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Emerging indications for stereotactic laser interstitial thermal therapy in pediatric neurosurgery

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ABSTRACT

Surgical treatment of deep or difficult to access lesions represents a unique and significant challenge for pediatric neurosurgeons. The introduction of stereotactic magnetic resonance-guided laser interstitial thermal therapy (LITT) over the last decade has had a dramatic impact on the landscape of pediatric neurosurgery. LITT provides a safe and effective option for children with epilepsy from hypothalamic hamartoma that represents a ground-breaking new therapy for a condition which was historically very difficult to treat with previous neurosurgical techniques. LITT has also been used as an alternative surgical technique for mesial temporal sclerosis, focal cortical dysplasia, MR-negative epilepsy, cavernoma-related epilepsy, insular epilepsy, and corpus callosotomy among other epilepsy etiologies. In some cases, LITT has been associated with improved cognitive outcomes compared to standard techniques, as in mesial temporal lobe epilepsy. Initial experiences with LITT for neuro-oncologic processes are also promising. LITT is often attractive to patients and providers as a minimally invasive approach, but the differences in safety and clinical outcome between LITT and traditional approaches are still being studied. In this review, we examine the emerging indications and clinical evidence for LITT in pediatric neurosurgery.

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Introduction

Surgical treatment of deep or difficult to access lesions represents a significant challenge for pediatric neurosurgeons. The morbidity of approaching deep subcortical pathology is a major consideration, particularly in epilepsy surgery [1,2]. For example, surgical treatment of epilepsy due to hypothalamic hamartoma (HH) represents the quintessential example of a deep, intrinsically epileptogenic lesion that can be challenging and dangerous to treat using conventional open approaches [3]. Yet, HH is often associated with catastrophic epilepsy, so surgeons have tried a variety of approaches over the years including microscopic resection/disconnection, endoscopic resection or disconnection, radiosurgery, and thermocoagulation [4]. Recently, stereotactic magnetic resonance (MR) -guided laser interstitial thermal therapy (LITT) was introduced, which provides a new and innovative treatment option for children with HH and other deep-seated brain lesions [5].

The introduction of stereotactic MR-guided LITT (MRgLITT) over the last decade has had a dramatic impact on the landscape of pediatric epilepsy surgery with clear potential to also impact pediatric neuro-oncologic surgery. On the one end, LITT provides a reasonably safe and effective option for children with epilepsy from HH that represents a ground-breaking new therapy for a condition that was previously very difficult to treat with previous neurosurgical techniques. In contrast, LITT also provides an alternative approach for pediatric epilepsy techniques that were already safe, well established, and effective, such as lesionectomy, selective mesial temporal resection, and corpus callosotomy [5]. In some cases, LITT has been associated with improved cognitive outcomes compared to standard techniques, as in mesial temporal epilepsy [6]. In these instances, LITT is often attractive to patients and providers as a minimally invasive approach, but the differences in safety and clinical outcome between LITT and traditional are still being studied [5].

Clinical studies over the last several years have begun to elucidate the role of LITT in pediatric neurosurgery. In this review, we examine the emerging indications and clinical evidence for LITT in pediatric neurosurgery.

History and surgical workflow in pediatric neurosurgery

Historically, LITT began as a treatment for deep, solid tumors that were felt to be exceedingly high risk for open surgery [7,8]. The first series of five patients documented tumor absence on post-treatment imaging in all cases, with three

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of the patients surviving at nine, 29, and 31 months follow-up [8]. Since the early 1990s, there have been numerous series of increasing size published in adults for treatment of lesions including gliomas, metastases, and radiation necrosis [9]. However, the first standalone pediatric report was not published until 2011, which described LITT treatment of a primitive neuroectodermal tumor located within thalamus and midbrain [10]. From the time of this report, the use of LITT in pediatric neurosurgery has expanded dramatically [9,11,12]. However, in one pediatric pathology, LITT has rapidly gained traction as a first-line treatment option: hypothalamic hamartomas [13]. An early report in 2012 of two previously untreated pediatric HH patients treated by LITT were included in a series of five patients, all treated with LITT for ablation of epileptogenic tumor foci [14]. Since then, numerous reports of LITT for HH treatment have been reported in adult and pediatric patients as both primary and secondary treatments, exceeding other pediatric pathologies in case volume [13,15,16].

In both adult and pediatric neurosurgeries, the application of LITT involves stereotactic placement of a laser ablation probe, often through a bone-based anchor bolt. Several techniques have been described including frame-based (e.g., Leksell frame), frameless robot-assisted, and image-guided. Each of these techniques has distinct registration techniques, advantages, and limitations, which are beyond the scope of this review, but are described elsewhere [17–19].

