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Case Report & Case Series

Responsive Neurostimulation System (RNS) in setting of cranioplasty and history of multiple craniotomies

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ABSTRACT

Introduction: Stereoelectroencephalography (SEEG) and subdural grids (SDG) are both effective options for localizing the ictal onset zone in patients with frequent seizures. The choice of intracranial monitoring technique utilized depends upon several factors, including the patient's clinical presentation and history. This article addresses a rare instance in which SEEG was not an option due to patient's morphology.

Case report

A 36-year-old man with history of medically intractable epilepsy and multiple craniotomies complicated by infection and subsequent cranioplasty was presented for possible surgical evaluation. Initially, SEEG was attempted but ultimately terminated because of difficulty related to prior cranioplasty and scarring to the brain. Eventually, a subdural grid system was placed to establish the patient's ictal onset zones after which RNS implantation was performed.

Discussion: The SDG placement was successful and localized the patient's ictal onset to the hand-motor region of the left hemisphere. RNS was then implanted and postoperatively the patient had a significant decrease in his seizure burden.

Conclusion: The case illustrates a possible limitation of SEEG placement, particularly in patients with a history of cranioplasty and multiple prior craniotomies. We also describe the first placement of an RNS generator and system in the setting of prior cranioplasty.

1. Introduction

Stereoelectroencephalography (SEEG) and subdural grid (SDG) are both trusted methods to localize the ictal onset zone in patients with medically intractable epilepsy. The choice of which intracranial monitoring technique is employed depends upon the patient's clinical presentation and history. Both practices involve the implantation of intracerebral electrodes in the patient according to pre-surgical, anatomical, clinical, and electrical correlations to more precisely determine the epileptogenic zone in the brain. Previous studies of SEEG have found that complication rates per electrode are typically low, and rates of seizure-free outcomes following resections guided by SEEG data often between 50 and 80% [2,3,5,8].

The case discussed in this article involves an instance in which SEEG was attempted but could not be performed due to the patient's morphology and prior cranioplasty. As a result, an alternative method of treatment was devised. The neurosurgeon (SV) decided to implant a subdural grid system, which would allow for intracranial EEG recordings and localization of the ictal onset zones [9]. SDG localized the ictal onset zone to the hand-motor region of the left hemisphere and an RNS System was inserted in the patient within a period of forty-eight hours. Implantation of the RNS system in these circumstances is unique in that, to the knowledge of these authors, a depiction of RNS installation through a cranioplasty has never been described [1,6,7,10].

2. Case report

2.1. History

The patient is a 36-year-old right-handed man with medically intractable epilepsy since he was 9 months old. In 2006, he underwent a VNS implantation operation, but he found that the treatment offered little-to-no improvement in regards to seizure frequency. He

Abbreviations: AED, antiepileptic drugs; ATL, anterior temporal lobectomy; DBS, Deep Brain Stimulation; EZ, Epileptic Zone; RNS, Responsive Neurostimulation System; SDG, Subdural Grid; SEEG, Stereoelectroencephalography; TLE, Temporal Lobe Epilepsy; VNS, Vagus Nerve Stimulation.

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underwent SDG monitoring in 2006 at an outside hospital and his ictal onset zone was localized to the hand-motor region of the left hemisphere, but no treatment was offered as the patient was right-handed and did not want a deficit. Unfortunately, this procedure was complicated by osteomyelitis, and in 2008, he underwent infected bone flap removal followed by subsequent cranioplasty.

2.2. Operation

The patient was discussed in our Epilepsy Management Conference and it was concluded that he would be a good candidate for reevaluation with SEEG in the left perirolandic region and that he would likely require RNS implantation if ictal onset was identified in this region. SEEG was chosen because of the history of multiple surgeries and the likely scarring of brain to dura, which would make SDG placement difficult [3,5].

The ROSA robotic system was utilized to implant the depth electrodes. During the first depth electrode implantation, it was noted that the skull bolt was not able to be fixed into the cranioplasty material. The cranioplasty material could not hold the bolt in place. A dural probe was also applied to open the dura, but this method also proved to be ineffective as the dura was thickened and calcified. The surgeon ultimately decided to discontinue the procedure, as the dura could not be opened safely or properly, and as the skull bolts were stripped in the cranioplasty material.

