scanner and the whole-body PET/computed tomography (wbPET) scanner

Upper row: flutemetamol image acquired using the conventional wbPET scanner.
Lower row: flutemetamol image acquired using the dbPET scanner.

A 67-year-old male with subjective cognitive impairment. At first glance, the patient appeared to be amyloid-negative. However, accumulations in the right temporal cortex (yellow arrows) were suspected on the wbPET image, whereas clear evidence of no accumulation in the right temporal cortex was observed on the dhPET image.
FIGURE 5. Areas of significant difference in fluorodeoxyglucose (FDG)-positron emission tomography (PET) images between the whole-body PET (wbPET) scanner and the dedicated head PET (dhPET) scanner

The glass brain (A) and section (B) show higher accumulation in the cerebellum, occipital lobe, and around the central sulci in images acquired using the wbPET scanner than in those acquired using the dhPET scanner.

The glass brain (C) and section (D) show higher peripheral ventricle area accumulations in images acquired using the dhPET scanner than in those acquired using the wbPET scanner. The scale bar indicates $t$-values.
FIGURE 6. Areas of significant difference in flutemetamol-positron emission tomography (PET) images between the whole-body PET (wbPET) scanner and the dedicated head PET (dhPET) scanner

The glass brain (A) and section (B) show higher cerebellar and occipitoparietal accumulations in images acquired using the wbPET scanner than in those acquired using the dhPET scanner. The glass brain (C) and section (D) show higher peripheral ventricle area and frontal white matter accumulations in images acquired using the dhPET scanner than in those acquired using the wbPET scanner. The scale bar indicates t-values.
Graphical Abstract