Briefly, at our institution, we utilize a frameless robot-assisted stereotactic technique, similar to what is previously described for stereoelectroencephalography (sEEG) implantation [20]. Preoperative magnetization prepared – rapid gradient echo (MPRAGE) magnetic resonance imaging (MRI) and computed tomography angiogram (CTA) are obtained and merged on the planning software for electrode implantation. We utilize bone fiducials with an OArm CT scan for registration and accept a root mean squared (RMS) < 0.8 for the purpose of most LITT targets (Figure 1(A)). Once registration is successful, the laser ablation guidance bolt is inserted with robotic guidance.

In pediatric patients, bone thickness can be a major consideration. For example, certain devices recommend a bone diameter is $\geq$4 mm for placement of the guidance bolt [21]. In some cases, trajectory to target may need to be modified, when possible, to place the guidance bolt through thicker bone.

In the MR suite, the probe is inserted through the guidance bolt where it is then advanced to the target. A preliminary MR image is obtained to confirm satisfactory positioning of the ablation probe relative to the planned trajectory. In the event that there is doubt regarding trajectory accuracy, MR images with the ablation probe can be merged with the planning software to confirm positioning of the probe. Once satisfactory trajectory positioning has been confirmed, the ablation probe is advanced to the most distal aspect of the planned ablation. Using MR thermography visualization of the 'irreversible damage zone', the ablation is performed (Figure 1(B)). Once all planned trajectories have been successfully ablated, acute post-ablation imaging is obtained, after which patients are returned to the operative suite, anchor bolts are removed, and stitches are placed (Figure 1(C)).

Post-operatively, we admit patients to the pediatric intensive care unit (PICU) where they are placed on high dose steroids and monitored closely overnight in case there is an increase in seizures or other symptoms related to cerebral edema. A recent case study by Tandon et al. involved three patients with drug-resistant epilepsy (DRE) who underwent laser ablation of epileptogenic foci [22]. It was concluded

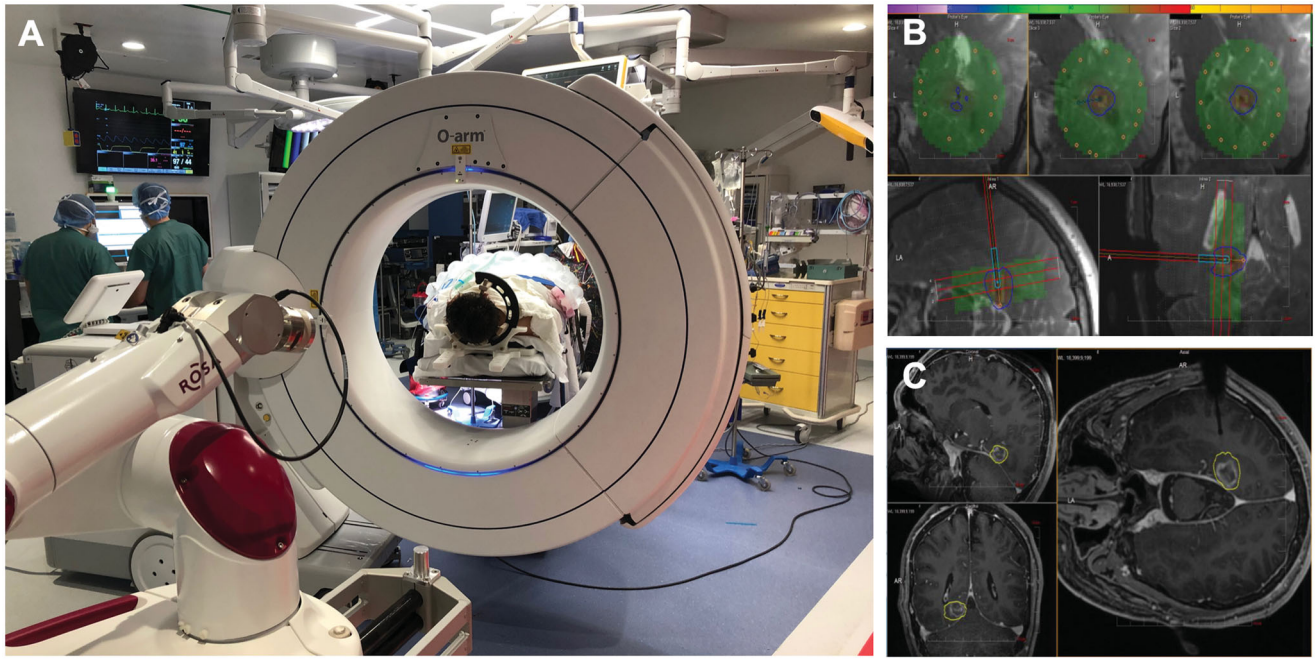

Figure 1. LITT operating room workflow. (A) At our center, bone fiducials and OArm CT are used for frameless registration. The robot is used for placement of the LITT guidance bolt. (B) Intra-ablation MR thermography provides online feedback demonstrating the extent of ablation. (C) Intra-operative post-ablation post-contrast T1-weighted MR showing ablation relative to MR thermography ablation volume.

