44 Treatment Planning

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In addition to previously discussed neuroimaging for seizure focus localization, a multitude of other diagnostic tests may be performed for both localization and surgical planning. Approximately 22–25% of epilepsy cases are medically refractory [1, 2]. These patients may be referred for surgical evaluation as an alternative treatment option. In fact, up to 80–90% of patients who undergo anteromesial temporal lobectomy (AMTL) for mesial temporal lobe epilepsy become seizure free [3, 4]. Accurate epileptogenic localization is crucial for optimal post-surgical seizure control.

High-Density Electroencephalography (HD EEG)

High-density electroencephalography (HD EEG) utilizes an increased number of scalp electrodes as compared to conventional electroencephalography, resulting in greater spatial coverage and spatial resolution. Although there is improved localization of the seizure onset zone, HD-EEG requires increased preparation time and electrode maintenance [5]. When there is a concordance of PET/CT or PET/MRI findings with scalp EEG localization, patients with medically refractory epilepsy demonstrate favorable postoperative outcomes [6].

Magnetoencephalography (MEG)

Magnetoencephalography (MEG) is a noninvasive tool that can be helpful in the evaluation of epilepsy. MEG uses a biomagnetometer to measure magnetic fields generated by electric currents in the brain. Not only does MEG offer greater temporal resolution compared to EEG, its measurement of magnetic fields does not make it susceptible to the different electric conductivities of the tissues (e.g., scalp and skull) [6, 7].

MEG can be utilized to (1) confirm seizure focus localization based on other noninvasive methods and thereby bypassing long term intracranial EEG monitoring and allowing epilepsy surgery to proceed; (2) demonstrate bilateral, multifocal, or generalized ictal onset zones and thus obviating potentially unsuccessful epilepsy surgery; (3) identify focal ictal zones that were previously incorrectly characterized as multifocal, but with rapid progression of seizure spread; or (4) help localize eloquent cortex to guide surgical intervention [8]. Of note, MEG is not as widely available as EEG or HD EEG.

Intracranial Electroencephalography

Intracranial EEG evaluation for an epileptogenic zone can be utilized when noninvasive diagnostic tests including MRI, routine scalp EEG, PET, and/or MEG are either inconclusive or discordant. However, these more invasive procedures carry a risk of intracranial hemorrhage and infection.

Stereotactic electroencephalography (SEEG) involves the stereotactic placement of depth electrodes to elucidate the epileptogenic zone and is useful for the evaluation of deep brain structures (Figs. 44.1, 44.2, and 44.3). Alternatively, strip and grid electrode placement are utilized more for cortical monitoring. Whether used individually or in combination, these invasive EEG techniques provide diagnostic information that can aid in epileptogenic focus localization and surgical planning [9].

Functional MRI and Neuropsychological Testing

Many patients who are considered for surgical treatment of epilepsy will undergo neuropsychological testing to determine the risk of postoperative cognitive morbidity [10].

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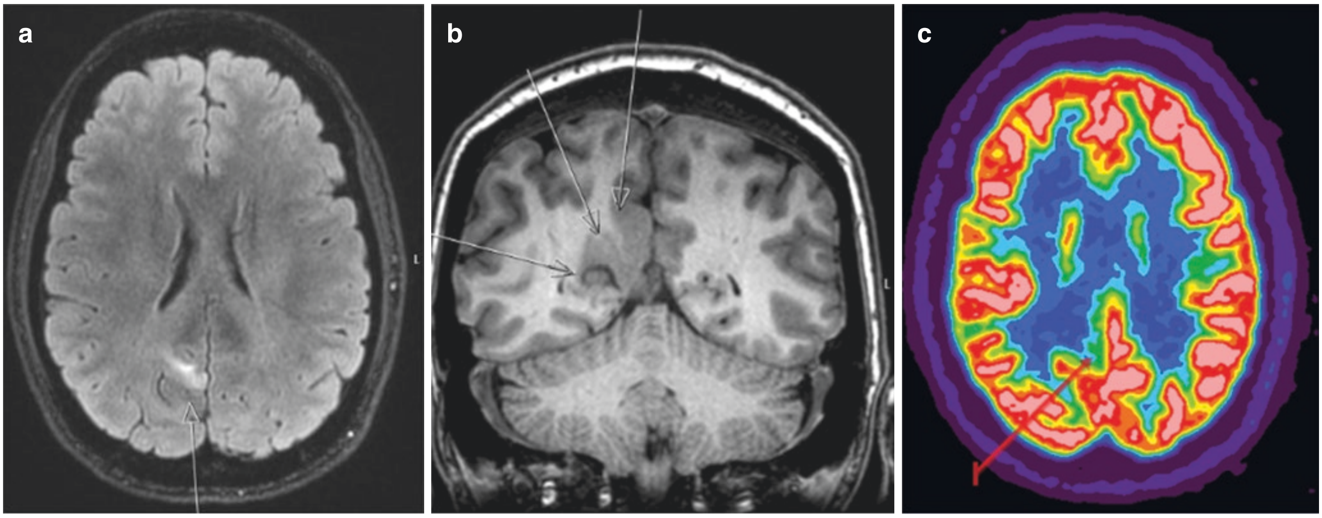

