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Review

Radiofrequency-thermocoagulation in pediatric epilepsy surgery: A systematic review and pooled analysis of cases

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ABSTRACT

Objective: To conduct a systematic review on radiofrequency thermocoagulation (RF-TC) in pediatric epilepsy surgery. In addition, due to the low number of dedicated pediatric series, to conduct a pooled analysis of cases published in the literature.

Methods: We conducted a literature search using PUBMED and EMBASE which produced 432 results. We excluded studies on hypothalamic hamartomas and non-RF-TC procedures such as stereotactic radiosurgery and laser interstitial thermal ablation. Stereotactic RF-TC and SEEG-guided RF-TC procedures were included. Case series and case reports with individualized data were further reviewed and pediatric cases were extracted for pooled analysis. Patient demographics, electroclinical and neuroimaging data, procedure outcomes, responder rates and complications were collected. Our unpublished experience in pediatric SEEG-guided RF-TC was included in the pooled analysis.

Results: We identified 33 articles for the literature review, 24 of them were selected for pooled analysis (93 cases). Sixty patients underwent SEEG-guided RF-TC. For adult and pediatric mixed series reported a 67% responder rate and 32% seizure freedom at 1 year. For exclusively pediatric series, 90% responder rate and 71% Seizure freedom. In the pooled analysis, seizure freedom was achieved in 45.2% and responder rate was 74.2% with a mean follow-up was 25.2 months (SD ± 26.6). Complication rates were low, transient neurological deficits were reported in 18 cases (19.4%) and no deaths were associated with RF-TC. The insula and the dominant frontal lobe were the most frequent targets for ablation. Studies included were highly heterogenous and quality of evidence was low.

Significance: There are few pediatric studies evaluating RF-TC. Safety and efficacy in children seem to be similar to that reported in larger adult series, although more studies are needed. Most cases reviewed where extracted from heterogeneous adult and pediatric series. Patients with small, high-risk surgical targets are ideal candidates for this procedure.

1. Introduction

Radiofrequency thermocoagulation (RF-TC) has been a therapeutic alternative for decades in epilepsy surgery [1–4]. Due to lower success rates than those reported for resective or disconnective procedures, it has mainly been considered a second-line option [5–7]. However, with the growth of SEEG as a diagnostic tool and the convenience of using depth electrodes to deliver thermo-ablations, many centers have

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adopted the method as a valid technique for small higher-risk targets and to predict surgical outcomes [8–10].

The more recent induction of MRI-controlled lesioning via Laser Interstitial Thermal Therapy (LITT) has shown comparable results to resective surgery in selected patients [11]. Yet, this technology is more costly and is not accessible in certain regions [12]. With these issues in consideration, RF-TC may still have a role in epilepsy surgery. While most literature and large series are focused on adult patients, little evidence exists on the effect of RF-TC in the pediatric population [5,13,14].

We conducted a systematic review and proportional metanalysis on radiofrequency thermocoagulation (RF-TC) in pediatric epilepsy patients. In addition, due to the expected low number of large dedicated pediatric series, we conducted a pooled analysis of individualized cases published in the literature.

2. Methods

2.1. Search strategy

We performed a comprehensive literature search following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and using MEDLINE and EMBASE (both via Ovid) electronic databases. Systematic literature searches were carried out from the inception until February 24th, 2023. The sensitive search strategy was designed and implemented in consultation with an expert librarian with experience in conducting electronic literature searches, based on a combination of synonymous searches comprised of database-specific subject headings, such as MeSH in MEDLINE and EMTree descriptors in Embase, and keywords using alternative word spellings and endings for the following search terms: “epilepsy,” “radiofrequency therapy,” “stereotactic,” “SEEG-guided,” “thermocoagulation,” “thermo-lesions,” “thermal gradient,” “RF-TC,” and “ablation.” The search was limited to the pediatric population, and English, Spanish and French language restrictions were applied. Previously identified articles relevant to the research question were used to validate the search strategy. The search strategies were modified for each database to include database-specific index terms. References of all the articles identified as relevant for inclusion were screened to identify other potentially relevant studies. A detailed description of our search strategy can be found in Supplementary Appendix 1. The records returned from the database search were imported into the Covidence (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia), where articles were reviewed, and duplicate articles were automatically removed.