that while postoperative fluid-attenuated inversion recovery (FLAIR) hyperintensities were 3–5 times the targeted volume, this increase was insignificant in the first 8 days after surgery, suggesting that prolonged usage of perioperative steroids is unnecessary beyond five days post-op. Patients are typically cleared for discharge immediately after obtaining a 24-h post-ablation MRI, given that there were no seizures or neurological deficits, and the patient is feeling generally well.

Pediatric epilepsy surgery

Hypothalamic Hamartoma

Since early reports of success in 2012 [17], HH has rapidly gained precedence as one of the optimal treatment targets for LITT due a combination of factors: deep seated location, high-risk eloquent adjacent tissues, little growth potential, and symptom responsiveness to ablative treatment. Hypothalamic hamartomas are concentrations of normal neuronal cells with abnormal architecture arising often within the tuber cinereum or other areas of the ventral hypothalamus [4]. The hallmark of HH symptomology is gelastic seizures, defined as short bursts of unprovoked, uncontrollable laughter in the absence of changes in consciousness and with the presence of epileptic discharges (often undetectable on surface electoencephalography) [4]. However, these lesions can cause other symptoms including non-gelastic epilepsy, precocious puberty, and severe neurocognitive issues including developmental regression secondary to epileptic encephalopathy. Symptom development appears to be correlated to the location of the lesion within the hypothalamus. Parahypothalamic HH attached to the floor of the third ventricle appear to be more associated with precocious puberty but less frequently with seizures. In contrast, intrahypothalamic HH are often seen to result in a greater displacement of tissues within the hypothalamus as well as the third ventricle and are seen to have a greater tendency toward displaying multiple symptoms including both gelastic and non-gelastic epilepsies, behavioral dysfunction, and intellectual disability. These associations are not absolute, and it is unclear exactly how much of a role size and tissue displacement play in these differences [23,24].

Traditionally, HHs were subdivided anatomically to best characterize potential surgical options based on factors such as involvement of the central versus lateral hypothalamus, intraventricular extension, interpeduncular cistern extension, or stalk involvement [25]. These divisions play less a role in LITT, which is amenable to treating across categories with comparable symptom resolution rates [4]. Very large lesions were described as unresectable, but there are data to suggest that pre-operative volume plays less of a role than post-operative residual, suggesting that staged LITT with several foci may be advantageous in particularly large lesions [26].

Treatment of seizures has had highly promising results with LITT. In a review of the existing adult and pediatric literature, 87% of patients with at least 1-year follow-up had gelastic seizure control after LITT and 60% of patients with non-gelastic seizures had control [5]. This compares favorably to other forms of treatment such as resection or radiosurgery. In one large series on radiosurgery, seizure freedom of any seizure semiology was documented in 37% of patients and substantial reduction in 22% of patients after at least 3 years [27]. In comparison, control rates ranged from 36% with a mean endoscopic resection of 80% up to 48.6% with complete endoscopic resection [28,29]. For open resection or combined open and endoscopic resection, one study cited seizure freedom rates as low as 0%, with other studies suggesting control rates for transcallosal resection ranging from 20% to 52% [13,28,30–32]. Neurocognitive improvements have also been sporadically documented after surgery [33–35].

LITT has been applied both as a primary treatment and in cases of previously treated HH with refractory epilepsy or other symptoms. It is important to note that disconnection of the lesion from the epileptogenic network is important, and often sufficient to resolve seizures rather than complete ablation or resection of the lesion itself. Burrows et al. reported three cases of patients with decades of refractory symptoms after initial presentation in childhood who had undergone resection or radiosurgery previously, of which one was seizure free and one had meaningful reduction in seizure frequency [36].

While volume of tumor reduction also appears to be strongly associated with seizure outcomes in both resective and ablative treatments, it is again important to note that network disconnection may be sufficient to achieve seizure freedom in some cases. Gadgil et al. conducted an assessment of 58 pediatric patients with HH in order to study the morphological considerations affecting ablation volume [26]. While pre-operative volume was not a factor in seizure control, patients with persistent gelastic seizures were found to have larger residual HH volumes compared to those who were seizure free (71% versus 43%).

