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Cognitive outcomes after magnetic resonance-guided laser interstitial thermal therapy for mesial temporal lobe epilepsy in adolescent patients

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ABSTRACT

Surgical treatment of medication-resistant mesial temporal lobe epilepsy (MTLE) is associated with cognitive deficits. Magnetic resonance-guided laser interstitial thermal therapy (MRgLITT) for MTLE has been shown to result in superior cognitive outcomes in adults when compared to open surgical resection. However, data regarding postoperative cognitive outcomes in adolescent and pediatric patients is limited. We retrospectively reviewed sequential cases of pediatric patients who underwent MRgLITT for MTLE between 2017 and 2023. Patients who had complete preoperative and 12 month postoperative neuropsychological evaluation were analyzed for changes in the neuropsychological domains of cognition, memory, executive functioning, visual scanning, graphomotor speed, and fine motor speed/dexterity. Six adolescent patients who underwent MRgLITT for MTLE ($\bar{x}$ age = 19.0 years, $SD = 1.2$) and had complete preoperative and postoperative neuropsychological evaluations were included in the analysis. There were no statistically significant changes across neuropsychological domains when comparing pre- and postoperative cognitive evaluations, including verbal memory scores. Clinically significant changes in phonemic fluency were observed when examining side-specific effects and improved for patients who received right-sided MRgLITT but declined for patients who received left-sided MRgLITT. 50 % of patients achieved Engel I outcome at last follow-up. Our preliminary results suggest minimal adverse neuropsychologic effects following MRgLITT for adolescent MTLE, including preservation of verbal memory. Clinical outcomes were similar with those reported in the literature.

1. Introduction

Nearly one quarter of all patients with epilepsy become refractory to medications [1], often necessitating other methods of seizure control such as surgical resection or neuromodulation [2]. Mesial temporal lobe epilepsy (MTLE) is the most common type of focal epilepsy, affecting approximately 20% of patients with epilepsy [3,4]. Traditionally, anterior temporal lobectomy (ATL) has been the mainstay of treatment and has been shown to have approximately 50–60% seizure freedom rate in adults [5] and a 70% seizure freedom rate in pediatric patients [6]. More recently, magnetic resonance-guided laser interstitial thermal therapy (MRgLITT) has gained popularity compared to open surgical resection due to its minimally invasive approach, lower infection risk, shorter duration of hospital stay, and preference by both patients and

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providers [7].

Cognitive deficits have been previously reported following ATL with decreased naming ability being observed after dominant hemisphere procedures [8–11], and deficits in recognizing famous faces and less common objects have been associated with non-dominant hemisphere procedures [9,11–13]. Selective approaches to amygdalohippocampectomy (SAH) have also been employed and utilize invasive approaches to spare the lateral neocortical structures; however, there is evidence that these approaches actually cause worse cognitive deficits due to disruption of the temporal stem [14]. MRgLITT for MTLE has an advantage over open approaches in that it allows for stereotactic ablation of the amygdala and hippocampus without collateral damage to surrounding temporal lobe structures [7]. Studies characterizing the cognitive outcomes in adult patients undergoing MRgLITT [7,15–17], predominantly show dominant-sided procedures are associated with worse verbal fluency and memory outcomes. In contrast, neuropsychological outcome data in pediatric patients undergoing epilepsy surgery, including those treated with MRgLITT, remains underreported. We present our neuropsychological outcomes for a series of adolescent patients with pediatric-onset epilepsy undergoing MRgLITT for MTLE and hypothesize that adolescent patients tolerate MRgLITT without significant changes to their postoperative neuropsychological scores. To our knowledge, this is the first paper that focuses on these data for adolescent MTLE patients.

2. Materials and methods

2.1. Study design

We performed a single-center, retrospective review of patients who underwent MRgLITT for MTLE and had preoperative and postoperative neuropsychological testing with a clinical neuropsychologist at Children's Hospital of Los Angeles (CHLA) between February 2017 and June 2023. The study received approval through the institution's Institutional Review board, CHLA-22-00279-AM003.