Because of this failure of SEEG implantation, a procedure involving SDG placement was devised. The patient agreed to proceed with an operation involving craniotomy for implantation of the subdural grid along the left frontoparietal and mesial frontal regions for localization of seizure onsets and RNS implantation (see Fig. 1). The incision was then made, and the skin flap was elevated, revealing the prior site of cranioplasty. The surgeon used a neuropace template to make the opening in the cranioplasty, at which point it was noted that the dura was extremely thickened and calcified and scarred to both the cranioplasty and the brain. Once the brain was identified, the surgeon removed the dura and implanted several subdural grids at predetermined locations using the stereotactic navigation system (see Fig. 2). The subdural grids were tunneled out through the skin, and the patient was then monitored for seizures.

During patient's hospitalization, the ictal onset zone was again identified to be within the left hand motor region. Craniotomy would be performed to remove the subdural grids. The patient was returned to the OR, and the prior craniotomy incision was opened. The electrodes that had picked up the most activity were localized, and the RNS neurostimulator device was then implanted (see Fig. 3). Three leads were placed along the region with highest activity corresponding with the ictal onset zone, and two of the leads (lateral and middle paddle electrode) were connected to the battery placed in the craniotomy defect. The third electrode, placed more medially near the sinus, was capped off and left in the wound for potential connection if needed at a later time.

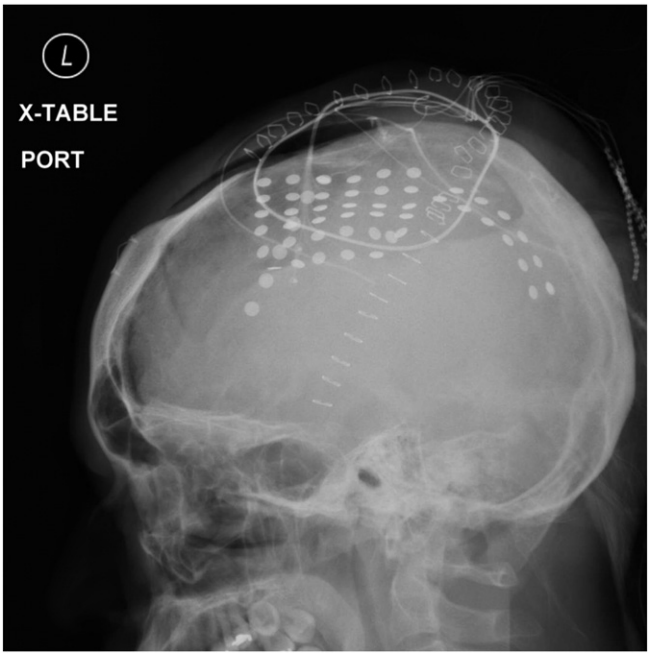

Fig. 1. XRAY images of the SDG in the patient.

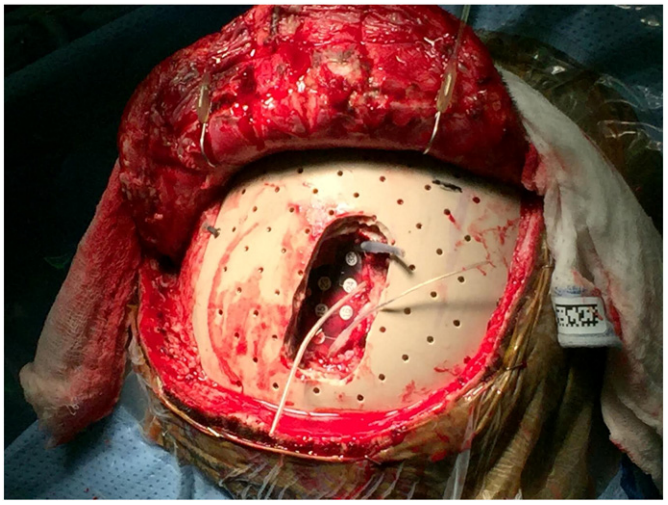

Fig. 2. Subdural grid implantation operation in progress.