The search identified a total of 432 citations; after duplicates were removed, 323 articles were screened. Sixty-four were selected for full-text evaluation, and 34 were finally included.

2.2. Eligibility/inclusion criteria

Studies with RF-TC in patients 18 years-old or younger at the time of the procedure were included. Articles were initially reviewed by title and abstracts, once selected additional selection was carried out by full article review. Reviews, conference abstracts, adult-only case series and other non-suitable publications were excluded. We excluded studies on hypothalamic hamartomas and non-RF-TC procedures such as stereotactic radiosurgery and LITT. Table 1 summarizes the inclusion and exclusion criteria.

2.3. Study selection

All studies including pediatric RF-TC procedures were selected. Stereotactic RF-TC and SEEG-guided RF-TC procedures were included. Series including adult and pediatric cases were classified as “mixed series”. Series including patients 18-yeards-old or younger at the moment of the procedure were classified as “pediatric series”. All articles which included individualized patient data where further selected for the cases pooled analysis (Fig. 1). Two analysts (JSB and FA) screened articles separately and conflicts were resolved by discussion. Risk of overlap was also considered and studies from the same group and time period were individually screened and if the risk of overlap of cases was evident, the most comprehensive series was included for metanalysis. For the pooled cases analysis, studies with patient-level data were analyzed individually to determine if they were duplicated, thus removed.

Table 1
Inclusion and exclusion criteria for the present study:

Inclusion criteria	Exclusion criteria
○ Age≤ 18 years. ○ Pediatric or pediatric and adult publications. ○ SEEG guided RF-TC or Stereotactic RF-TC. ○ Case series and case reports.	○ Adult-only publications. ○ Hypothalamic hamartoma publications. ○ Laser Interstitial Thermal therapy (LITT). ○ Reviews, expert opinions and other non-relevant publications

2.4. Data extraction

Patient demographics, electroclinical and neuroimaging data, technical characteristics of the procedure, region of ablation, procedure outcomes, complications, and time of follow up were collected when available. Primary outcomes were responder rate (defined as $\geq$ 50% seizure frequency reduction) and seizure freedom at 1 or 2 years. To homogenize the disparity in reported outcomes, we considered seizure freedom Engel I, ILAE class 1 and 2 or seizure freedom. Secondary outcomes were deaths, transient or permanent neurological deficits and percentage of seizure reduction. Our unpublished series in pediatric SEEG-guided RF-TC was included as a pediatric series and in the pooled analysis. Supplementary Appendix 2 includes case descriptions of our case series.

2.5. Quality assessment

Publication bias was evaluated qualitatively. Level of quality was assessed with the NIH quality assessment tool (https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools) for Case-control as studies and for case series studies. Using this guide, we classified the studies into “Good”, “Fair” and “Poor” in relation to the research question.

2.6. Statistical analysis

As most publications included are single-group studies a proportional meta-analysis was conducted with R using a Random effects model [15]. The meta-analysis was conducted for all studies, then for mixed adult and pediatric studies and finally, for pediatric only series.

3. Results

3.1. All studies

Thirty-three studies were included for systematic review, of these, 25 series were mixed between adults and pediatric cases. Eight series and case reports were exclusively pediatric. Most publications included were small case series or case reports. Twenty-three case series and case reports with individualized patient data were further reviewed and pediatric cases were extracted for pooled analysis (Table 2). Eight series had a risk of overlap, therefore removed from metanalysis.

The total number of patients included was 852. Twenty-seven studies were included for the proportional metanalysis, removing studies with risk of patient overlap. Metanalysis showed responder rates ($\geq$ 50%