2.2. Inclusion and exclusion criteria

Medically refractory MTLE pediatric patients evaluated at the CHLA Comprehensive Epilepsy Center who were recommended to undergo MRgLITT were included. At our institution, we can evaluate and treat pediatric patients up to the age of 21. Only patients who had preoperative and postoperative neuropsychological evaluation at 12 months after their operation were included in our analysis. Patients who received MRgLITT for other foci or who had open surgical resection for MTLE as the initial surgical management were excluded.

2.3. Patient selection

All patients included in the study underwent noninvasive seizure localization per our institution's typical protocol. All patients underwent video electroencephalography (vEEG) in the Epilepsy Monitoring Unit (EMU) and high-resolution 3T MRI. Some of the patients underwent ancillary studies, including positron emission tomography (PET), single photon emission computerized tomography (SPECT), Wada testing, and intracranial monitoring. This information was combined to establish the diagnosis of MTLE. The patients were discussed at comprehensive Epilepsy Surgery conference consisting of a multidisciplinary team of neurologists, neurosurgeons, neuropsychologists, and neuroradiologists at CHLA. The decision to proceed with MRgLITT versus open surgical resection was made on a case-by-case basis at Epilepsy Surgery conference based on comprehensive review of the presurgical electrophysiologic, radiographic and neuropsychological data. After considering the options, there was a consensus to proceed with MRgLITT for treatment of MTLE.

2.4. Surgical technique

MRgLITT of the amygdala and hippocampus was carried out using the Medtronic Visualase (Medtronic, Dublin, Ireland) system. Preoperative trajectory planning was conducted on a contrasted, 3D volumetric T1-weighted MRI image on the Medtronic Framelink (Medtronic, Dublin, Ireland) or ROSA (Zimmer Biomet, Warsaw, IN, USA) software. An occipital entry site along the long axis of the amygdala and hippocampus was planned; the trajectory traversed the tail, body and head of the hippocampus and terminated in the amygdala in an avascular fashion. The majority of patients required one laser fiber for ablation of the mesial temporal structures, however patient (patient #5) required two fibers to completely cover the amygdala and hippocampus due to an expansive nature of the lesion. On the day of surgery, bone fiducial markers were placed in the operating room to assist with stereotactic registration, a high-resolution computerized tomography (CT) scan was obtained with the markers in place and merged to the preoperative plan. The Visualize anchor bolt and 10 mm laser fiber was placed with the Cosman-Roberts-Wells (CRW) frame or ROSA surgical robot (Zimmer Biomet, Warsaw, IN, USA). The patient was then transported to the MRI suite for MRI thermography. Axial T2 and sagittal T2 images were obtained, and target and safety regions were defined. Real-time MR thermography was used to ensure a temperature between 60 and 80°C within the target region. After ablation of the amygdala, the laser fiber was withdrawn 6-8mm along the trajectory axis until the head, body and tail of the hippocampus were ablated. Ablation was confirmed with a volumetric T1 sequence with contrast, a T2 sequence, and a diffusion weighted imaging (DWI) sequence (Fig. 1).

2.5. Neuropsychological testing

All patients received both a preoperative and a postoperative comprehensive neuropsychological evaluation. Preoperative testing was completed approximately 14 months prior to surgery ($\bar{x}$ time = 14.67 months, SD = 6.98 months), while postoperative testing occurred approximately 12 months after surgery ($\bar{x}$ time = 12.00 months, SD = 5.80). The following standardized tools were used: Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV),[18] Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II),[19] Wide Range Assessment of Learning and Memory, Second Edition (WRAML-2),[20] Delis-Kaplan Executive Function System (D-KEFS),[21] California Verbal Learning Test – Second Edition (CVLT-II),[22] Child and Adolescent Memory Profile (ChAMP),[23] Finger Tapping Test,[24] and Grooved Pegboard Test.[25] An estimated IQ (EIQ) was derived from vocabulary and matrix reasoning subtests of the WAIS-IV (5 participants) or the WASI-II (1 participant). Story memory included WRAML-II Story Memory (3 participants) and ChAMP Instructions (3 participants). List Learning included CVLT-II (1 participant), WRAML-II Verbal Learning (2 participants), and ChAMP Lists (3 participants). Visual Memory included WRAML-II Design Learning (3 participants) and ChAMP Places (3 participants).