Complications with LITT are frequently transient in nature but can be severe. In early experiences of mixed adult and pediatric cohorts, up to 40–50% of patients experienced temporary neurological symptoms such as hemiparesis, speech difficulty, or vision changes, warranting pre-operative counseling [16]. Patients, particularly those with a history of anterior temporal lobectomy, may be more prone to memory dysfunction after treatment that injures the adjacent mammillothalamic tracts. Low energy settings are, therefore, critical in order to avoid thermal injury to adjacent deep limbic and brainstem structures. Other complications include hyponatremia, weight gain, procedural related hemorrhage, transient seizure worsening, and hormonal dysfunction [5]. While laser ablation for palliative treatment of intrinsic hypothalamic tumors has been shown to be associated with a higher risk of serious adverse events, LITT is increasingly being utilized as a safe and effective treatment intervention for patients with deep or previously inoperable HH [37]. In a series of 71 adult HH patients who underwent laser ablation by Curry et al., over 90% achieved gelastic seizure freedom at 1-year follow-up with less than 25% of patients requiring a subsequent additional ablation [3]. Often the complication profile of LITT for HH outweighs the severity of drug-resistant epilepsy associated with HH.

Tuberous sclerosis

Tuberous sclerosis complex (TSC) is a debilitating neurocutaneous syndrome that is typically first identified in infancy and childhood by skin lesions, diffuse hamartomas, and seizures [38]. Approximately 90% of TSC patients experience seizures, less than a third of which are manageable with antiepileptic drugs alone [39]. The characteristically epileptogenic tubers are often multifocal and located within deep brain structures. However, when successfully identified and subsequently disconnected, seizure freedom rates are reported to be as high as 50% at 2-years post-op. [40]. The use of LITT to ablate deep lesions or those that are anatomically difficult to access safely *via* open resection represent a safe and effective intervention for children with TSC that enables treatment of multiple or bilateral cortical tubers without a need for large, multiple, or bilateral craniotomies [41].

The best outcomes in TSC-related epilepsy are achieved when there are concordant findings between lesion, EEG, and other localization modalities [42,43]. Invasive monitoring may be important to establish the role of a tuber in epilepsy prior to LITT. Recently, Tovar-Spinoza and colleagues reported on seven TSC patients who underwent LITT of cortical tubers for treatment of focal DRE [41]. All of these patients had improvement in seizures and >70% were able to reduce their anti-seizure medications. In a pediatric series by Hale et al., two patients exhibited TSC. One patient, a 13-year-old female with no prior history of epilepsy surgery, underwent stereotactic LITT of a right frontal lesion and the right superior insula. She experienced no procedural or medical complications and was Engel class II at 1.20 years follow-up. The second TSC patient, a 7.9-year-old female underwent open resection of a right frontotemporal lesion and insula with corpus callosotomy. Post-operatively, she experienced left-sided hemiparesis, which resolved after one week, and was Engel class III at 3.85 years follow-up [44]. Thus, LITT is a promising therapy for children with TSC as it provides the opportunity to ablate one or more tubers in a less invasive fashion. However, further research is necessary to better define the role of LITT in TSC-related epilepsy.

Cavernoma-related epilepsy

Cerebral cavernous malformations (CCMs) are benign clusters of abnormal vasculature most often found in the brain and spinal cord [45]. Patients with cavernoma-related epilepsy (CRE) are often treated with resective surgery, however LITT has increasingly been proposed as an alternative treatment [45–48]. Retrospective cohort studies suggest that early surgical treatment of CRE with LITT is associated with higher long-term seizure freedom rates and higher rates of discontinuing anti-seizure medication as opposed to resection. Potential to offer a less invasive approach through LITT may be associated with patients and families electing to have surgical treatment for CRE earlier.

In a five-patient series by McCracken et al., patients experienced zero adverse events, such as hemorrhage or neurological deficits, and 80% of patients achieved Engel class I seizure freedom at latest follow-up which ranged from 12 to 28 months [49]. In a larger adult series by Willie et al., 14 out of 17 patients undergoing LITT for stereotactic laser ablation of CCMs were seizure free (i.e., Engel class I) at greater than 1-year follow-up. Of these patients, 10 achieved Engel class IA seizure freedom. There were two patients who did not achieve seizure freedom post-ablation and underwent an additional sEEG-informed open resection [48]. The reduced morbidity and improved tolerability of LITT compared to open resection is highly promising for children with cavernoma-related epilepsy [50]. Further investigation into the utility of stereotactic LITT is necessary to determine the potential therapeutic benefits for pediatric patients.

sEEG-guided seizure onset zone ablation

The first study to apply LITT to treat epilepsy, by Curry et al. showed that the LITT technique was effective at ablating focal epileptic lesions and led to seizure freedom in all 5 pediatric patients [14]. However, in patients with MR-negative epilepsy, there are no specific lesions to target though the epileptic focus may still be quite focal. For example, sEEG-guided thermocoagulation has been used extensively throughout Europe and can be associated with seizure freedom rates as high as 20% despite creating quite small lesions [51]. When an anatomoelectroclinical hypothesis can be formulated on the basis of non-invasive evaluation by video-EEG, seizure semiology, fluorodeoxyglucose-positron emission tomography (FDG-PET), and other measures, then sEEG electrodes can be implanted to finely delineate the seizure onset zone [52]. When a highly focal SOZ is identified by sEEG, LITT may be applied for ablation of the SOZ in the absence of an identifiable lesion of MR imaging similar to thermocoagulation methods described above. The long-term seizure freedom rates associated with this approach will need to be studied carefully.

