Clinical Atlas of Brain PET/CT

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Khulood Al Riyami and Francesco Fraioli

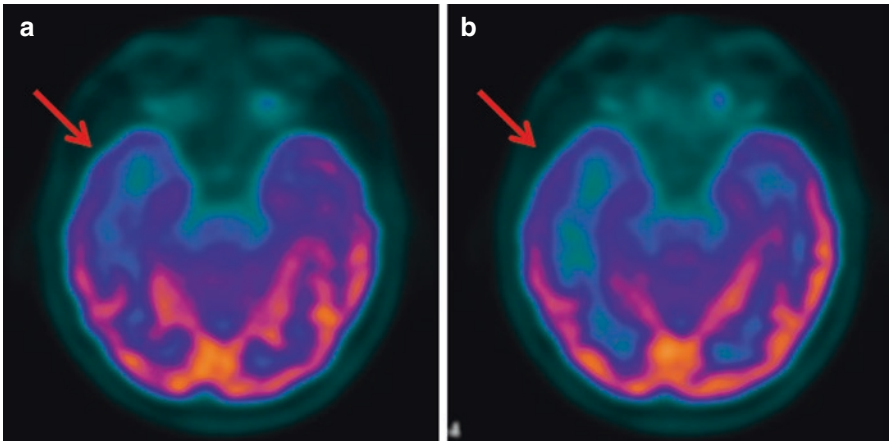

Fig. 14.1 (**a**–**d**) A 30-year-old patient with non-lesional right frontotemporal lobe epilepsy. Axial ^{18}F FDG PET (**a**, **b**) and fused ^{18}F FDG PET/MR (**c**, **d**) show perfect agreement between the two techniques with area of hypometabolism in the right temporal lobe (**a**–**d**, *arrows*) representing an epileptogenic focus.
Teaching point: Alteration in FDG metabolism can help determine epileptogenic foci in patients with non-lesional epilepsy

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F. Fraioli (ed.), *PET/CT in Brain Disorders*, Clinicians' Guides to Radionuclide Hybrid Imaging, https://doi.org/10.1007/978-3-030-01523-7_14

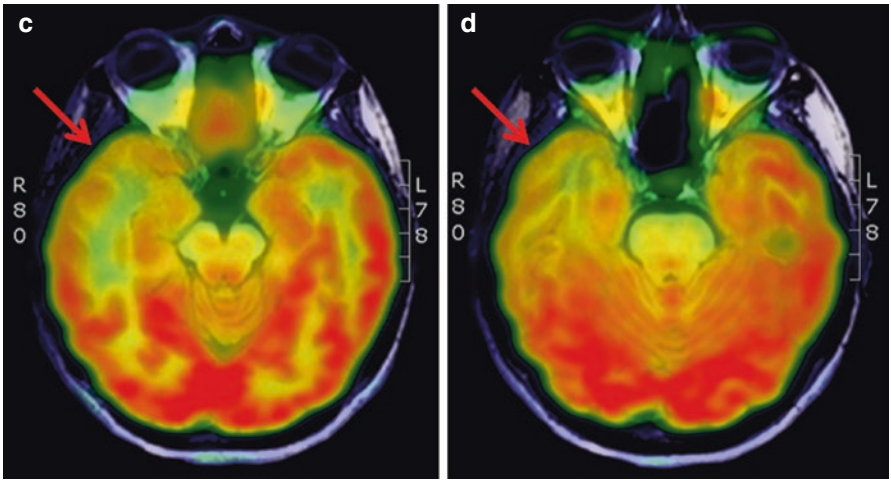

Fig. 14.1 (continued)

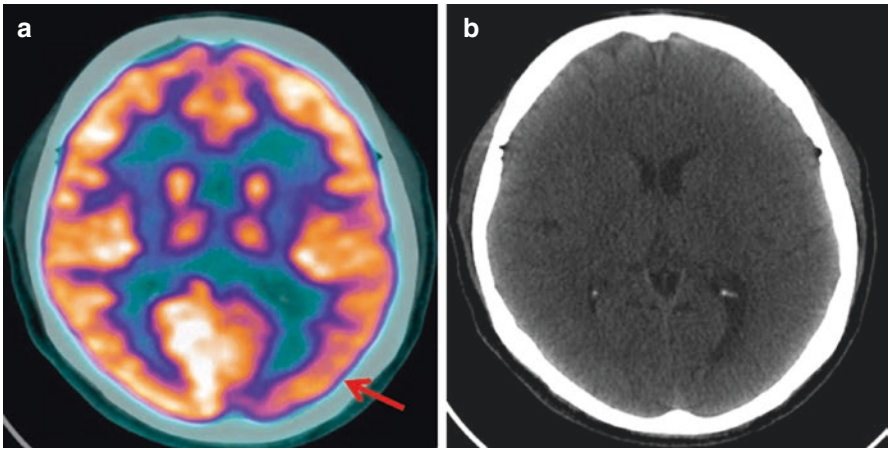

Fig. 14.2 (**a**–**d**) A 31-year-old patient with left hemisphere epilepsy. Axial fused ^{18}F FDG PET/CT (**a**), axial CT (**b**), fused ^{18}F FDG PET/MR (**c**) and T2 FLAIR (**d**) at the level of the thalami show area of hypometabolism in the left occipitotemporal region (**a**, **c** *arrows*) with corresponding high signal intensity in the periventricular region of the posterior horn of the left lateral ventricle (**d**, *arrow*) raising the suspicion of previous encephalitis.
Teaching point: Combined FDG PET/MR can assist in diagnosing location of epileptogenic focus and correlative morphological changes to determine possible underlying cause

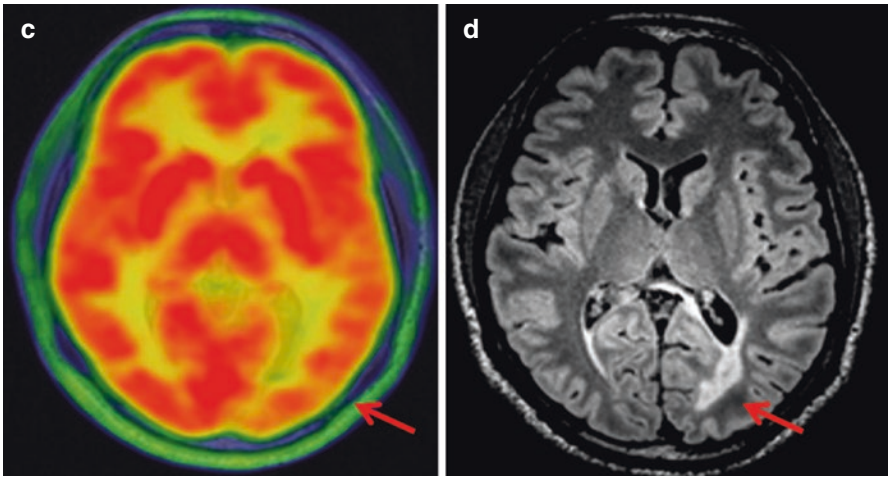

Fig. 14.2 (continued)