2.6. Data collection and analysis

Patient data was obtained retrospectively through review of the electronic medical record and the neuropsychology patient database.

2.7. Statistical methods

Descriptive statistics, including measures of central tendency and frequency, were computed to describe the sample. Pre-surgical and post-surgical scores from the tests were compared using a paired-sample, two-tailed Wilcoxon Signed-Rank Test. Our threshold for significance was $p < 0.05$. All statistical analyses were done using SPSS (IBM, Armonk, New York, USA). Subgroup analysis of right sided vs left sided surgery was also examined. Given the small sample sizes and power

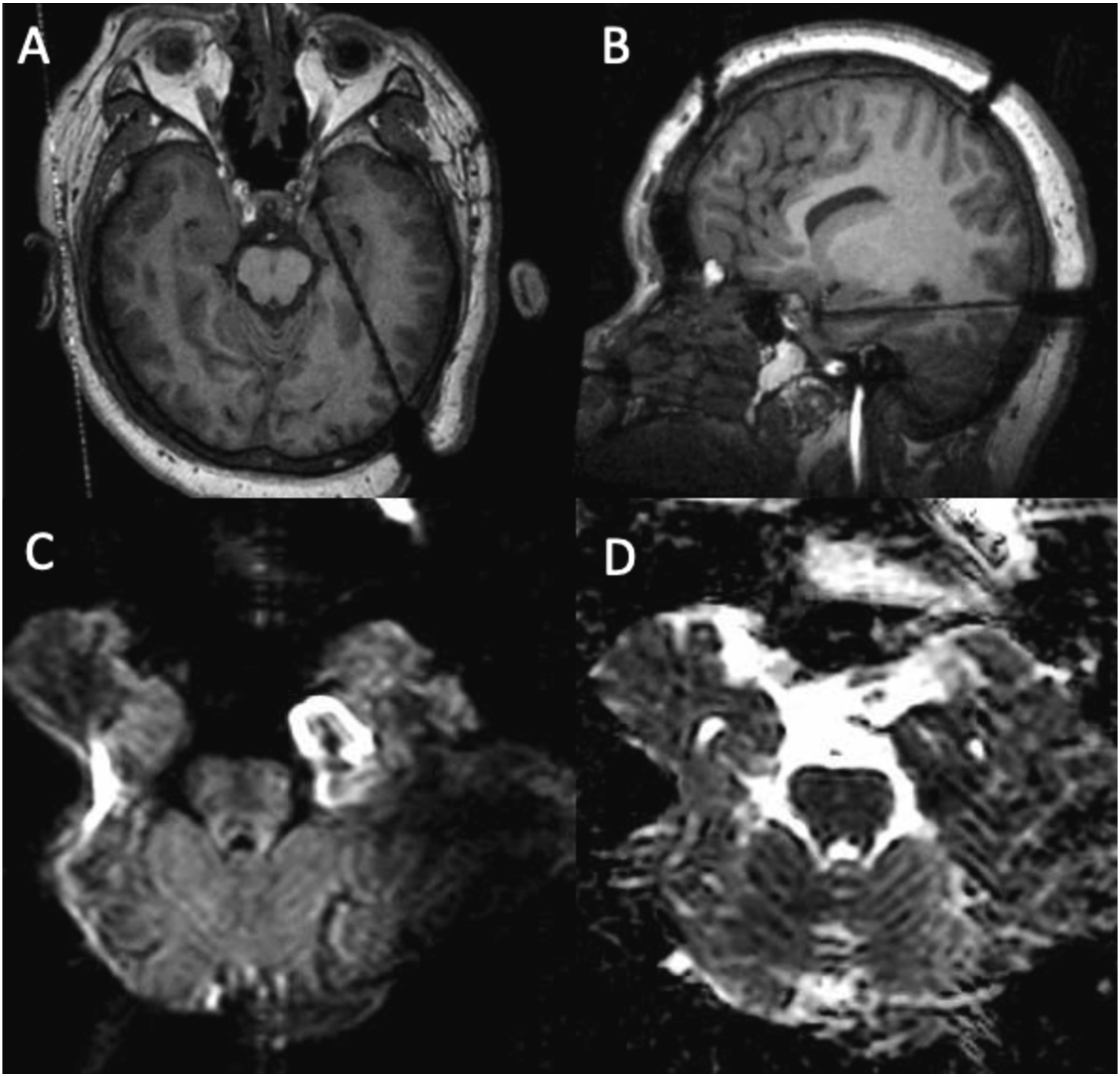

Fig. 1. MR Images of MRgLITT Procedure. A and B) Axial and Sagittal volumetric T1 images in line with the laser catheter; C and D) post-ablation B1000 and dADC axial images confirming the diffusion-restricting ablation area in the amygdala and hippocampus.

limitations, these side-specific effects are reported in terms of clinical significance as opposed to statistical ones.

3. Results

3.1. Patient characteristics

Between February 2017 and June 2023, 14 consecutive patients underwent MRgLITT for MTLE. Of these, 6 patients had complete preoperative and postoperative neuropsychological testing. All six patients (100%) meeting inclusion criteria were male, and the majority identified as Hispanic/Latino (66.7%). The average age at time of surgery was 19.0 years ($SD = 1.2$ years, range 17–20). Three of the patients (50%) had a left-sided procedure, while the other three patients (50%) had a right-sided procedure. Radiographic findings on MRI included a normal MRI (n=2), MTS (n=2) and T2 hyperintense expansile lesions of the amygdala and hippocampus (n=2). For the expansile lesions, no tissue diagnosis was obtained and the main differential included focal cortical dysplasia vs a low grade glial/neuroglial tumor of the mesial temporal structures. Five of the six patients (83%) were right-handed, and one patient (17%) was left-handed. The average duration of epilepsy was 7.6 years (range 1.3–15.2 years). Two of the six patients (33%) underwent Wada testing. Three of the six patients (50%) underwent SEEG for seizure localization before undergoing MRgLITT. Patient characteristics are summarized in Table 1.