It is anticipated that sEEG-guided LITT in MR-negative epilepsy will be associated with lower rates of seizure freedom than conventional open craniotomy with resection given a smaller more focal lesion. However, given the less invasive nature of LITT and the stigma associated with traditional epilepsy surgery it may be a safe and reasonable first-line approach [53]. Further clinical studies will elucidate the role of sEEG-guided LITT.

Corpus callosotomy

LITT has also been proposed as an alternative approach for corpus callosotomy with initial studies showing efficacy similar to traditional open callosotomy [54]. LITT callosotomy can be complete, anterior two-thirds only, or complete callosotomy using additional laser trajectories (Figure 2). In a previous study investigating the effectiveness of LITT in completion callosotomy, two adult patients saw zero recurrence of targeted atonic seizures, while the remaining four (including two pediatric) saw substantial reduction in the frequency of their targeted atonic or generalized tonic clonic seizures [55]. Fractional anisotropy (FA) can be used as a

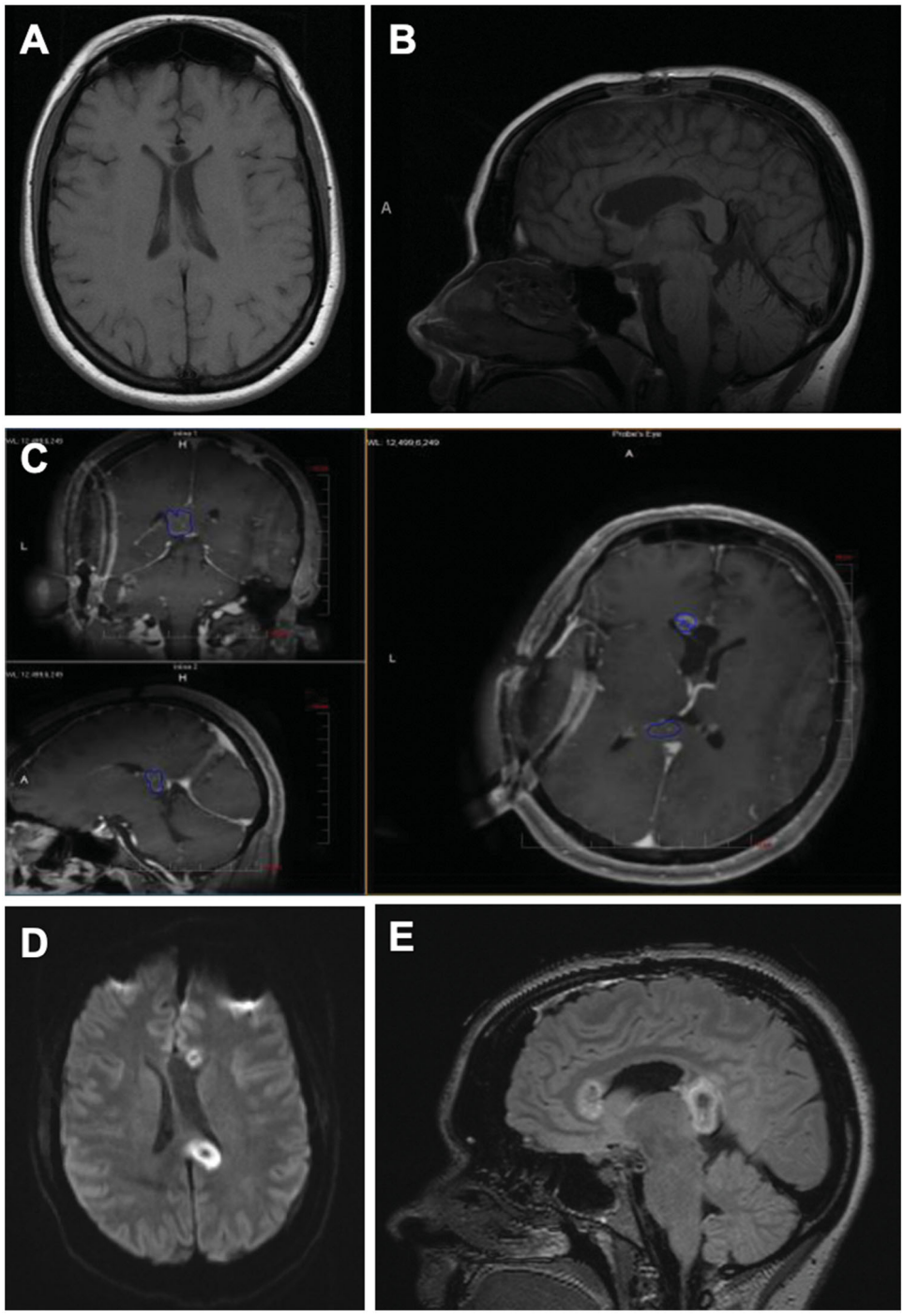

Figure 2. Stereotactic LITT completion callosotomy in a patient with previous callosotomy. (A and B) Preoperative T1 axial (A) and sagittal (B) imaging demonstrating residual anterior corpus callosum and splenium of corpus callosum, which are targets of the planned ablation. (C) Intra-ablation MR thermography demonstrating ablation of the residural genu and splenium of the corpus callosum. (D and E) Postoperative axial (D) and sagittal (E) DWI MR images demonstrating complete callosotomy.

measure to quantify the anisotropic diffusion in white matter fiber tracts, reflecting the directionality and structural organization of white matter and may be used in planning or post-ablation evaluation of LITT callosotomy. This study showed that in four of the patients that had pre and post-operative FA data, including two pediatric patients, FA in the corpus callosum decreased after surgery, suggesting that the LITT procedure was effective at disrupting the organization and structure of the callosal fiber tracts [55]. Similar to other emerging indications for LITT, further work is necessary to characterize the long-term outcomes of LITT callosotomy.

Periventricular nodular heterotopia

Periventricular nodular heterotopia (PNH) is often associated with DRE [56,57]. Furthermore, nodular heterotopias can be accompanied by other types of cortical malformations, such as focal cortical dysplasia and polymicrogyria. The presence

of even a single nodule deep to benign white matter and eloquent cortex makes surgical intervention a challenge. Treatment by LITT after a period of sEEG has become an increasingly popular alternative for these patients as it is an effective means of targeting these lesions in a controlled focal ablation [14].