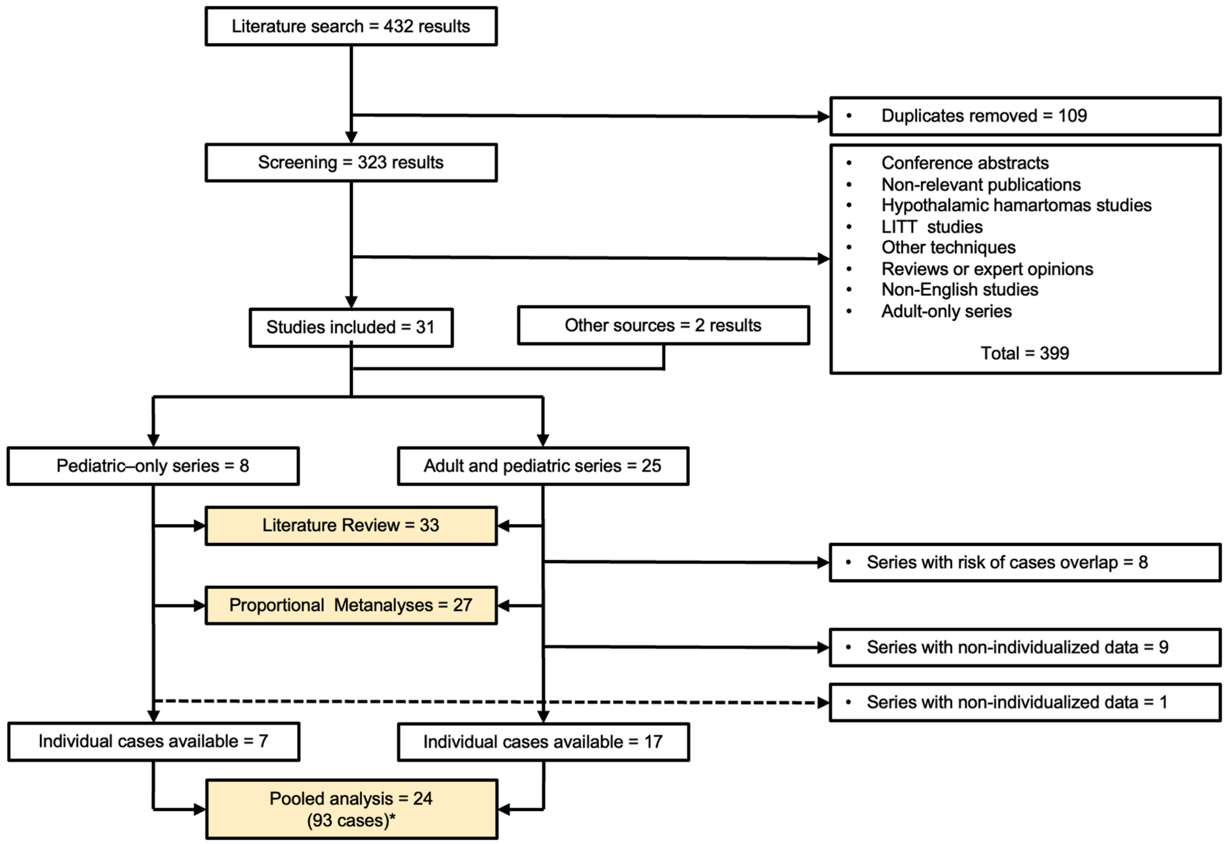

Fig. 1. Flow diagram of the literature search and systematic review.

seizure frequency reduction) of 79% and seizure freedom at 1 year was reported in 50% of patients, with high heterogeneity (r^2=0.070 and r^2=0.084 respectively. p <0.01) (Fig. 2A).

Quality of evidence for RF-TC in pediatric population was low. No randomized control trials have been reported on pediatric population. In terms of quality assessment, 7 (19.4%) studies were found to be "Good", 17 (24.3%) "Fair" and 9 (25%) "Poor". The results for quality assessment can be found in Supplementary Appendix 3.

Only 10 studies reported results for post-ablation resective surgery [10,13,16–23]. Engel I outcomes in patients undergoing subsequent resective surgery ranged from 71.4 to 90% when reported. Two of the largest series evaluated the positive predictive value of RF-TC response to resective surgery, resulting in 83% [13] and 93% [8].

From a technical standpoint, 26 studies used SEEG-guided RF-TC; seven of which were exclusively pediatric series. Ten studies were Stereotactic RF-TC. Two were performed in exclusively pediatric patients.