3.2. Group-level neuropsychological outcomes

We sought to demonstrate if there were any group-level changes in any of the cognitive domains assessed by the neuropsychological testing

Table 1
Patient characteristics.

Patient	Sex	Age (years)	Handedness	MRgLITT Side	Seizure Duration (years)	Semiology	Imaging	Wada Findings	SEEG Findings	Engel Outcome at Last Follow-Up	Time to Last Follow-Up (Months)
1	Male	20	Right	Left	15.2	Aura, nonsensical speech, oromotor automatisms	MRI: Normal PET: left temporal hypometabolism	Left language, bilateral memory	N/A	I	43
2	Male	20	Right	Left	2.0	Mouth pulling, unresponsiveness	MRI: left expansile T2 hyperintense lesion of amygdala and hippocampus, left choroidal fissure cyst PET: N/A	Left language, bilateral memory	N/A	III	26
3	Male	18	Right	Right	12.0	Aura (headache), staring	MRI: no MTS PET: bitemporal hypometabolism	N/A	N/A	I	29
4	Male	17	Right	Right	2.1	Dizziness, nausea, automatisms	MRI: Right MTS, anterior temporal FCD PET: negative	N/A	Right mesial temporal onset	I	37
5	Male	17	Right	Right	2.1	Left visual field prism auras, confusion	MRI: Right, expansile T2 hyperintense lesion of amygdala and hippocampus PET: right temporal hypometabolism	N/A	Broad right temporal onset	IV	21
6	Male	19	Left	Left	12.8	Mostly nocturnal, wake up confused, drooling	7T MRI: Left MTS PET: left anterior hypometabolism	N/A	Left mesial temporal onset	II	16
Average		**19**			**7.7**						**28.7**

tools. When comparing preoperative and postoperative neuropsychological test scores, there were no group-level statistically significant changes in the following neuropsychological domains: cognition (i.e., nonverbal reasoning, vocabulary, EIQ), verbal memory (i.e., story memory, list learning), visual memory, executive functioning (i.e., semantic fluency, phonemic fluency, verbal switching, visual-motor switching), visual scanning, graphomotor speed, or fine motor speed and dexterity (i.e., finger tapping, grooved pegboard) ($p > 0.05$, Wilcoxon Signed-Rank Test, Table 2).