Historically, minimally invasive approaches for the management of PNH have included stereotactic radiosurgery, stereotactic guided radio-frequency lesioning, or open thermocoagulation. However, the coupling of highly localizable sEEG recordings with minimally invasive LITT has shown promising clinical results in PNH patients, with many achieving complete seizure freedom (i.e., Engel I outcome) [57–61]. While outcome data among pediatric patients are limited, seizure freedom rates among adults are encouraging. Among four separate case reports in eight adult PNH patients treated with LITT, three studies reported a 100% post-ablation seizure freedom rate along with a 0% rate of adverse events [57–61]. Esquezani et al. reported seizure freedom in two patients who underwent LITT for ablation of PNHs, yet these outcomes were achieved in conjunction with changes in antiepileptic medication in one patient, and subsequent resective surgery in the other [61]. While the application of LITT for treatment of PNH is relatively novel, recent literature suggests comparatively favorable outcomes and should therefore be considered as a safe and effective treatment option.

Mesial temporal lobe epilepsy

Several studies have examined a role for LITT for mesial temporal lobe epilepsy (MTLE) [62–67]. This technique has been used previously to treat 13 adult patients with drug-resistant MTLE, with 10 of these patients having a successful outcome of decreased seizure burden after surgery [68]. In a larger cohort of 43 MTLE patients with and without mesial temporal sclerosis (MTS), all patients required only a 1-day post-operative hospital stay, and only one serious complication of optic neuritis was observed [63]. Of these MLTE patients treated with LITT, 79.5% were at an Engel I outcome at 6 months post-operatively, which declined to 67.4% at 20.3 months [63]. Importantly, there was no statistically significant difference in achieving seizure freedom when comparing a subgroup of patients with MTS that did not go undergo sEEG monitoring before ablation and a subgroup without MTS that underwent sEEG evaluation before ablation. This suggests that LITT is a viable option in MTLE patients without an identifiable lesion on MRI. In another study by Drane et al., patients with temporal lobe epilepsy (TLE) who underwent stereotactic laser amygdalohippocampectomy had better cognitive outcomes compared to patients who underwent open resection [69]. Specifically, for patients with TLE in their dominant hemisphere, those undergoing open surgery experienced more weakened performance on a naming task post-surgery versus preoperatively, when compared to those who had LITT. Furthermore, for patients with epilepsy in their non-dominant hemisphere, patients who had laser ablation retained better ability to perform on a recognition task post-surgically when compared to those who had open resection.