Fig. 44.1 A 40-year-old female with medically refractory seizures. Coronal T1 BRAVO (**a**) shows the area of cortical thickening and blurring of the gray-white matter junction (*arrows*). Axial CUBE T2 FLAIR (**b**) with associated signal abnormality (*arrow*). Concurrent PET (**c**) demonstrates corresponding interictal hypometabolism in the medial right parietal lobe (*red arrow*). Findings consistent with FCD

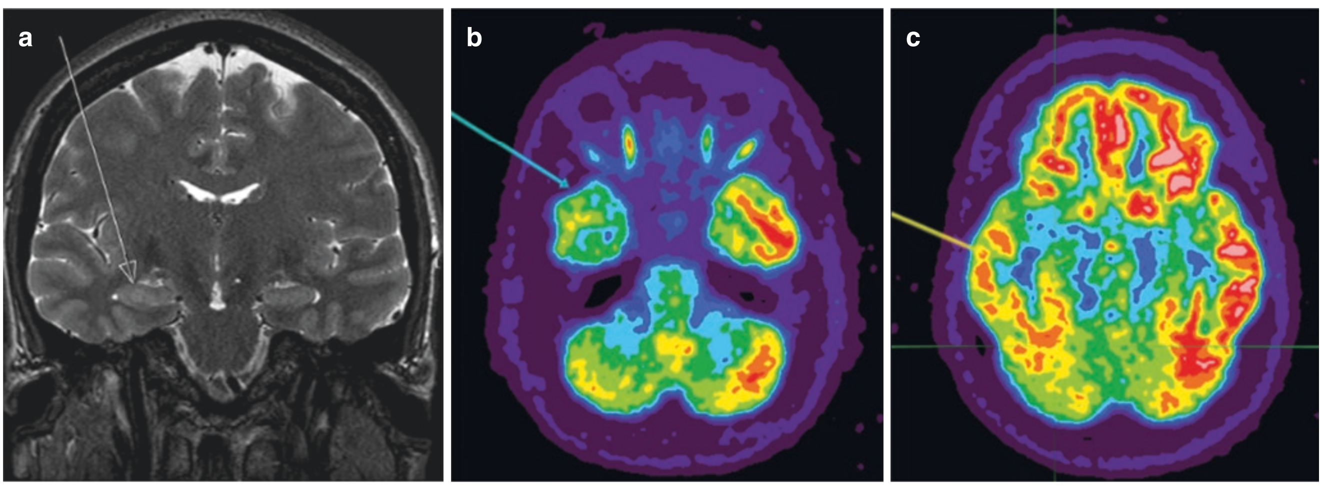

Fig. 44.2 The same patient and same hybrid PET/MR exam demonstrating a mild increased signal (*arrow*) in the right hippocampal hilus on coronal T2 (**a**), but without architectural distortion or volume loss. PET images (**b**, **c**) with broad areas of hypometabolism in the right temporal lobe (*colored arrows*)

Functional MRI (fMRI) examinations provide valuable spatial information regarding language, memory, motor, and sensory dominance. In conjunction with identifying the relative position of epileptogenic lesions to sites of eloquent cortex, fMRI studies may help determine postoperative deficits and therefore add to presurgical decision making [11, 12] (Fig. 44.4).