3.3. Subgroup analysis: phonemic fluency

Given no group-level statistically significant differences, we examined clinically significant changes based on subgroups (right- vs. left-sided procedures). We observed a clinically significant improvement in phonemic fluency (7.00 relative units preoperative average vs. 10.33 relative units postoperative average) for all patients who underwent right-sided MRgLITT. In contrast, there was a clinical decline in phonemic fluency for all patients who underwent left-sided MRgLITT (9.67 relative units preoperative average vs. 6.33 relative units postoperative average) (Fig. 2, Table 3).

3.4. Seizure outcomes

Postoperative Engel classification outcomes were acquired for all patients who completed postoperative neuropsychological testing. At time of last follow-up after MRgLITT, three of the six patients (50%) had Engel I outcome; one patient had Engel II outcome (16.7%); one patient had Engel III outcome (16.7%), and one patient had Engel IV outcome (16.7%). The average length of follow-up was 28.7 months (range: 16 – 43 months). Clinical outcomes are summarized in Table 1.

4. Discussion

Although there have been a number of studies that present clinical outcomes for MRgLITT in pediatric patients with MTLE (reviewed by Hoppe and colleagues), no studies to date have provided a comprehensive analysis of post-surgical neuropsychological outcomes [26]. In our study, we demonstrated that there were no statistically significant group-level differences between preoperative vs. postoperative neuropsychological metrics amongst our adolescent patients who underwent MRgLITT for MTLE. Importantly, this finding included verbal memory. Interestingly, our subgroup analysis showed a clinical improvement in phonemic fluency for patients who underwent a right-sided procedure, and a decrease in phonemic fluency in patients who underwent a left-sided procedure. Our results revealed similar seizure freedom rates to those reported in the literature [26].

In pediatric patients, several studies have characterized cognitive outcomes in open temporal lobe surgery. Sbazó et al. observed a decrease in delayed verbal memory for patients undergoing left-sided temporal lobectomy [27]. In contrast, Westerveld et al. found that patients undergoing temporal lobectomy did not experience significant declines in cognitive function, though some individual patients experienced a decrease in verbal intellectual functioning [28]. Similarly, Skirrow et al. found that there were no group-level declines in cognitive functioning, but did observe that improved verbal memory scores correlated with residual hippocampal residual volume after surgery [29]. Finally, Flint and colleagues conducted meta-analysis on 73 studies that examined postsurgical neuropsychological outcomes among pediatric patients after resective temporal lobe surgery. While the literature supports improvement or unchanged neuropsychological outcomes in the majority of pediatric patients, a proportion experienced postoperative neuropsychological declines in cognition (10%), memory (25%), language (11%), and behavior (3%) [30].

Outcome literature addressing pediatric patients undergoing MRgLITT for MTLE, at best, includes qualitative statements on cognitive functioning and no reported quantitative cognitive outcomes [16,26,31–33]. Our findings contribute to this existing literature by providing objective data to support preservation of several neuropsychological domains following MRgLITT in adolescent patients. This is in contrast to outcomes reported in adult patients, where patients were at risk of verbal memory decline, especially with dominant-sided

Table 2
Group-level Neuropsychologic Outcomes.

Neurocognitive Variable	Pre-Op Average	Post-Op Average	Z-value	p-value
Estimated IQ	89.00	93.83	−1.57	0.12
Vocabulary	7.67	8.17	−1.34	0.18
Matrix Reasoning	8.83	9.17	−0.27	0.79
Story Memory				
Story Memory Recall	6.33	6.17	−0.14	0.89
Story Memory Delay	7.17	6.50	−0.43	0.67
Story Memory Recognition	6.50	8.33	−0.81	0.42
List Learning				
List Learning Recall	5.00	6.33	−1.22	0.22
List Learning Delay	5.67	5.50	−0.42	0.67
List Learning Recognition	5.67	7.50	−0.67	0.50
Visual Memory				
Visual Memory Recall	9.17	8.83	−0.41	0.69
Visual Memory Delay	8.00	8.33	−0.14	0.89
D-KEFS Semantic Fluency	7.83	6.50	−1.24	0.22
D-KEFS Phonemic Fluency	8.33	8.33	0.00	1.00
D-KEFS Visual Scanning	10.17	7.83	−1.83	0.07
D-KEFS Visual-Motor Switching	6.00	7.67	−0.74	0.46
D-KEFS Motor Speed	8.83	10.33	−1.16	0.25
Finger Tapping Test (FTT)				
FTT Dominant	−1.91	−2.13	−0.11	0.92
FTT Nondominant	−1.92	−2.23	−0.52	0.60
Grooved Pegboard Test (GP)				
GP Dominant	−0.94	−1.32	−0.11	0.92
GP Nondominant	−1.54	−1.03	−0.52	0.60