It is important to consider that the pathologies associated with MTLE in pediatrics are different than in adult patients, which may influence the outcomes of LITT. Additionally, the influence of LITT on cognitive outcomes in children is poorly understood and represents another important research opportunity.

Insular epilepsy

While insular epilepsy is rare, many studies suggest that the prevalence of epilepsies with insular and surrounding cortical ('insular-plus') involvement may be underestimated [70]. Given the complex connectivity and functional neuroanatomy of insular and insular-plus epilepsies, localization of the SOZ using conventional non-invasive methods presents a substantial obstacle toward achieving seizure freedom [71]. Insular involvement calls for careful investigation of the insular cortex and surrounding regions, especially in patients with DRE [72]. Invasive monitoring with sEEG can be important, potentially revealing the full extent of involvement, and therefore guiding a more complete resection which can be carefully targeted with LITT (Figure 3). LITT is an attractive option for treatment of insular and insulo-opercular epilepsy given the density of vascular structures in this brain region and the associated risk of infarct with open resection.

In a large cohort of 20 pediatric DRE patients who underwent a total of 24 LITT procedures, Perry et al. demonstrated a post-ablation seizure freedom rate that is comparable to conventional open resection or other surgical techniques [43]. All patients were followed for a minimum of six months, with adverse events reported in 29% of procedures. Among the adverse events reported were mild hemiparesis (25%) and expressive language dysfunction (4%), all of which were either completely resolved or left with minimal residual dysfunction at six months post-op. Another large cohort of pediatric patients by Hale et al. also reported similar seizure freedom rates following LITT compared to alternative surgical interventions [44]. These favorable outcomes suggest that not only is LITT a viable treatment option for the management of DRE, it is an especially remarkable alternative to open resection given both its accuracy and minimal invasiveness.

Pediatric neuro-oncology

There is an emerging literature on the use of LITT for treatment of adult brain tumors [73,74], but less attention has been paid to the role of LITT in pediatric brain tumors [11,12,75]. LITT has several potential advantages over traditional techniques that include (1) the ability to ablate deep-seated lesions without traversing the significant normal brain tissue, (2) potentially decreased complication rates, (3) decreased postoperative length of stay, and (4) decreased discomfort [12,75]. However, how LITT influences the biology of various tumor pathologies and influences clinical outcomes remains an open question.

