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Resection of an occipital lobe epileptogenic network resulting in improvement of a visual field deficit: illustrative case

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BACKGROUND Drug-resistant epilepsy leads to significant morbidity and mortality. Epilepsy surgery for resection of seizure foci is underused, particularly when a seizure focus is located in eloquent cortex. Epileptogenic networks may lead to neurological deficits out of proportion to a causative lesion. Disruption of the network may lead not only to seizure freedom but also reversal of a neurological deficit.

OBSERVATIONS A 32-year-old male with new-onset generalized tonic-clonic seizure was found to have an occipital lobe cavernous malformation. On visual field testing, he was found to have a right-sided hemianopsia. He did not tolerate antiepileptic drugs and had a significant decline in quality of life. Resection was planned using intraoperative electrocorticography to remove the cavernous malformation and disrupt the epileptogenic network. Immediate and delayed postoperative visual field testing demonstrated improvement of the visual field deficit, with near resolution of the deficit 6 weeks postoperatively.

LESSONS Epilepsy networks in eloquent cortex may cause deficits that improve after the causative lesion is resected and the network disrupted, a concept that is underreported in the literature. A subset of patients with frequent epileptiform activity and preoperative deficits may experience postoperative neurological improvement along with relief of seizures.

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KEYWORDS seizures; epilepsy surgery; visual fields; epileptogenic network; cavernous malformation; occipital lobe

Epilepsy is a common condition with a reported prevalence of 1 in 200 people.[1] Despite optimal pharmacotherapy, 20%–40% of patients with epilepsy have inadequate seizure control, known as drug-resistant epilepsy (DRE).[2] In such patients with localizable seizure foci, resection is an effective treatment that may render patients seizure-free, reduce antiepileptic drug (AED) adverse effects, and improve quality of life.[3,4] Epilepsy surgery should be considered in patients with DRE and seizures that result in an increased morbidity, mortality, or disruption in quality of life.[5] Despite outreach efforts, epilepsy surgery is still underused in patients with DRE, with the mean time from onset of DRE to surgical treatment being 20 years.[4,6,7] With eloquent cortical seizure foci, the concern for new postoperative neurological deficits explains some of this hesitancy.[8]

The current goal and primary objective of epilepsy surgery is the resection of the seizure focus and epileptogenic zone to achieve seizure freedom. Driven by advances in imaging and electrophysiological techniques, the established concept a of a discrete seizure focus is being supplanted by new theories of epileptogenic networks. The theory suggests that local neurons produce and propagate epileptogenic activity to distant neurons, which then to recruit more distant neurons.[9,10] In the context of epilepsy surgery, epileptogenic networks are important to anatomically identify because the success of a surgery may depend not only on resection of the seizure focus and epileptogenic zone but also on the disruption of this network.[9,10]

An epileptic network within eloquent cortex may itself generate focal neurological deficits, particularly in patients with frequent seizure activity or focal status epilepticus.[11] In such patients, resections that simply interrupt the epileptogenic network can lead to a paradoxical situation where neurological improvement occurs after an eloquent cortical resection. In this report, we describe a patient with occipital lobe seizures and a large preoperative visual field deficit who experienced improvement in his visual fields postoperatively

ABBREVIATIONS AED = antiepileptic drug; DRE = drug-resistant epilepsy; ECoG = electrocorticography.

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along with resolution of his seizures. We postulate that frequent epileptiform discharges in an occipital epileptogenic network caused the visual field deficit. Resection of a small causative lesion sufficed to disrupt the network and led to overall neurological improvement.

Illustrative Case

A 32-year-old previously healthy male presented for neurosurgical evaluation after a new-onset seizure and was found to have a small left occipital lesion consistent with vascular malformation. Although the patient had no recollection of the event, a witness described a generalized tonic-clonic seizure directly after the patient cried out, "I can't see." The patient also reported that for several weeks prior he had experienced transient episodes of blurry vision and "squiggly lines" in his right visual field.

Magnetic resonance imaging of the brain with contrast demonstrated a 5 $\times$ 7–mm lesion in the left occipital lobe. A cerebral angiogram did not show any evidence of arteriovenous malformation, and overall the radiological findings were most consistent with a cavernous malformation and associated developmental venous anomaly (Fig. 1). On ophthalmological evaluation, the patient had a right-sided congruous homonymous visual field deficit (Fig. 2, upper).