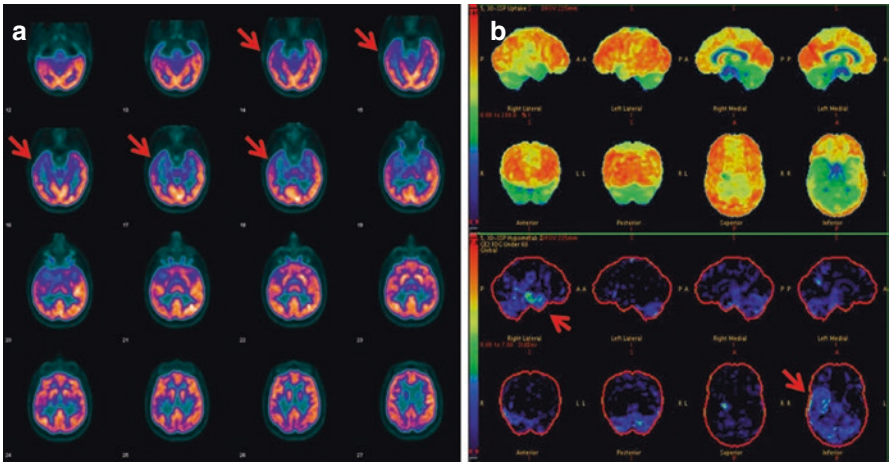

Fig. 14.3 (**a**, **b**) Patient evaluated for right hemispheric epilepsy. Axial FDG PET images (**a**) and *Z*-score maps (**b**) show right temporal lobe hypometabolism (**a**, *arrows*) which is confirmed on quantification assessment (**b**, *arrows*), in keeping with an epileptogenic focus.
Teaching point: The use of quantification maps can help in giving a more confident diagnosis when determining the most likely epileptogenic focus in patients with epilepsy

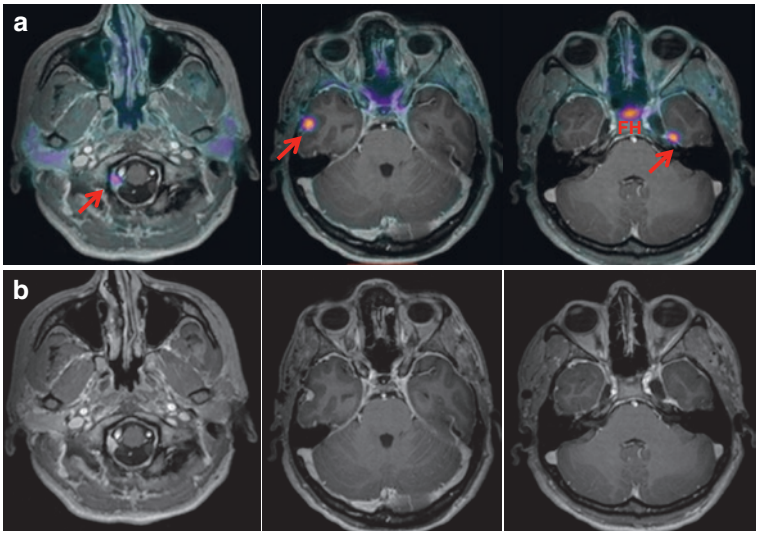

Fig. 14.4 (**a**, **b**) Fused 68Ga DOTATATE PET/MR (**a**) and axial post-contrast T1WI (**b**) show tracer-avid extra-axial lesions in the right side of the foramen magnum, right temporal lobe laterally and left temporal lobe medially (**a**, *arrows*). The focal hyper intensity adjacent to the clivus bone is the normal tracer uptake in the pituitary gland (**a**, FH). These correspond to small enhancing meningeal lesions (**b**), in keeping with multiple meningiomas.
Teaching point: Meningiomas may be considerably small-sized, and osseous structures (e.g. skull base) may hamper the diagnosis. ^{68}Ga DOTATATE is a tracer selective for the evaluation of somatostatin receptors which are rich in different tumours, such as neuroendocrine, meningioma and paraganglioma

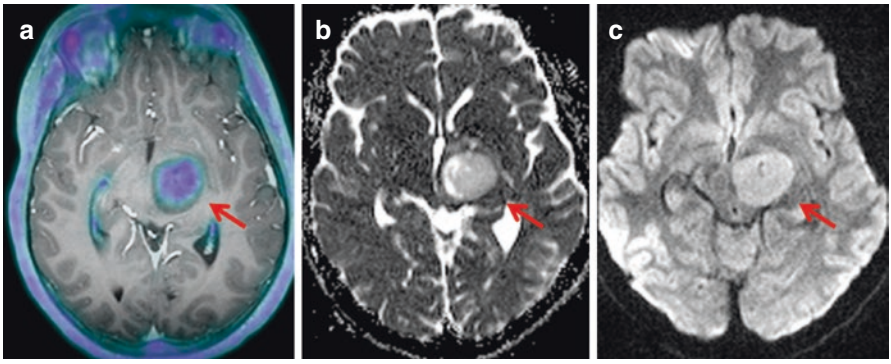

Fig. 14.5 (**a**–**c**) Axial fused ^{18}FCholine PET/MR (**a**), ADC map (**b**) and DWI (**c**) show an ^{18}FCholine avid lesion in the left thalamus (**a**, *arrow*), with corresponding restricted diffusion on the diffusion-weighted images (**b**, **c** *arrows*).
Teaching point: The use of multiparametric evaluation can help identify different components of the tumour including metabolism and cellularity

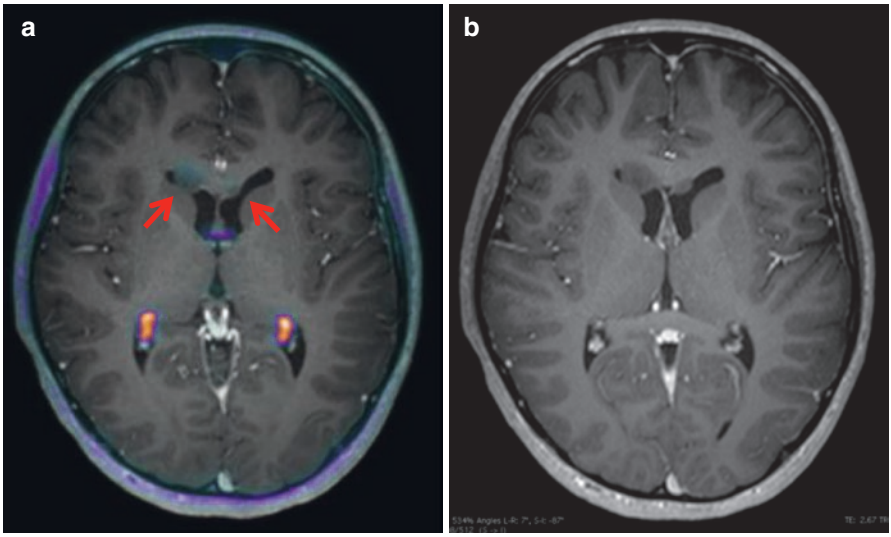

Fig. 14.6 (**a**, **b**) Axial fused ^{18}FCholine PET/MR (**a**) and axial post-contrast T1WI (**b**) show mildly avid subependymal lesions with partial intraventricular extension in the anterior horn of the lateral ventricle bilaterally (**a**, *arrows*) which correspond to non-enhancing small hypointense lesions (**b**).
Teaching point: Non-enhancing lesions can still present with uptake on ^{18}FCholine imaging and might be useful for treatment evaluation