Diffusion Tensor Imaging (DTI)

Diffusion tensor imaging (DTI) is an MRI technique that revolves around the concept of diffusion and the displacement of water molecules. Measuring the diffusion of water molecules allows for the calculation of fractional anisotropy (FA) and mean diffusivity (MD); from this information an approximation of neuronal or white matter tractography is created. This is invaluable in presurgical work-up, giving surgeons an approximate roadmap of vital tracts that should be avoided intraoperatively. For example, the corticospinal tracts or arcuate fasciculi may need to be outlined and avoided depending on lesion location. The optic radiations such as Meyer's loop often course along the ventricular temporal horn but are difficult to accurately delineate with tractography. This creates an opportunity for surgeons to have a discussion with patients regarding their postsurgical expecta-

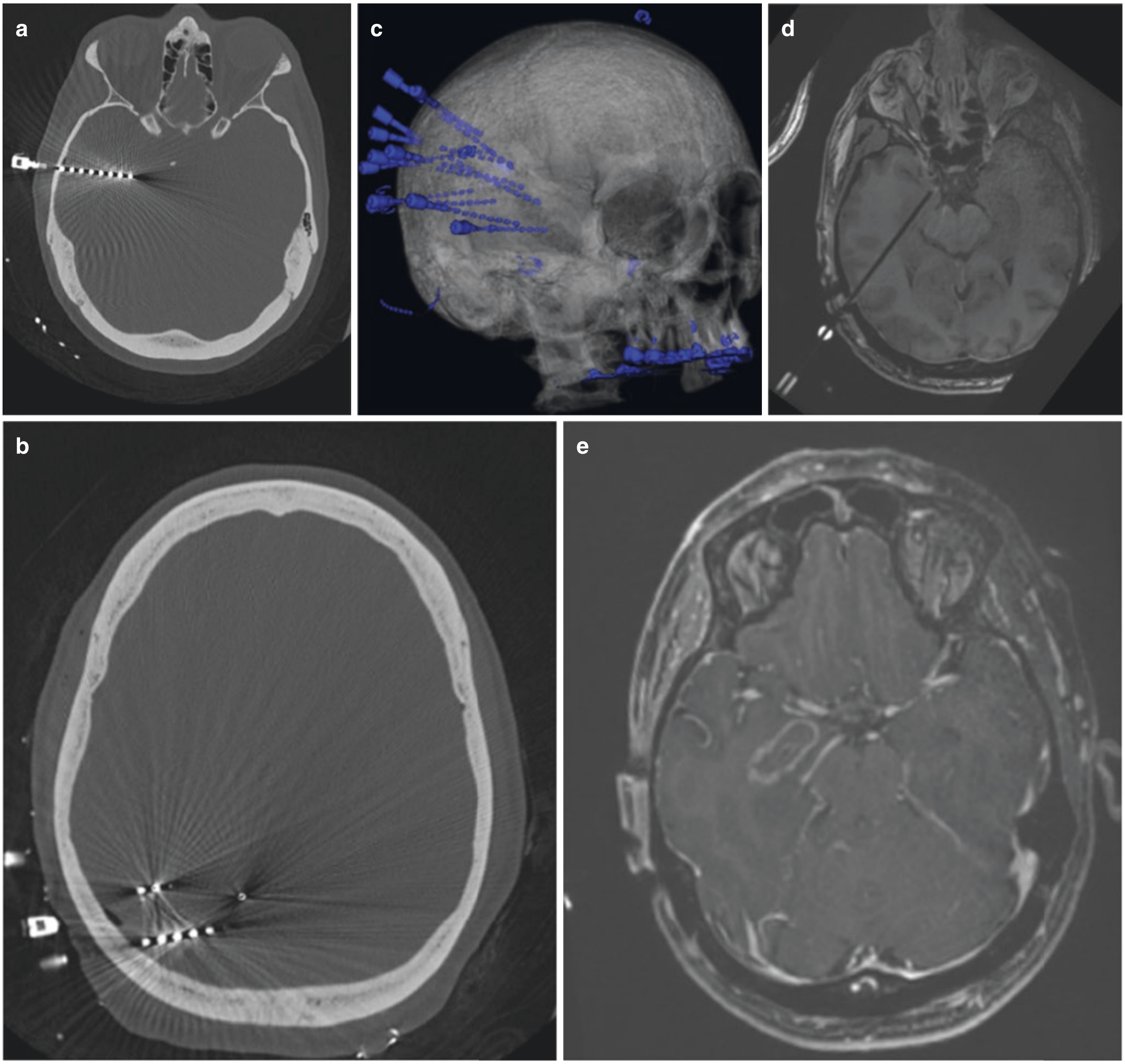

Fig. 44.3 Same patient with further evaluation by SEEG to determine epileptogenic zone. Stereotactic head CT (**a**, **b**) and 3D reconstruction (**b**) demonstrate intracranial EEG lead placement in the right temporal and right parietal lobes, in the regions of clinical interest. Seizures were localized to the right anterior and posterior hippocampus. Intraoperative MRI-guided laser ablation (**c**, **d**) of the right amygdala and hippocampus resulted in postprocedural seizure freedom. Small amount of postprocedural hemorrhage at the ablation site in the right temporal lobe (**e**)

tions and prognostications about what deficits may occur because of surgical treatment of epilepsy. However, it is important to note the limitations of resolution and overreliance on tractography; the data should be used in conjunction with all other relevant clinical and imaging information available. DTI may yield both false positives and false-negative results with many ways of performing the same task yielding different results.