He was started on levetiracetam and lamotrigine but did not tolerate the AEDs, experiencing significant weight loss. He also continued to experience multiple daily visual phenomena in the right hemifield despite multiple AEDs. He had significant decline in his quality of life because of medication side effects and remained legally unable to drive and work. Given these issues, he opted for resection.

We performed an occipital craniotomy using frameless stereotactic neuronavigation and intraoperative electrocorticography (ECoG). Preresection ECoG was performed using a four-contact strip, demonstrating frequent burst episodes of spike epileptiform activity (Fig. 3A and B). Microdissection under the microscope was performed to develop a corridor along the tentorium inferior to the occipital lobe. The cortex overlying the lesion was entered and the location confirmed using frameless stereotactic neuronavigation. The lesion, hemosiderin-stained tissue, and approximately 1-cm margin of normal tissue surrounding the lesion were resected. Postresection ECoG revealed the absence of epileptiform activity (Fig. 3C).

The 3-day postoperative visual field testing revealed that there was near-complete resolution of the homonymous inferior quadrantanopia and improvement of the right paracentral upper quadrantanopia. However, there was also a new deficit in the central region of the right superior quadrant. Repeat visual field testing 6 weeks postoperatively showed near resolution of the preoperative right paracentral quadrantanopia. There was also continued improvement of the new postoperative deficit in the right superior central quadrant. At 6 months, the patient did not have significant limitations and was able to safely return to his job. Eight months postoperatively, the patient remained seizure-free and was receiving lamotrigine, which he was tolerating well.