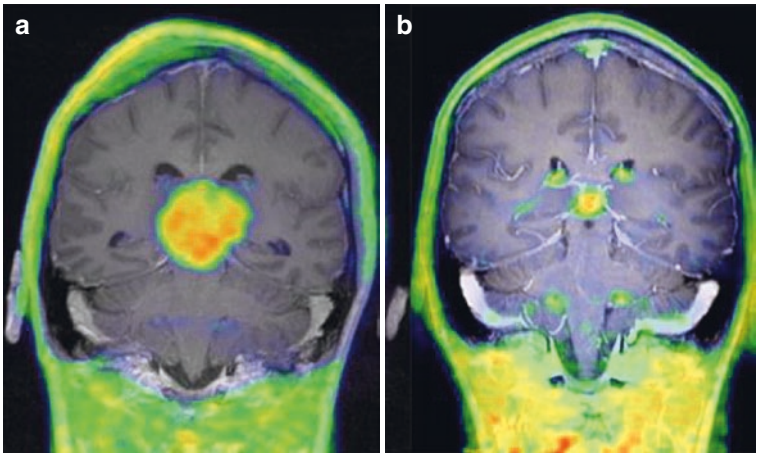

Fig. 14.7 (**a**, **b**) Coronal fused ^{18}FCholine PET/MR (**a**, **b**) show a large ^{18}FCholine avid non-germinomatous germ cell pineal body tumour prior to treatment (**a**) which shows interval reduction in size and tracer uptake post-treatment (**b**), in keeping with partial metabolic response.
Teaching point: The importance of having appropriate metabolic imaging prior to treatment as a baseline can help with better post-treatment assessment

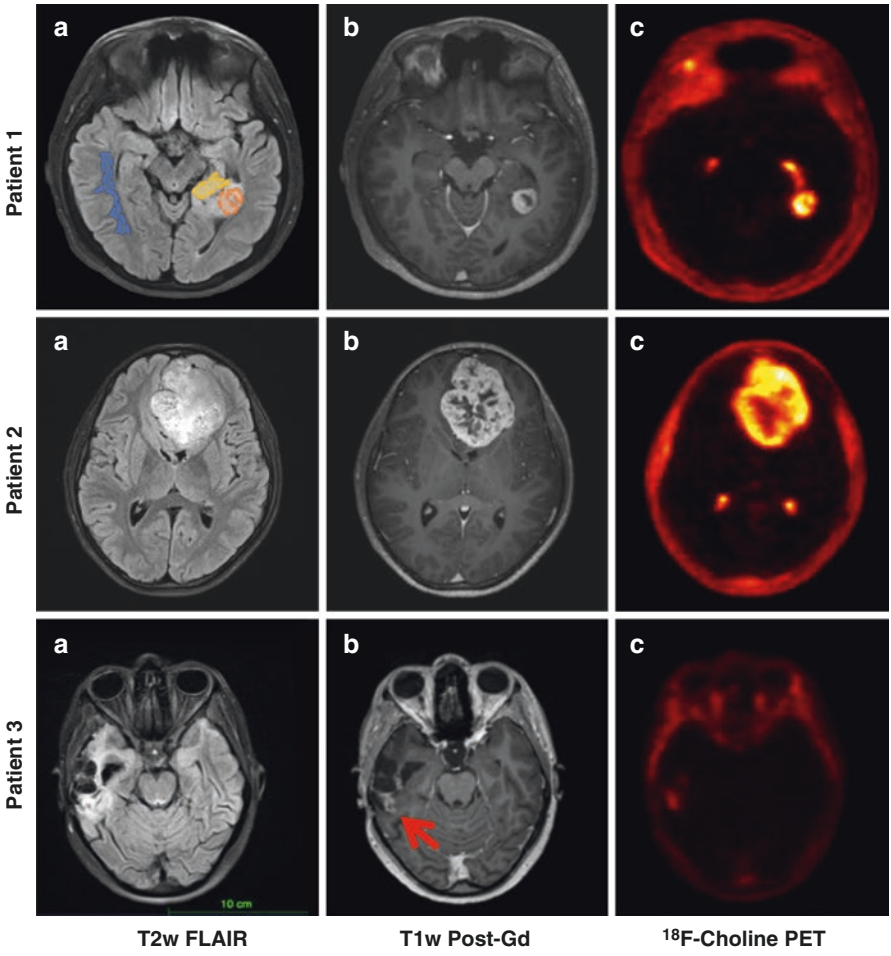

Fig. 14.8 Axial T2W FLAIR (**a**), axial post-contrast T1WI (**b**) and axial ^{18}FCholine PET (**c**) in Patients 1–3
Patient 1: A 17-year-old patient with grade I pilocytic astrocytoma demonstrates normal appearing 'white matter' ROI (blue), 'non-enhancing' tumour ROI (yellow) and 'enhancing' tumour ROI (pink) (**a**), enhancing tumour (**b**) with increased ^{18}FCholine uptake in the enhancing component (**c**)
Patient 2: An 18-year-old patient with grade I schwannoma demonstrates a high-intensity left frontal lobe mass (**a**), which shows peripheral enhancement with central non-enhancing area (**b**) which corresponds to increased ^{18}FCholine uptake in the enhancing component (**c**)
*Patient 3***:** A 21-year-old patient with grade IV glioblastoma (GBM) demonstrates high signal in the right temporal lobe with areas of susceptibility artefacts (**a**), which shows minimal enhancement at its posterior-lateral component (**b**, *arrow*) that corresponds to mildly increased ^{18}FCholine uptake.
Teaching point: The use of multiparametric evaluation can help identify different components of the tumour and possible sites for treatment targeting

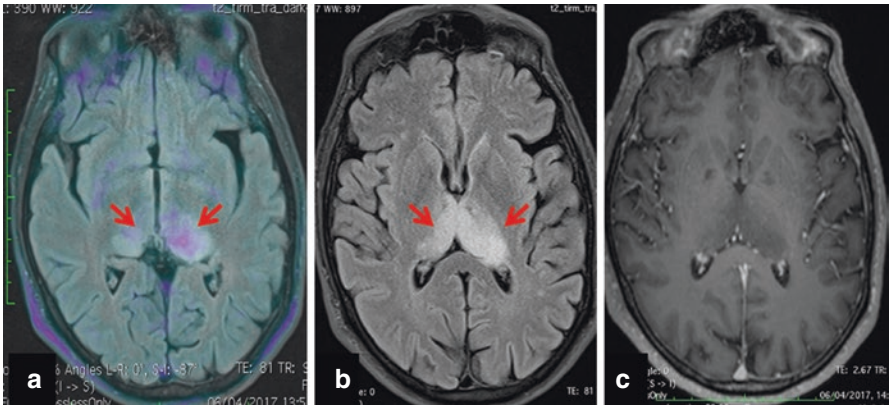

Fig. 14.9 (**a**–**c**) Axial fused ^{18}F DOPA PET/MR (**a**), axial T2W FLAIR (**b**) and axial post-contrast T1WI (**c**) show bilateral increased ^{18}F DOPA tracer uptake in the thalami (left > right) (**a**, *arrows*) with corresponding high-signal changes (**b**, *arrows*) and no significant enhancement on the post-contrast image (**c**). The left thalamic lesion was proven upon biopsy to be a low-grade tumour with transformation into high-grade glioma.
Teaching point: ^{18}F DOPA tracer uptake can detect early transformation of gliomas and impact treatment decision