Note: An estimated IQ (EIQ) was derived from vocabulary and matrix reasoning subtests of the Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV) or the Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II); Story Memory included the Wide Range Assessment of Memory and Learning, Second Edition (WRAML-II) Story Memory subtest and the Child and Adolescent Memory Profile (ChAMP) Instructions subtest; List Learning included the California Verbal Learning Test, Second Edition (CVLT-II), the WRAML-II Verbal Learning subtest, and the ChAMP Lists subtest; Visual Memory included the Wide Range Assessment of Memory and Learning, Second Edition (WRAML-II) Design Learning subtest and the ChAMP Places subtest; Finger Tapping Test norms from Strauss et al., 2006;[24] Grooved Pegboard Test norms from Skogan et al., 2018.[25].
Abbreviations: Delis-Kaplan Executive Function System (D-KEFS).

procedures, and declines in delayed verbal memory performance following dominant-sided procedures [7,17,34]. Recently, Drane et al. 2021 reported on verbal memory outcomes in a large series of adult patients who underwent open surgery versus MRgLITT.[35] Although verbal memory decline was observed in both the open surgery and MRgLITT groups, this effect was significantly greater in patients undergoing open surgery. Patients undergoing language-dominant, open procedures were at highest risk. Importantly, the authors' results suggest that verbal memory may not solely involve the amygdala and hippocampus, but also include the extrahippocampal mesial temporal lobe, white matter tracts, and lateral neocortical regions that are typically spared during MRgLITT.

We observed similar results with preservation of verbal memory in our cohort of adolescent patients and this finding was independent of procedure sidedness. This may be due to a combination of factors, including the focused targeting of the amygdala and hippocampus without disruption extrahippocampal structures involved in verbal memory, as well as a relative robustness of pediatric population to neuropsychological decline following temporal lobe surgery as described above [30]. Future investigations should focus on identifying these factors.

The observed clinical changes in phonemic fluency are unexpected when considering the current structure–function relationship underlying phonemic fluency. Verbal fluency is comprised of semantic fluency and phonemic fluency [36], which both involve executive processing, including self-monitoring, selective attention and inhibition, and working memory [36,37]; however, semantic fluency relies on semantic memory while phonemic fluency relies on phonological memory. Lesion studies have demonstrated that both semantic and phonemic fluency involve large left hemispheric networks with considerable overlap, though semantic fluency involves more left temporal structures while phonemic fluency involves more left frontal structures [38]. As all our patients underwent MRgLITT of mesial temporal structures only, the underlying explanation as to the observed clinical changes in this frontal lobe network warrants further investigation.

One important consideration is the cognitive effects of antiseizure medications (ASMs). Carbamazepine, in particular, has been associated independently with negative cognitive effects. Aikiä et al. found that patients taking carbamazepine had worse verbal fluency scores than those taking other ASMs [39]. Similarly, Hessen et al. demonstrated that scores on verbal tasks and Stroop tasks improved after discontinuation