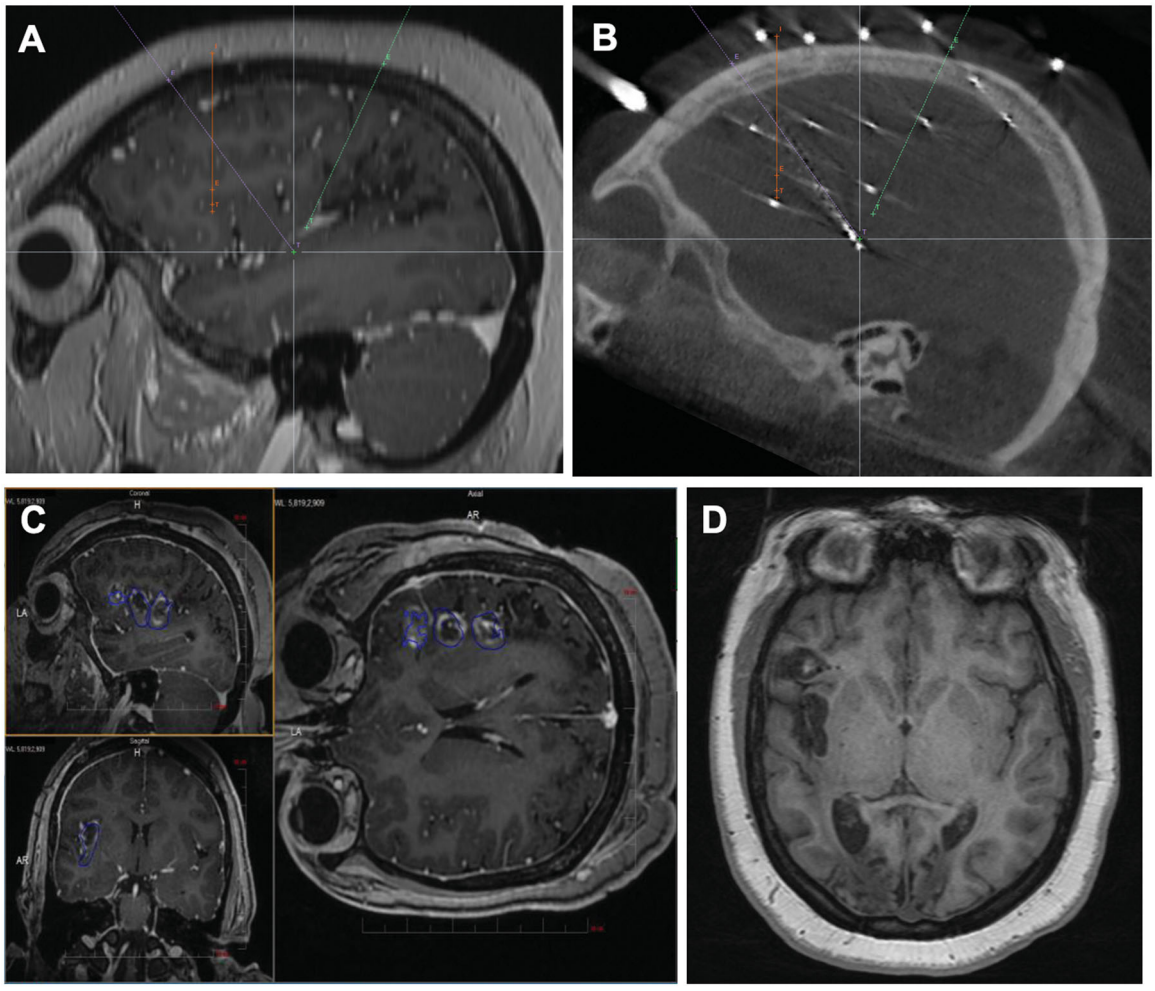

Figure 3. sEEG-guided ablation of insulo-opercular epilepsy. (A) sEEG trajectory planning; (B) post-sEEG implantation CT demonstrating electrode contact corresponding to the seizure onset zone; (C) intra-ablation MR thermography demonstrating ablation of the insulo-opercular target. (D) Postoperative (3 months) T1-weighted MR image showing insulo-opercular lesion.

Tovar-Spinoza and Choi published one of the largest series of pediatric brain tumors treated by LITT [12,75]. In this highly heterogeneous cohort of 11 patients with different tumor pathologies, LITT was associated with decreased tumor volume at both 3 months and 6 months post-ablation. Most of the tumors in this series were in areas difficult to access using traditional approaches including the thalamus and midbrain. The mean hospital stay was 3.25 d and 2 out of 11 patients experienced neurological complications. The authors concluded that LITT is a safe and effective therapy for pediatric brain tumors and noted that future clinical trials are important to elucidate the role of LITT.

We agree with the Tovar-Spinoza and Choi that initial data are promising for the use of LITT in pediatric brain tumors and that clinical trials are key to determining the role of LITT in their treatment. We believe there are two categories that may benefit the most from LITT therapy: patients with deep lower grade lesions where traditional resection would cause significant morbidity and patients with metastatic or recurrent tumors where morbidity from an open craniotomy would not be desired. While metastatic brain tumors in pediatric patients are rare when compared to their prevalence among adult cohort, their presence is often indicative of a late manifestation of disease and, as a result, are often inoperable. Nonetheless, LITT may have additional applications in the future due to its potential for blood–brain barrier breakdown and chemotherapeutic agent administration in pediatric neuro-oncology patients [76]. Unfortunately, treatment with LITT in pediatric brain tumors may preclude eligibility for clinical trials. There is still little known about the longer-term influence of LITT on tumor biology, therefore we propose clinical trials are necessary to understand the long-term safety and efficacy of LITT in pediatric neuro-oncology.

Best use of LITT: a call for data

There is a substantial need for data regarding MR-guided LITT in pediatric patients. While technological innovations and surgeon experience have increased its utility for DRE patients and those with benign or malignant brain tumors, the specific indications for its use remain controversial. Further in-depth investigation and contribution to existing literature is necessary to better identify the clinical profiles of patients who would most substantially benefit from intervention with LITT and the specific procedures that would provide such benefits.

Retrospective registries are uniquely positioned to address gaps in existing knowledge regarding LITT usage. Since receiving its FDA approval in 2009, the NeuroBlate System (NBS) has been used in over 2000 procedures at over 56 institutions in the United States alone. The registry enrolls both adult and pediatric patients, and collects procedural, clinical, and quality of life data for up to 24 months post-LITT. With an estimated enrollment of over 1000 participants, this registry represents an invaluable data resource for examining pediatric outcomes following LITT.

Future clinical trials, prospective clinical studies, and technical reviews are also crucial to understanding the applications of and clinical benefits from LITT in both drug-resistant epilepsy and neuro-oncology patients. Such investigations should place emphasis on the indications, outcomes, and costs of LITT compared to open procedures in average and high-risk pediatric patients. In recent years, LITT has had a dramatic impact on the landscape of pediatric epilepsy and neuro-oncologic surgery. The potential to treat deep lesions without traversing the cortical surface provides an attractive alternative for several conditions. Large well-controlled studies are necessary to delineate the role of LITT in each of these pathologies.

Disclosure statement

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