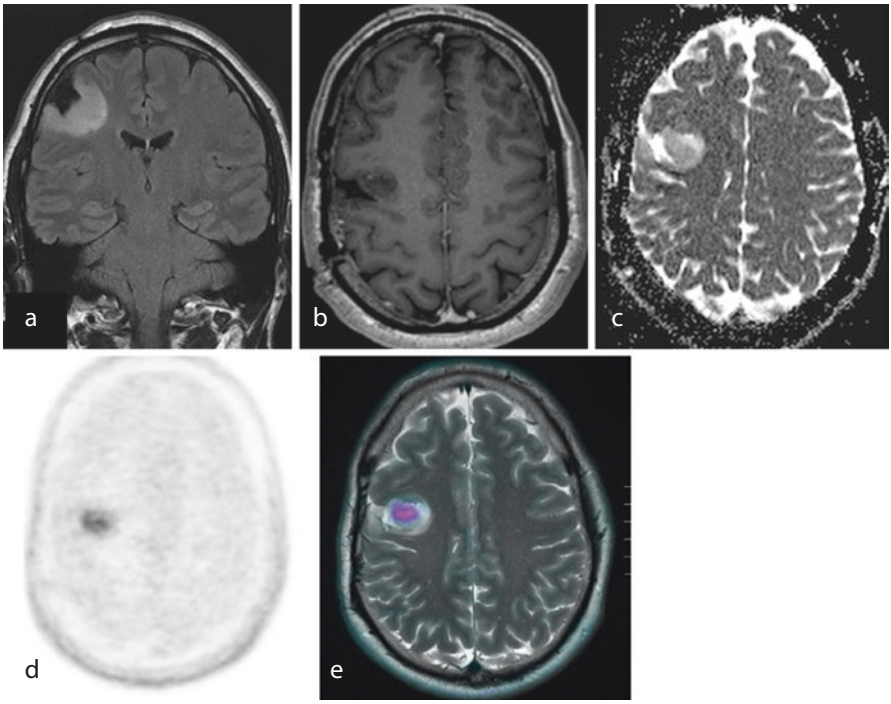

Fig. 14.10 (**a**–**d**) Coronal T2W FLAIR (**a**), axial post-contrast T1WI (**b**), axial ADC map (**c**), axial ^{18}F DOPA PET (**d**) and axial fused ^{18}F DOPA PET/MR (**e**) demonstrate a high-signal, non-enhancing area in the right frontal lobe (**a**, **b**) with diffusion restriction (**c**) in a patient previously operated for a high-grade glioma tumour in the right frontal lobe with similar stable postoperative MR appearances compared to prior postoperative imaging over the last 4 years. However, further imaging with ^{18}F DOPA shows increased tracer uptake in the right frontal lobe tumour (**d**, **e**), consistent with active residual disease. The patient had further treatment 2 weeks later which demonstrated active tumour which was completely removed.
Teaching point: Functional imaging can detect residual disease in otherwise morphologically stable changes in postoperative brain tumours

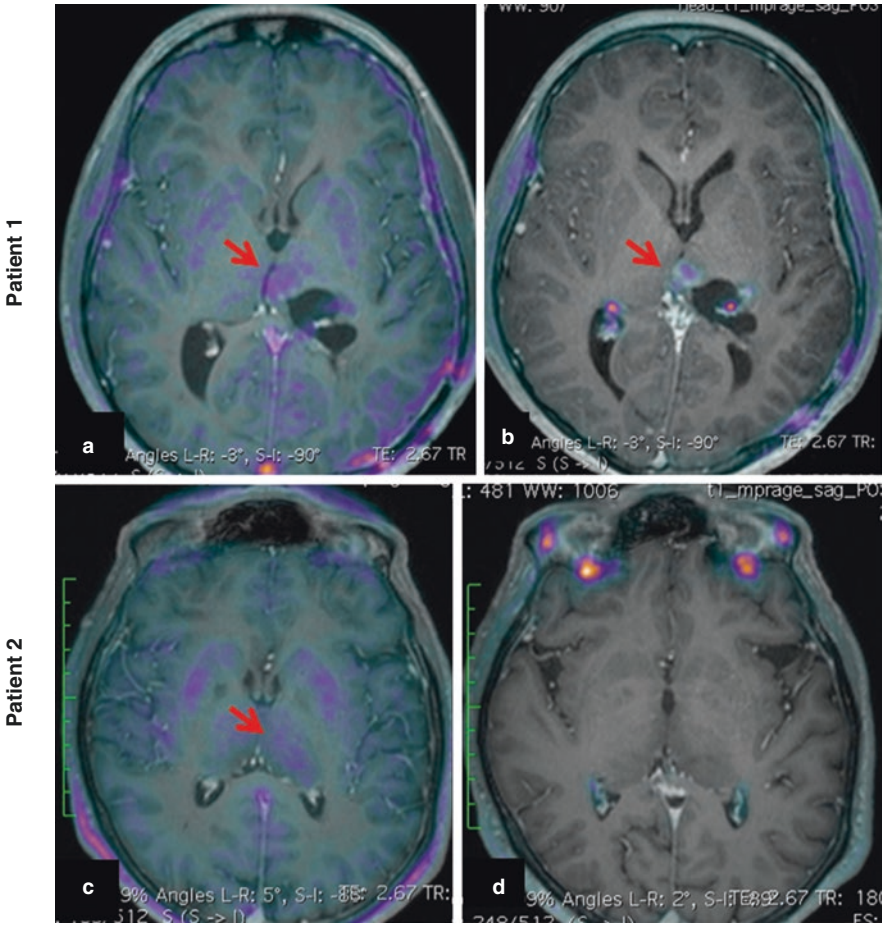

Fig. 14.11 (**a**–**d**) Axial fused ^{18}F DOPA PET/MR (**a**, **c**) and axial fused ^{18}FCholine PET/MR (**b**, **d**) in Patients 1 and 2. *Patient 1:* Biopsy-proven WHO grade IV left thalamic GBM demonstrates increased ^{18}F DOPA and ^{18}FCholine tracer uptake in the left thalamic lesion (**a**, **b**, arrows). *Patient 2:* Biopsy-proven WHO grade II left thalamic glioma with feature of transformation to grade III shows increased ^{18}F DOPA tracer uptake in the left thalamus (**c**, *arrow*) but no corresponding ^{18}FCholine tracer uptake (**d**).

Teaching point: The evaluation of brain lesions with different tracers can give an insight of various components within the tumour which help in assessing tumour grade and further impact management decision

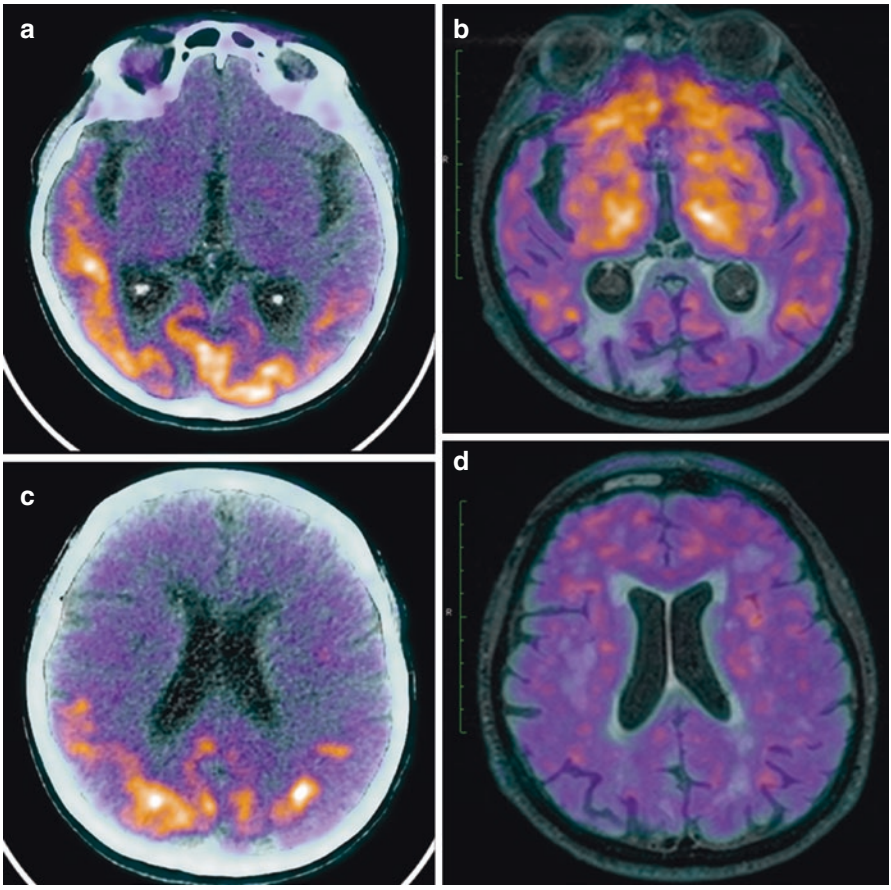

Fig. 14.12 (**a**–**d**) Axial fused Tau tracer PET/CT (**a**, **c**) and axial fused amyloid PET/MR (**c**, **d**) in the same patient imaged 2 weeks apart demonstrated increased Tau tracer uptake in the posterior parietal and occipital regions of the brain cortex (**a**, **c**) with amyloid PET showing completely different regions of amyloid deposition in the frontal lobes (**d**).
Teaching point: Tau and amyloid tracers can show different patterns of tracer distribution in the same patient. This may aid in the understanding of the different mechanisms in the degenerative changes occurring in patients presenting with dementia-like features