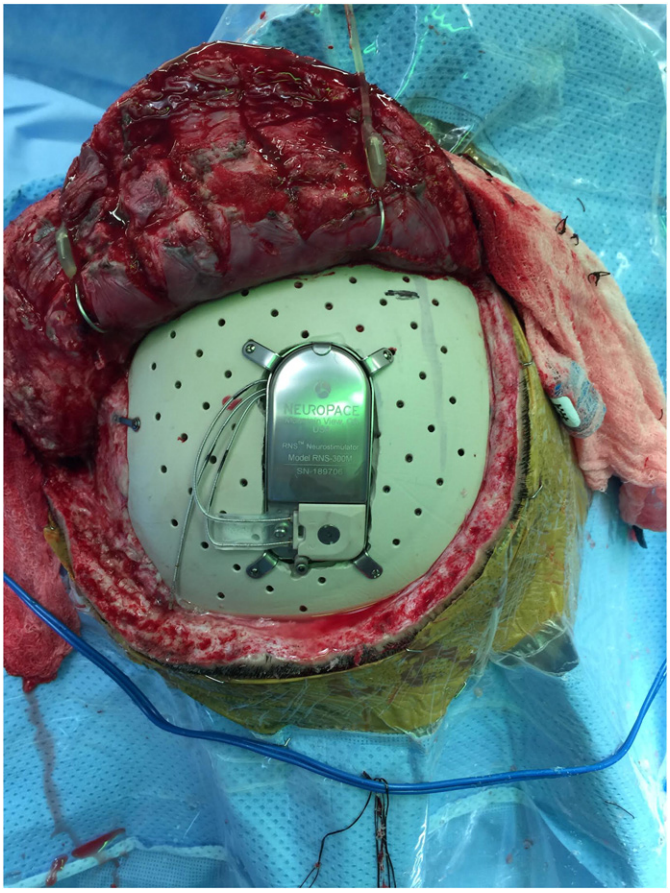

Fig. 3. Implantation of the neuropace device battery into PEEK cranioplasty.

3. Results

Though the initial SEEG placement was unsuccessful, the craniotomy and SDG placement followed by RNS were able to localize ictal onset. SEEG was not possible because of thickened and calcified dura as well as an inability to place bolts into the cranioplasty material. After the operation, the patient still had feelings of aura, but early extinction occurred prior to seizure propagation. The patient previously experienced 40 to 60 seizures per month and seizure cluster every one to two weeks. One year after surgery, the patient's, seizure burden has significantly decreased to less than 75%, though clusters still occurred every two to three weeks.

4. Discussion

A third of patients with epilepsy are defined as refractory to medical treatment, meaning that they continue to have seizures despite two or more AEDs at therapeutic doses. Common responses to refractory epilepsy involve treatment with vagus nerve stimulation, deep brain stimulation and responsive neurostimulation, with each of these treatments entailing implantation of a neurostimulation device to suppress seizure activity [4].

This case report describes a rare instance in which SEEG was not effective because of the limits of the patient's morphology and clinical history. In patients that may have calcified or thickened dura that cannot be coagulated for implantation of SEEG electrodes, and certain types of cranioplasty materials that may not hold standard skull bolts, one may consider implantation using SDG instead.

Overall, however, SEEG has established itself as a trusted practice in localizing the ictal onset zone in patients with medically intractable epilepsy. Systematic reviews covering scientific literature between 1980 and 2012 have recognized this method as having low rates of complication, as SEEG safely defines epileptogenic zones using stereotactic trajectories despite the large number of electrodes in use [2]. In some instances, such as cases in which the EZ is outside of the subdural grid recording area, SEEG implantation is known to be preferable to subdural grid placement. SEEG is also preferable when the EZ is difficult to localize and subdural grid evaluation fails [3]. This practice is beneficial because it is the only procedure offering three-dimensional information concerning ictal discharges, and also allows for the production of recordings of deep and subcortical regions [2,3,5].

The case study explored in this article involved a rare instance in which complications restricted the implementation of SEEG. As a result, a subdural grid system and RNS implantation were deemed necessary and sufficient to treat the patient. Thus, the case demonstrated that SEEG was limited as a result of the patient having a history of cranioplasty, and demonstrated the feasibility and efficacy of RNS systems implantation immediately after SDG placement that successfully localized ictal onset. Though this practice is somewhat uncommon, it was considered advantageous in this patient and borne out to be effective.

The authors advocate for all aspects of a patient's background, including history of cranioplasty, to be taken into consideration in devising each patient's treatment plan.

5. Conclusion

The case illustrated that RNS is both safe and effective for patients with a history of cranioplasty and multiple prior surgeries. Though it requires early planning, placement of the RNS system immediately after invasive monitoring appears to be both possible and effective under certain cases. The case also demonstrates a key limitation of SEEG, specifically in regards to patients who have undergone prior cranioplasty.

Disclosures

None.

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