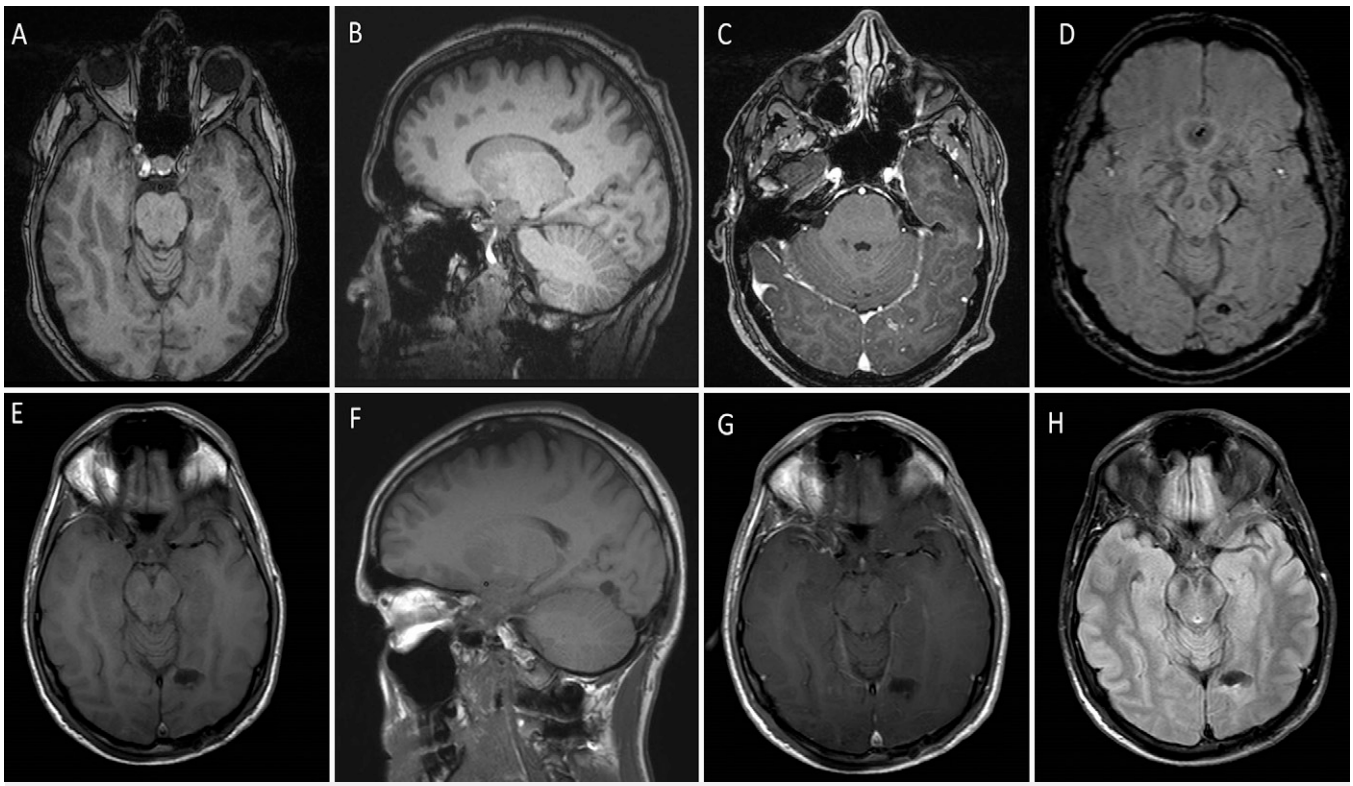

FIG. 1. Magnetic resonance imaging showing an occipital lobe lesion (*upper row*) and postoperative resection (*lower row*). On T1-weighted imaging (T1WI), the lesion was heterogeneously iso- and hypointense on axial (**A**) and sagittal (**B**) sequences. Intrinsic contrast enhancement was evident (**C**) with hypointensity on T2-weighted imaging (T2WI; **D**). Postoperatively, there was evidence of complete resection of the lesion on T1WI (**E and F**), contrast-enhanced imaging (**G**), and T2WI (**H**).

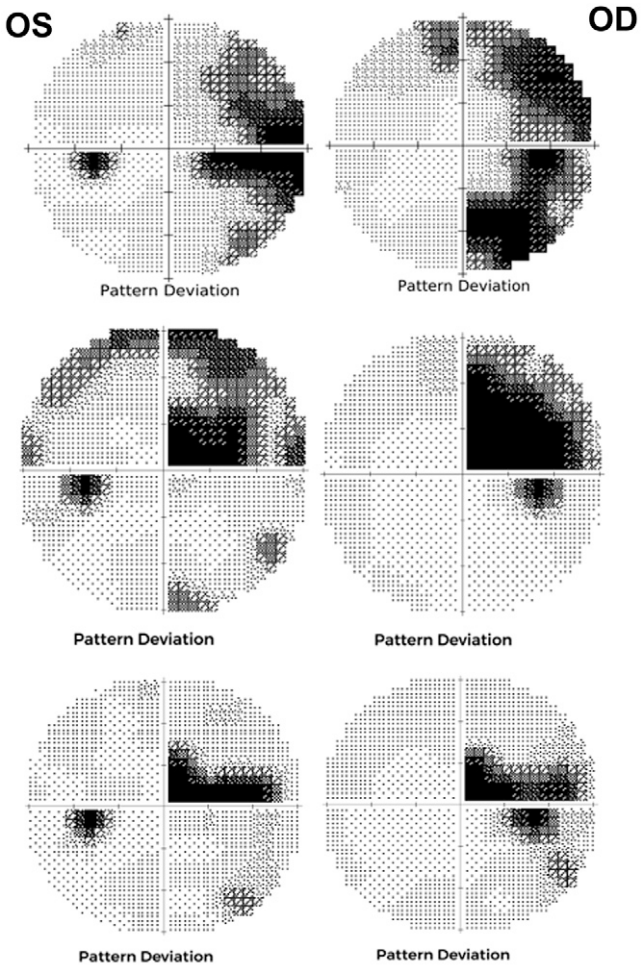

FIG. 2. Patient visual fields preoperatively (*upper*), immediately postoperatively (*center*), and 6 weeks postoperatively (*lower*). The preoperative visual field demonstrated a partial right hemianopsia (*upper*). Visual fields were examined 3 days postoperatively (*center*) and demonstrated improvement of the visual deficit and a residual superior right quadrantanopia. Six weeks postoperatively (*lower*), visual fields continued to improve with near resolution of the quadrantanopia. OD = right eye; OS = left eye.

Discussion

Observations

DRE is a malignant condition with significant morbidity, mortality, and negative influence on quality of life.[12–14] Resection of a seizure focus is a common and effective intervention for DRE. However, seizure foci in eloquent cortex present a significant management challenge due to the risk of new postoperative deficits with resection.[15–17] Nonresective alternatives, such as multiple subpial transections or responsive neurostimulation, unfortunately are rarely curative.[18–21]

This report describes a clinical situation in which patients stand to doubly benefit from eloquent cortical resection with regard to seizure outcome and neurological function. Although only a minority of patients with eloquent cortical lesions are likely to fall into this category, it is nonetheless important to recognize them, given the profound benefit resective surgery may offer. We were able to find only one similar case reported in the existing literature.[22] Furthermore, our case is unique in providing intraoperative ECoG data as well as visual field assessments at multiple stages of recovery that allow delineation of the improved preoperative deficit from the new postoperative deficit.