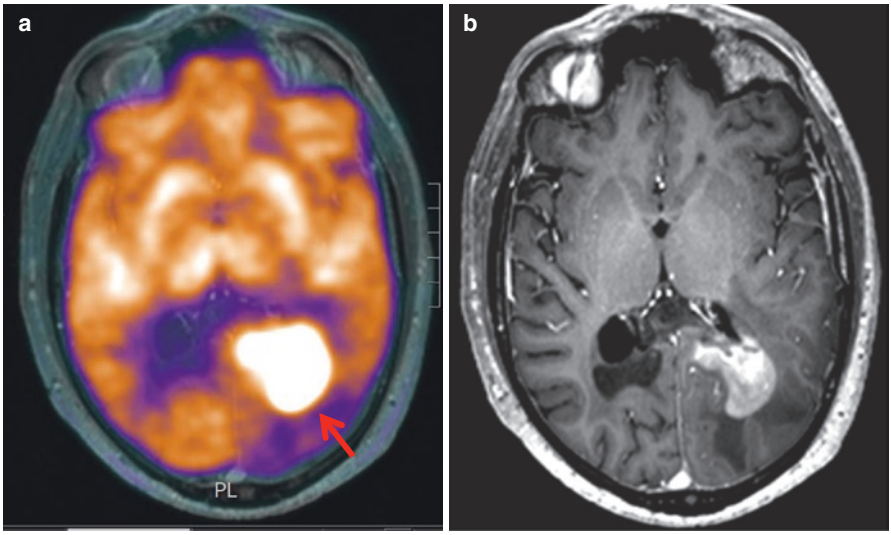

Fig. 14.13 (**a**, **b**) Axial fused ^{18}F-FDG PET/MR (**a**) and post-contrast T1WI (**b**) demonstrate intense increased FDG uptake in the periventricular region of the posterior horn of the left lateral ventricle (**a**, *arrow*) which corresponds to an enhancing lesion on the post-contrast MR (**b**), in a patient with CNS lymphoma.
Teaching point: Intense uptake on FDG can differentiate between CNS lymphoma and primary brain tumours like GBM which usually show less FDG uptake

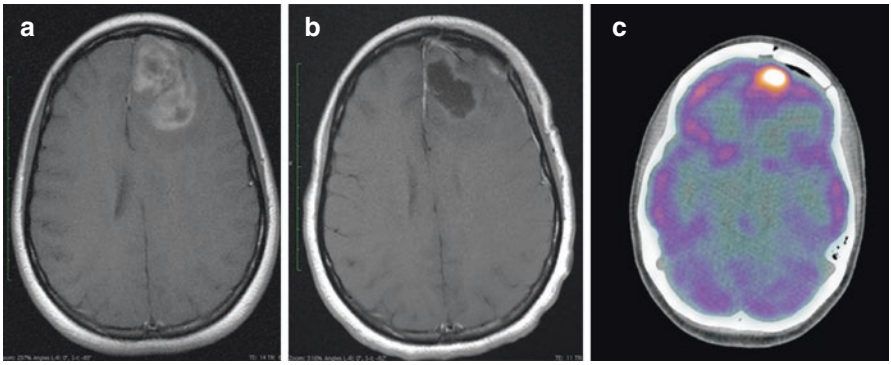

Fig. 14.14 (**a**–**c**) Axial post-contrast T1WI (**a**, **b**) and axial fused ^{18}F-FDG PET/CT (**c**) demonstrated an enhancing left frontal lobe mass in a patient diagnosed with GBM (**a**). Follow-up postoperative MR imaging shows postoperative changes in the left frontal lobe with no convincing enhancement of residual tumour (**b**). Additional functional imaging with ^{18}F-FDG PET/CT shows an avid focus in the left frontal lobe (**c**) which is consistent with active residual disease.
Teaching point: Functional imaging can determine the presence of residual disease in postoperative patients with unremarkable postoperative morphological imaging

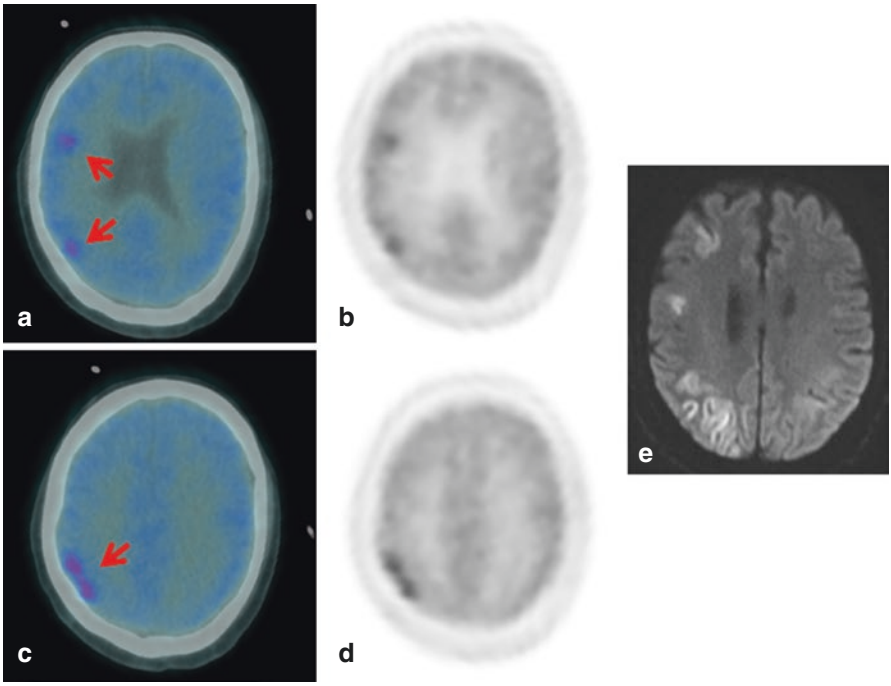

Fig. 14.15 (**a**–**e**) A 64-year-old patient with background AL amyloidosis treated with chemotherapy, presenting with widespread myoclonus, confusion, seizures and reduced consciousness. Axial fused ^{18}F FDG PET/CT (**a**, **c**), axial PET (**b**, **d**) and DWI image (**e**) show focal increased cortical uptake in right frontal and right parietal lobes (**a**–**d**, *arrows*), which correspond to areas of restricted diffusion on MRI (**e**), raising possible vasculitis secondary to cerebral amyloid angiopathy.
Teaching point: Visualization of vascular wall uptake in small vessel vasculitis is beyond the resolution of PET, however indirect signs can be demonstrated by the presence of abnormal cortical tracer uptake in the corresponding vascular territory. Furthermore, multiparametric imaging is required in assessing these challenging cases