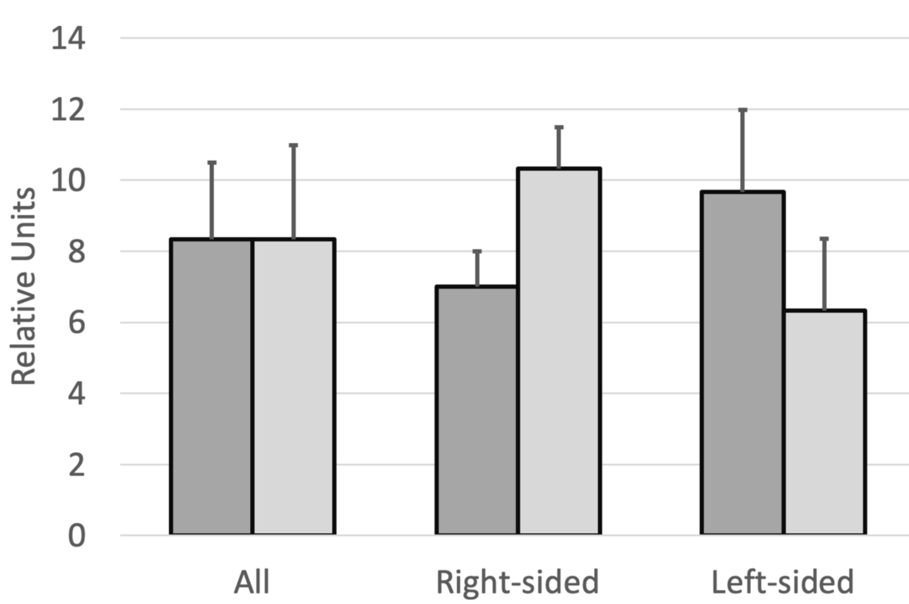

Fig. 2. Phonemic fluency scores improved for patients who underwent a right-sided MRgLITT and decreased for patients who underwent a left-sided procedure. Phonemic fluency scores have a normative mean of 10 and standard deviation of 3. Error bars represent the standard deviation of individual scores.

Table 3
Right- vs. Left-sided Neuropsychological Outcomes.

Neurocognitive Variable	Right		Left	
	Pre-Op Average	Post-Op Average	Pre-Op Average	Post-Op Average
Estimated IQ	97.00	101.00	81.00	86.67
Vocabulary	9.33	10.33	6.00	6.00
Matrix Reasoning	10.67	10.00	7.00	8.33
Story Memory				
Story Memory Recall	4.67	6.33	8.00	6.00
Story Memory Delay	5.00	6.33	9.33	6.67
Story Memory Recognition	5.67	10.67	7.33	6.00
List Learning				
List Learning Recall	5.33	7.67	4.67	5.00
List Learning Delay	4.67	6.67	6.67	4.33
List Learning Recognition	6.33	9.00	5.00	6.00
Visual Memory				
Visual Memory Recall	7.00	9.00	11.33	8.67
Visual Memory Delay	6.00	8.33	10.00	8.33
D-KEFS Semantic Fluency	9.00	7.33	6.67	5.67
D-KEFS Phonemic Fluency	7.00	10.33	9.67	6.33
D-KEFS Visual Scanning	10.33	9.00	10.00	6.67
D-KEFS Visual-Motor Switching	4.67	8.00	7.33	7.33
D-KEFS Motor Speed	9.33	11.67	8.33	9.00
Finger Tapping Test (FTT)				
FTT Dominant	−2.50	−2.07	−1.33	−2.19
FTT Nondominant	−2.38	−2.47	−1.45	−1.99
Grooved Pegboard Test (GP)				
GP Dominant	−0.09	−0.15	−1.78	−2.48
GP Nondominant	−0.89	−0.25	−2.18	−1.82

Note: An estimated IQ (EIQ) was derived from vocabulary and matrix reasoning subtests of the Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV) or the Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II); Story Memory included the Wide Range Assessment of Memory and Learning, Second Edition (WRAML-II) Story Memory subtest and the Child and Adolescent Memory Profile (ChAMP) Instructions subtest; List Learning included the California Verbal Learning Test, Second Edition (CVLT-II), the WRAML-II Verbal Learning subtest, and the ChAMP Lists subtest; Visual Memory included the Wide Range Assessment of Memory and Learning, Second Edition (WRAML-II) Design Learning subtest and the ChAMP Places subtest; Finger Tapping Test norms from Strauss et al., 2006;[24] Grooved Pegboard Test norms from Skogan et al., 2018.[25].
Abbreviations: Delis-Kaplan Executive Function System (D-KEFS).