The neurological improvement in this case is best understood through the network model of epilepsy, where clinical manifestations are related to neural network dynamics and functional connectivity ranging from the microscale (neuronal level) to macroscale (brain areas).[9] This model is replacing older concepts of epilepsy that describe seizures as "focal" or "generalized" and instead describes seizures as a result of paroxysmal and pathological activation of specific neuronal connections.[23,24] In this model, lesions may be synaptically connected to physiological neural networks such that epileptic activity propagates along the connecting pathways.[25]

Viewed within this framework, there are several strategies for surgical management of refractory epilepsy. One is to disrupt the network by resection of a causative lesion, as in this case. Minimally invasive treatments are also available and are able to achieve high rates of seizure freedom in patients.[26] Image-guided radiofrequency ablation and laser interstitial thermotherapy can target deep brain structures that would be difficult to access with an open approach. Alternatively, when there is no discrete lesion, modulation of the entire network is possible through stimulation of the thalamus or vagus nerve or responsive neurostimulation of the specific regions.[21]

The clinical pattern in this case should be recognized as a situation where eloquent cortical resection may lead to neurological improvement: a causative lesion with deficits greatly out of proportion to the lesion's size combined with frequent (multiple per day) episodes of clinical and/or electroencephalographic epileptiform activity. Even without ECoG confirmation, it can be deduced that the lesion is causing broad network dysfunction that could be interrupted by resection.

However, resection of lesions, particularly in the eloquent cortex, is not without risk and should always be considered on a case-by-case basis. In a review by Hader et al.,[27] rates of minor and major neurological complications after resective surgery were 10.9% and 4.7%, respectively. The most common neurological complication was minor visual field deficit. Other deficits can include hemiparesis, cranial nerve deficits, dysphagia, and cognitive deficits. In addition, certain types of lesions may increase the risk of deficit. In this case lesson, we presented a cavernous malformation that was well demarcated without functional brain tissue. Other types of lesions may result in increased risk of deficit, such as with focal cortical dysplasia, where borders are less well defined.

Lessons

This case illustrates an important lesson that eloquent cortical resections in epilepsy do not always cause neurological worsening. A subset of patients with frequent epileptiform activity and preoperative deficits may experience postoperative neurological improvement along with relief of seizures. Importantly, this case lesson does not imply that these resections do not cause deficits. Indeed, this patient had a small new area of superior quadrant visual loss postoperatively consistent with the resection. Nonetheless, given the persistent underuse of epilepsy surgery in appropriate candidates, this lesson merits awareness.[28] Given the malignant nature of medically refractory epilepsy and the persistent underuse of epilepsy