Another newer utilization of DTI in presurgical epilepsy planning builds upon the idea of dysfunction within white matter tracts of epilepsy patients [13, 14], both in temporal and extratemporal locations. DTI connectivity can potentially serve as a noninvasive method of lateralization of temporal lobe epilepsy, adding another tool to the presurgical arsenal, especially in patients with previously unrevealing work-up [15, 16].

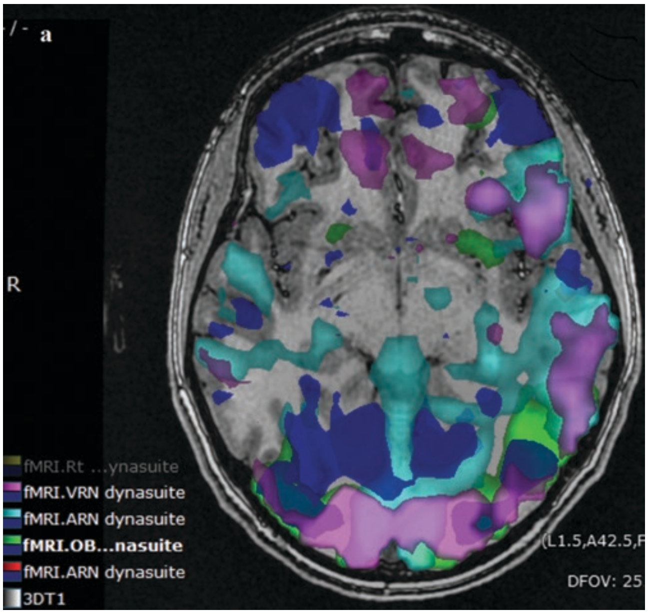

Fig. 44.4 Axial fMRI image from evaluation of a patient with temporal lobe epilepsy demonstrating strong left hemisphere language dominance. Activation of Broca's, Wernicke's, and basal temporal language areas are stronger on the left during visual naming (purple), auditory naming (teal), and object naming (green) paradigm tasks

Deep Brain Stimulation (DBS), Vagal Nerve Stimulation (VNS), and Responsive Neurostimulation (RNS) for Epilepsy Treatment

Patients who are not candidates for surgical treatment of epilepsy, oftentimes due to lack of a discrete epileptogenic abnormality, do have other options to achieve seizure control. This includes either intracranial (vagal nerve stimulation or VNS) or extracranial neurostimulation. Extracranial neurostimulation can either mean deep brain stimulation (DBS) or responsive neurostimulation (RNS).

Deep brain stimulation employs the use of electrical stimulation to a neuronal structure to attain seizure freedom. Two recent large meta-analyses found statistically significant seizure frequency reduction in trials of anterior thalamic DBS and hippocampal DBS [17, 18].

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