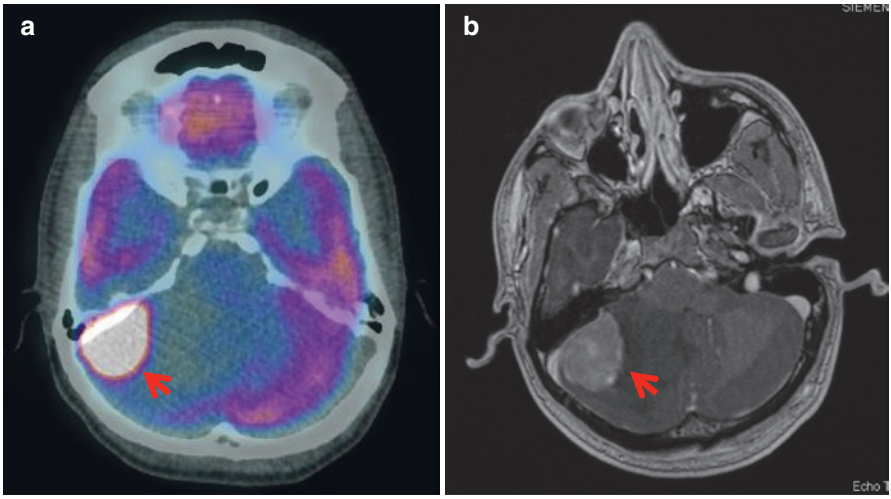

Fig. 14.16 (**a**, **b**) Patient with previous lymphoma completed chemotherapy 2 months ago and presented with cerebellar signs, and MRI showed a right cerebellar mass. Axial fused ^{18}F FDG PET/CT (**a**) and post-contrast T1WI (**b**) show intensely avid right cerebellar lesion (**a**, *arrow*) corresponding to the enhancing lesion (**b**, *arrow*), in keeping with relapsed CNS lymphoma.
Teaching point: Given the usual intense ^{18}F FDG uptake in lymphoma, evaluation of areas with usually high metabolic activity like the brain is possible, and evaluation with FDG PET/CT is particularly useful in assessing disease relapse in patients with prior history of lymphoma

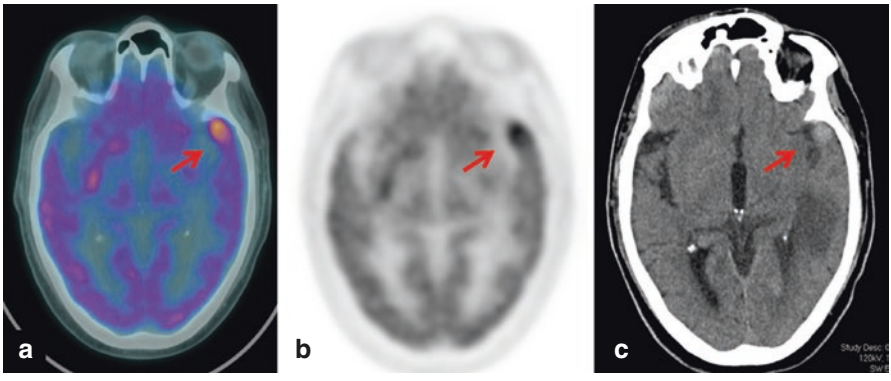

Fig. 14.17 (**a**–**c**) Axial fused ^{18}F FDG PET/CT (**a**), axial ^{18}F FDG PET (**b**) and noncontrast CT (**c**) show a FDG-avid lesion in the left temporal lobe (**a**, **b** *arrows*) which corresponds to a hyperdense lesion on subsequent CT (**c**, *arrow*) in a patient who underwent PET/CT for lung cancer staging, in keeping with brain metastasis.
Teaching point: Including the brain in the whole-body PET/CT imaging can sometimes detect metastatic brain lesions and is advised to be routinely done in cases with suspected malignancies that have or are likely to have brain metastasis

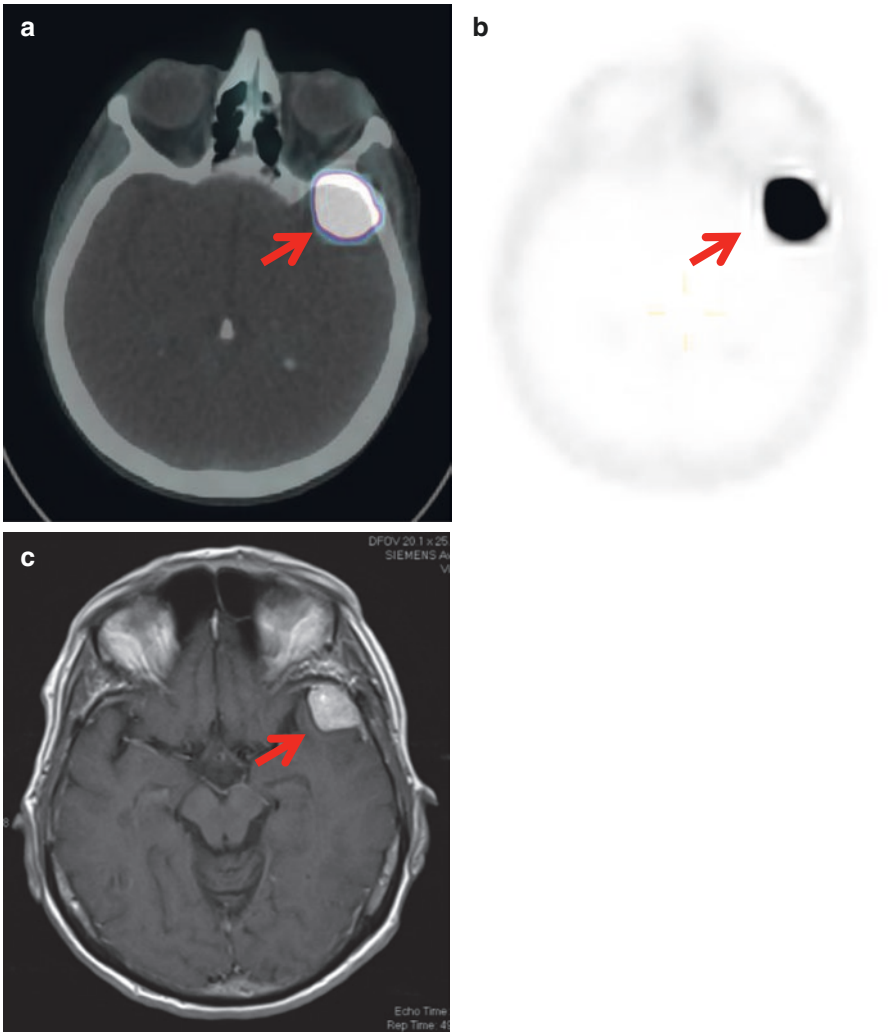

Fig. 14.18 (**a**–**c**) Axial fused ^{68}Ga DOTATATE PET/CT(**a**), axial ^{68}Ga DOTATATE PET (**b**) and contrast-enhanced T1WI MRI (**c**) show ^{68}Ga DOTATATE intensely avid left temporal fossa lesion (**a**, **b** arrows) corresponding to an enhancing left temporal extra-axial lesion on MRI (**c**, arrow) in which the differential included dural-based metastasis and meningioma. The reminder of the^{68}Ga DOTATATE PET/CT did not show uptake elsewhere, and findings were keeping with a meningioma.