of carbamazepine [40]. Lee et al. showed that carbamazepine had worse cognitive effects than levetiracetam [41], and Gillham et al. similarly showed that carbamazepine had more cognitive effects than lamotrigine [42]. In our cohort, two patients were on carbamazepine. One of the patients had a right-sided procedure with an improvement in phonemic fluency, and subsequent seizure freedom. The other patient had a left-sided procedure and a decrease in phonemic fluency and had continued seizures. Given the heterogeneity of changes in ASMs between pre- and post-neuropsychological testing, an analysis for correlation between ASM and neuropsychological was challenging to accomplish. Two patients had decreases in ASMs, two patients had increases in ASMs, and two patients had replacements of one ASM for another in their regimens. From our data, it is unclear if there is a direct interaction between ASMs and MRgLITT with respect to cognitive outcomes, and more patients would need to be analyzed to reveal any effects of such medications.

One of the major limitations of this study is that it is a single-center, retrospective investigation with a small number of patients. Our overall number of MRgLITT patients (n = 14) was comparable to previously published multi-institutional studies; however, our report was significantly limited by the number of patients who had complete post-operative neuropsychological evaluations due to medical limitations during the COVID-19 pandemic, patients that may have aged out or those that were lost to follow-up (n = 8). With a small number of patients, it may be difficult to make statistical inferences and we attempted to combat this by using nonparametric statistical analysis at the group level. However, the observed clinically significant differences seen in phonemic fluency will need to be verified by a larger population sample. Along those same lines, it would be interesting to explore the relationships between neuropsychological outcomes and clinical outcomes like Engel classification and medication effects; however, the sample size in this study was too small to evaluate these interactions. Another limitation of our study is that it included only male patients and only adolescent/young adult patients. This fact did, however, limit confounds of sex and age. Furthermore, older pediatric patients allow for more comprehensive neuropsychological testing due to increased maturity and cognitive ability compared to younger patients. Further analysis could focus on younger patients and include female patients as well. On a technical note, one limitation is that while most pre/post-neuropsychological data represents a direct comparison between test measures, intelligence measures, list learning, story memory, and visual memory testing varied across subjects, limiting conclusions about these measures. Another intriguing facet to investigate would be the influence of social determinants of health (e.g. socioeconomic status) on neurological and clinical outcomes within this population. As we collect more data in the future, we will be able to investigate interactions between sex, age, socioeconomic status, and clinical outcome with regards to neuropsychological measures before and after MRgLITT for MTLE.

5. Conclusion

This study is the first study to report comprehensive neuropsychological outcomes in pediatric patients undergoing MRgLITT for MTLE. Our results suggest MRgLITT can preserve neurocognitive effects, including verbal memory, in pediatric patients with MTLE and can offer effective seizure control. We also observed clinically significant improvements in phonemic fluency for patients who underwent non-dominant-sided surgery, while there was a decrease in phonemic fluency for patients who underwent dominant-sided procedure. A larger sample is required to replicate these neuropsychological findings, though our data shows preliminary evidence that MRgLITT is a well-tolerated procedure in pediatric population.

Author contributions

All authors meeting authorship criteria are listed, and all authors certify that sufficient participation was given in order to take public responsibility for the content contained within this manuscript. Furthermore, all authors certify that this material has not been submitted to or published any other publication.

Ethics approval statement

The study was approved by the Institutional Review Board (IRB).

Patient consent statement

Not applicable, this is a retrospective analysis.

CRediT authorship contribution statement

Jonathon M. Cavaleri: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Jenna A. Chiang:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Danielle M. Wishart:** Writing – review & editing. **Keiko M. Kang:** Writing – review & editing. **Patrick R. Ng:** Writing – review & editing. **Leanne Mendoza:** Writing – review & editing. **Kenneth Hartline:** Writing – review & editing. **Michele Van Hirtum-Das:** Writing – review & editing. **Latanya D. Agurs:** Writing – review & editing. **Madeline Kahan:** Writing – review & editing. **Brittany Jordan:** Writing – review & editing. **Charles Y. Liu:** Writing –

review & editing. **Brian Lee:** Writing – review & editing. **Peter A. Chiarelli:** Writing – review & editing. **Jason K. Chu:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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