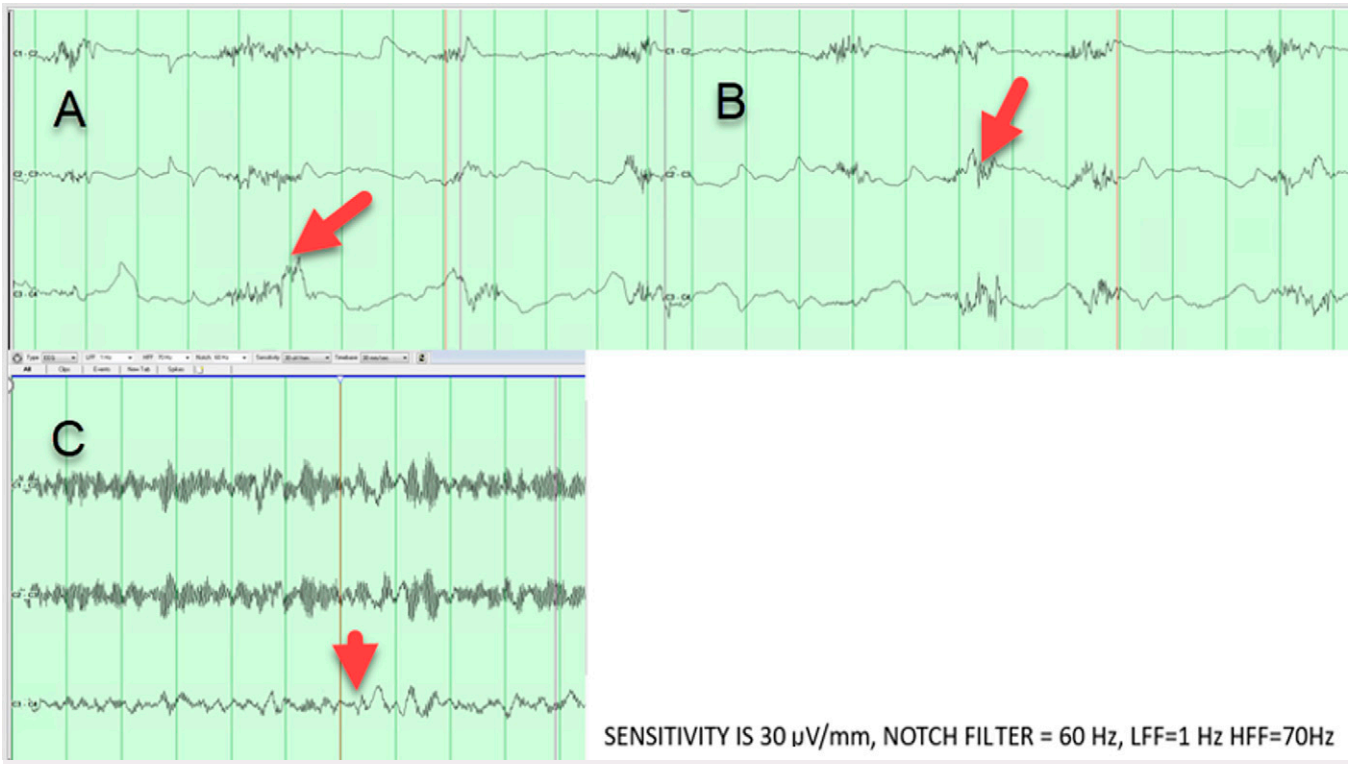

FIG. 3. Intraoperative ECoG before resection (**A and B**) and postresection (**C**) of the occipital cavernous malformation. Preoperative epileptiform discharges in the occipital lobe over the region of the cerebral cavernous malformation, as indicated with *red arrows* (**A and B**). Postresection ECoG (**C**) showed a relative paucity of epileptiform discharges (*red arrow*). HFF = high-frequency filter; LFF = low-frequency filter.

surgery, we advocate that in the appropriate patient population, epilepsy surgery may be appropriate for seizure foci located within eloquent cortex.