Teaching point: Imaging with ^{68}Ga DOTATATE PET can help narrow down the differential diagnosis due to the positive uptake in lesions with somatostatin receptors, e.g. meningiomas or other neuroendocrine tumours

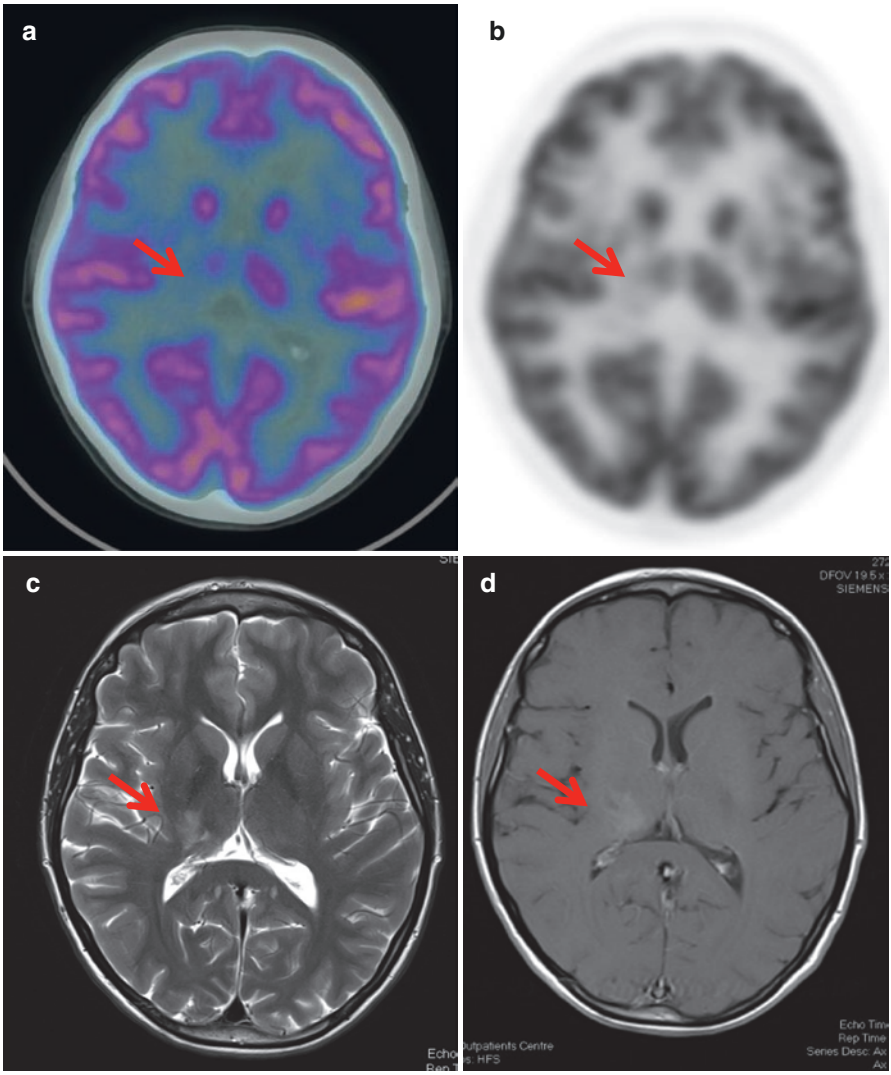

Fig. 14.19 (**a**–**d**) Axial fused ^{18}F FDG PET/CT (**a**), axial ^{18}F FDG PET (**b**), axial T2WI (**c**) and post-contrast T1WI (**d**) show area of focal reduction of tracer uptake in the right thalamus (**a**, **b**, *arrows*) which correspond to an area of high T2 signal and mild enhancement on MRI (**c**, **d** *arrows*) in a patient with multiple sclerosis.
Teaching point: Brain lesions can present as areas of reduced tracer uptake which may be missed, and comparison between both hemispheres is key

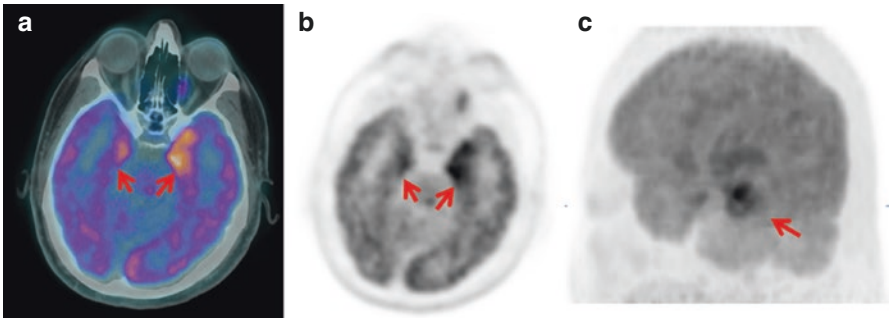

Fig. 14.20 (**a**–**c**) Axial fused ^{18}F FDG PET/CT (**a**), axial ^{18}F FDG PET (**b**) and 3D MIP (**c**) in a patient with worsening left arm, leg weakness and ataxia show increased tracer uptake in the medial temporal lobes, much more marked on the left side (**a**–**c**, *arrows*). These appearances can be seen in limbic encephalitis.
Teaching point: Recognizing uptake patterns in certain conditions can help aid in the diagnosis

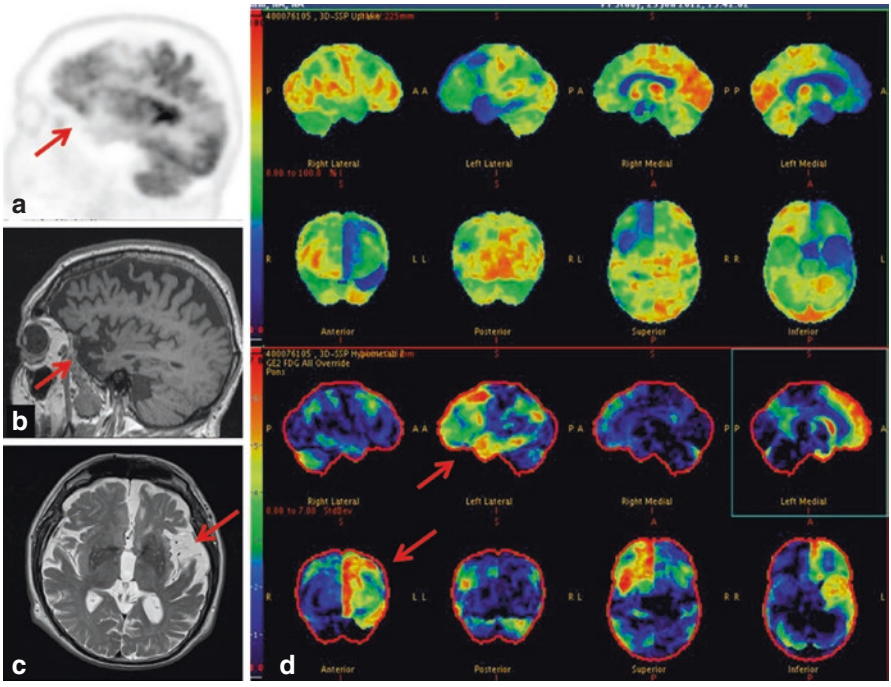

Fig. 14.21 (**a**–**d**) Sagittal ^{18}F FDG PET (**a**), sagittal T1WI (**b**), axial T2WI (**c**) and *Z*-score maps (**d**) show reduced FDG uptake in the left frontotemporal lobe (**a**, *arrow*) corresponding to cerebral atrophy on MRI (**b**, **c** *arrows*) and confirmed on quantification assessment (**d**, *arrows*), in keeping with frontotemporal dementia.
Teaching point: Multimodality imaging can help recognize different patterns of dementia