References

1. Fisher RS, Acevedo C, Arzimanoglou A, et al. ILAE official report: a practical clinical definition of epilepsy. *Epilepsia.* 2014;55(4): 475–482.
2. Kalilani L, Sun X, Pelgrims B, Noack-Rink M, Villanueva V. The epidemiology of drug-resistant epilepsy: a systematic review and meta-analysis. *Epilepsia.* 2018;59(12):2179–2193.
3. Go C, Snead OC 3rd. Pharmacologically intractable epilepsy in children: diagnosis and preoperative evaluation. *Neurosurg Focus.* 2008;25(3):E2.
4. Cascino GD, Brinkmann BH. Advances in the surgical management of epilepsy: drug-resistant focal epilepsy in the adult patient. *Neurol Clin.* 2021;39(1):181–196.
5. Engel J Jr, Wiebe S, French J, et al. Practice parameter: temporal lobe and localized neocortical resections for epilepsy: report of the Quality Standards Subcommittee of the American Academy of Neurology, in association with the American Epilepsy Society and the American Association of Neurological Surgeons. *Neurology.* 2003;60(4):538–547.
6. Englot DJ, Ouyang D, Garcia PA, Barbaro NM, Chang EF. Epilepsy surgery trends in the United States, 1990-2008. *Neurology.* 2012; 78(16):1200–1206.
7. Jette N, Quan H, Tellez-Zenteno JF, et al. Development of an online tool to determine appropriateness for an epilepsy surgery evaluation. *Neurology.* 2012;79(11):1084–1093.
8. Chang EF, Gabriel RA, Potts MB, Berger MS, Lawton MT. Supratentorial cavernous malformations in eloquent and deep locations: surgical approaches and outcomes. Clinical article. *J Neurosurg.* 2011;114(3):814–827.
9. Bartolomei F, Lagarde S, Wendling F, et al. Defining epileptogenic networks: contribution of SEEG and signal analysis. *Epilepsia.* 2017;58(7):1131–1147.
10. Banerjee J, Chandra SP, Kurwale N, Tripathi M. Epileptogenic networks and drug-resistant epilepsy: present and future perspectives of epilepsy research - utility for the epileptologist and the epilepsy surgeon. *Ann Indian Acad Neurol.* 2014;17(suppl 1):S134–S140.
11. Hilkens PHE, de Weerd AW. Non-convulsive status epilepticus as cause for focal neurological deficit. *Acta Neurol Scand.* 1995; 92(3):193–197.
12. Ridsdale L, Wojewodka G, Robinson E, et al. Characteristics associated with quality of life among people with drug-resistant epilepsy. *J Neurol.* 2017;264(6):1174–1184.
13. Leestma JE, Walczak T, Hughes JR, Kalelkar MB, Teas SS. A prospective study on sudden unexpected death in epilepsy. *Ann Neurol.* 1989;26(2):195–203.
14. Earnest MP, Thomas GE, Eden RA, Hossack KF. The sudden unexplained death syndrome in epilepsy: demographic, clinical, and postmortem features. *Epilepsia.* 1992;33(2):310–316.
15. Kumar S, Nayak D, Rao RM, et al. Epilepsy surgery at or near eloquent cortex: challenges, approaches and outcomes. *J Neurol Sci.* 2019;405(suppl):22–23.
16. Pondal-Sordo M, Diosy D, Téllez-Zenteno JF, Girvin JP, Wiebe S. Epilepsy surgery involving the sensory-motor cortex. *Brain.* 2006; 129(Pt 12):3307–3314.

17. Gilliam F, Wyllie E, Kashden J, et al. Epilepsy surgery outcome: comprehensive assessment in children. *Neurology.* 1997; 48(5):1368–1374.
18. Rolston JD, Deng H, Wang DD, Englot DJ, Chang EF. Multiple subpial transections for medically refractory epilepsy: a disaggregated review of patient-level data. *Neurosurgery.* 2018; 82(5):613–620.
19. Onal C, Otsubo H, Araki T, et al. Complications of invasive subdural grid monitoring in children with epilepsy. *J Neurosurg.* 2003;98(5):1017–1026.
20. Patil AA, Andrews R, Torkelson R. Isolation of dominant seizure foci by multiple subpial transections. *Stereotact Funct Neurosurg.* 1997;69(1-4 Pt 2):210–215.
21. Thomas GP, Jobst BC. Critical review of the responsive neurostimulator system for epilepsy. *Med Devices (Auckl).* 2015;8:405–411.
22. Yamamoto T, Hamasaki T, Nakamura H, Yamada K. Improvement of visual field defects after focal resection for occipital lobe epilepsy: case report. *J Neurosurg.* 2018;128(3):862–866.
23. Holmes MD, Tucker DM. Identifying the epileptic network. *Front Neurol.* 2013;4:84.
24. Stefan H, Lopes da Silva FH. Epileptic neuronal networks: methods of identification and clinical relevance. *Front Neurol.* 2013;4:8.
25. Aubert S, Wendling F, Regis J, et al. Local and remote epileptogenicity in focal cortical dysplasias and neurodevelopmental tumours. *Brain.* 2009;132(Pt 11):3072–3086.
26. LaRiviere MJ, Gross RE. Stereotactic laser ablation for medically intractable epilepsy: the next generation of minimally invasive epilepsy surgery. *Front Surg.* 2016;3:64.
27. Hader WJ, Tellez-Zenteno J, Metcalfe A, et al. Complications of epilepsy surgery: a systematic review of focal surgical resections and invasive EEG monitoring. *Epilepsia.* 2013;54(5):840–847.
28. Jobst BC, Cascino GD. Resective epilepsy surgery for drug-resistant focal epilepsy: a review. *JAMA.* 2015;313(3):285–293.

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Kryzanski, Dincer, Herendeen. Acquisition of data: Herendeen, Oster. Analysis and interpretation of data: Dincer, Herendeen, Oster. Drafting the article: Kryzanski, Dincer, Herendeen. Critically revising the article: Kryzanski, Dincer, Herendeen. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Kryzanski. Study supervision: Kryzanski.

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