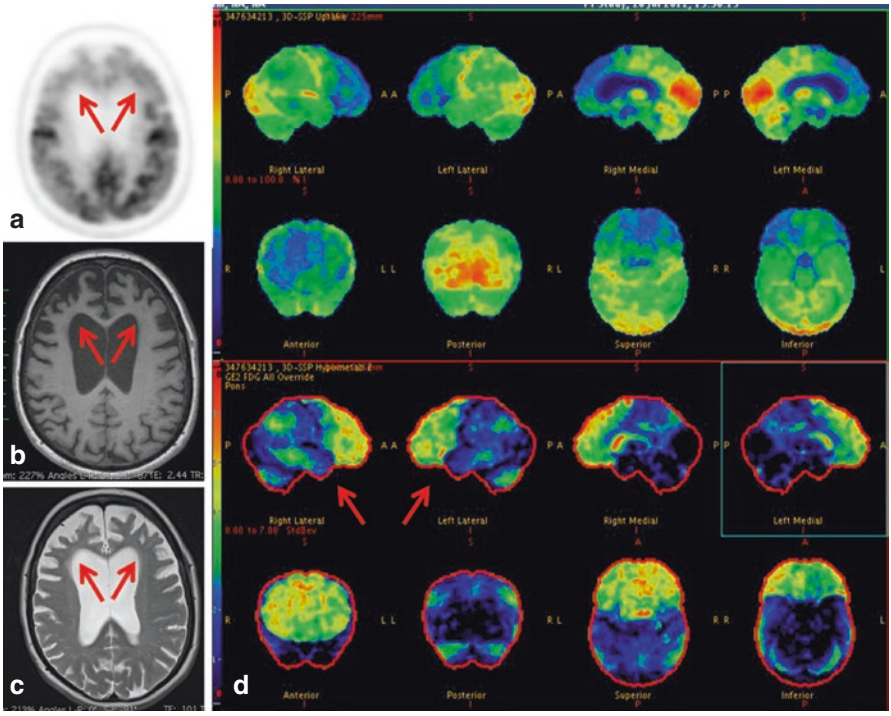

Fig. 14.22 (**a**–**d**) Axial ^{18}F FDG PET (**a**), axial T1WI (**b**), axial T2WI (**c**) and *Z*-score maps (**d**) show reduced FDG uptake in the frontotemporal lobes bilaterally more pronounced in the frontal lobes (**a**, *arrows*) corresponding to cerebral atrophy on MRI (**b**, **c** *arrows*) and confirmed on quantification assessment (**d**, *arrows*), in keeping with frontotemporal dementia.
Teaching point: Multimodality imaging can help recognize different patterns of dementia

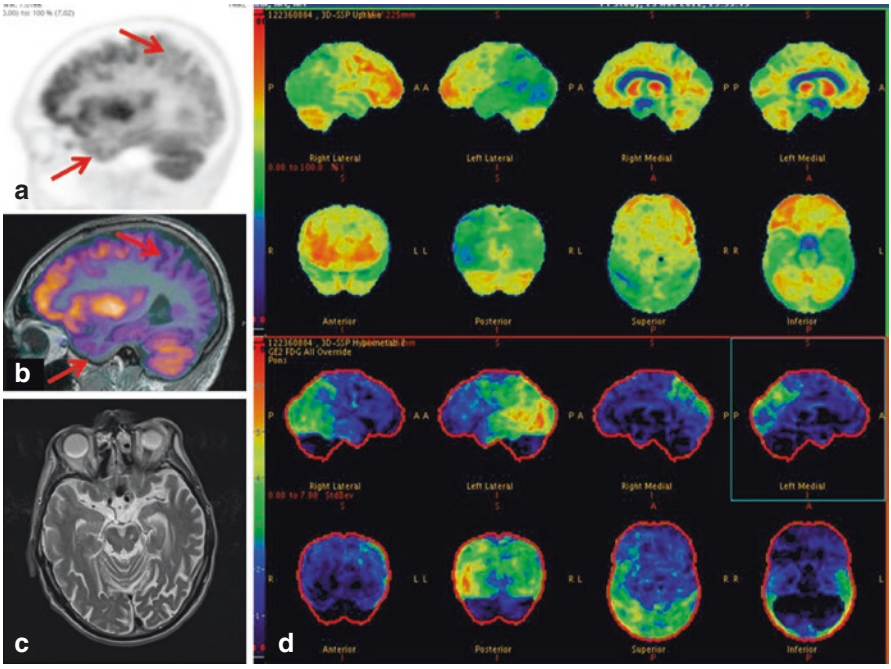

Fig. 14.23 (**a**–**d**) Sagittal ^{18}F FDG PET (**a**), sagittal fused ^{18}F FDG PET/MR (**b**), axial T2WI (**c**) and *Z*-score maps (**d**) show reduced FDG uptake in the temporoparietal lobes bilaterally (**a**, **b** *arrows*) corresponding to cerebral atrophy on MRI (**c**) and confirmed on quantification assessment (**d**), in keeping with Alzheimer's dementia.
Teaching point: Multimodality imaging can help recognize different patterns of dementia

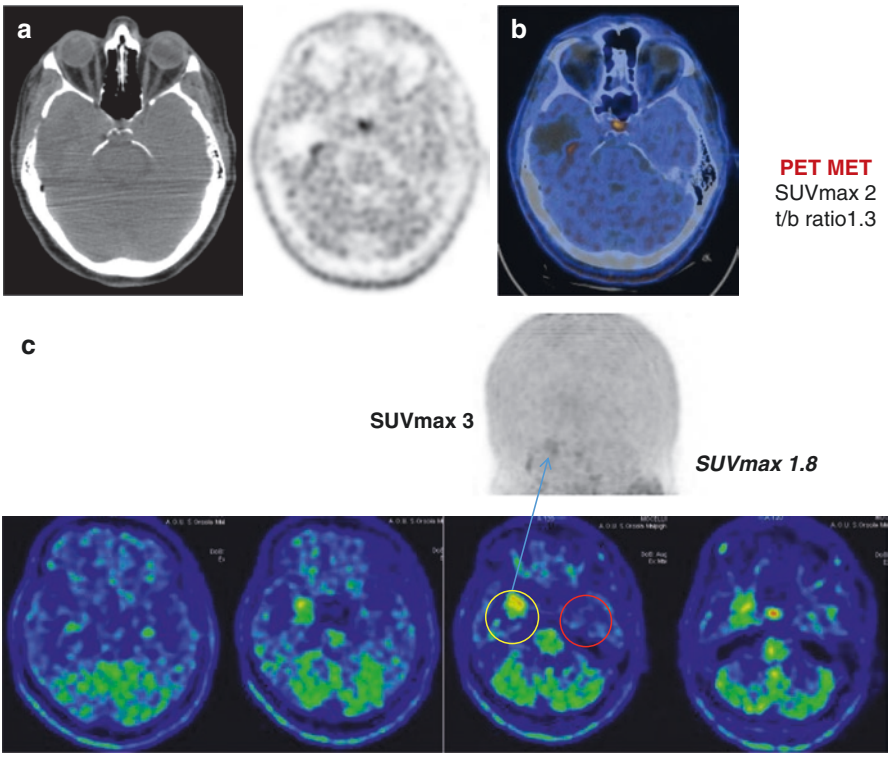

Fig. 14.24 (**a**–**c**) Axial CT (**a**), MET/PET (**b**) and axial fused PET/CT (**c**) show increased uptake in the residual tumour in the right temporal lobe. Bottom images show the differences in uptake in the tumour region and in the contralateral normal lobe.
Teaching point: MET/PET has a significant impact in assessing tumour recurrence. *Case courtesy of Dr. Castellucci, University St. Orsola Malpighi, Bologna, Italy*