3.1.1. *Mixed series*

In total, 16 studies were included. These series summed up to 440 adults and pediatric patients who have undergone RF-TC. The number of patients in each series ranged between 2 to 162 cases. MRI-positive cases accounted for 53.3%. Publications were heterogeneous in their focus. Twelve studies were focused on specific aetiologies, regions or techniques: mesial temporal lobe epilepsy (3), ablations in eloquent areas (2), periventricular nodular heterotopias (PVNH) (1), SEEG (2), robot-assisted RF-TC (2), thalamic ablation (1), and malformations of cortical development (MCD) (1).

The effect of RF-TC in these series showed a 72% responder rate (Seizure reduction >50%) and 39% seizure freedom at 1 year. Heterogeneity was high (r^2=0.075 and r^2=0.069 respectively. p <0.01) (Fig. 2B).

The mean follow-up period was 25.8 months (SD ± 18.5). Transient deficits were reported in 7.3% of patients and permanent deficits in 1.4%. There were no deaths associated to RF-TC in these series. Only one patient died due to an intracranial hemorrhage after depth electrodes implantation, but not related to RF-TC. Sixteen series had individualized data on pediatric patients and these cases were further extracted for the pooled analysis. Summary of the results are shown on Table 3.

3.1.2. *Pediatric series*

In total, 8 pediatric case series were included for review. We additionally included our series (4 cases, 5 procedures in 10 sessions). In total, these series summed up 76 patients with RF-TC. The number of patients published in the literature ranged between 2 to 46 and two were single case reports. MRI-positive cases accounted for 78.6%. Publications were heterogeneous in their focus: one series focused on RF-TC hemispherotomies [24], tuberous sclerosis complex (TSC) [25], insular epilepsies [26] and robot-assisted procedures [27] among others.

The overall result in these series was 90% of responders (seizure reduction >50%) to RF-TC and 71% of Seizure freedom. Heterogeneity was slightly lower for this group (r^2=0.052 and r^2=0.056 respectively. p <0.01) (Fig. 2C). The mean follow-up period was of 12.4 months (SD ± 8.5). Transient deficits were reported in 16.7% of patients and permanent deficits in only one case. There were no deaths associated to RF-TC in these series. Eight of the 9 exclusively pediatric studies had individualized data to extract for pooled analysis.

3.1.3. *Pooled analysis*

Twenty-four case series from both, mixed and pediatric patients were selected for pooled analysis (93 cases, consisting of adult and pediatric cases) [1,4,6,12,17,19–21,23–26,28–39]. No cases were identified as duplicated from overlapping series. Seventy-three patients underwent SEEG-guided RF-TC, 20 patients stereotactic RF-TC. Median age was 12 years (*IQR*=8). Median age of seizure onset was 4 (*IQR*=7). 57% of the cases had MRI-positive epilepsies. Seizure freedom was achieved in 45.2%. Overall responder rate was 74.2%. Mean follow-up was 25.2

Table 2

Studies included in the present series. Number of total cases is shown on the third column and the number of pediatric cases -if known- is depicted between brackets. %: percentage; CMN: centromedian nucleus; FCD: focal cortical dysplasia; MCD: malformation of cortical development; MEG: magneto-electroecephalography; mTLE: mesial temporal lobe epilepsy; N: number; NA: not available; PVNH: periventricular nodular heterotopia; RF-TC: radiofrequency thermocoagulation; SEEG: stereo-electroencephalography; Sz: seizure,; TLE; temporal lobe epilepsy; TSC: tuberous sclerosis complex;.

Author	Mixed series	Pooled Analysis		Retrospective	Focus	RF-TC procedure	MRI-positive (N)	Responders (%)	Sz-free (%)
Aguado Carrillo et al, 2020	Mixed series	Yes	6 (2)	Prospective	RF-TC in CMN	Stereotactic	0	79.8-98.6%	0,0%
Bottan et al, 2024 (*)	Pediatric only	Yes	4 (4)	Retrospective	RF-TC	SEEG-guided	2 (50%)	100%	75,0%
Bourdillion et al, 2017(**)	Mixed series	No	162	Retrospective	RF-TC	SEEG-guided	107 (66%)	48%	14.1%
Cardinale et al, 2019 (**)	Mixed series	No	153	Retrospective	SEEG	SEEG-guided	NA	16.3%	9.8%
Catenoix et al, 2015 (**)	Mixed series	Yes	14 (1)	Retrospective	RF-TC in MCD	SEEG-guided	14 (100%)	64%	43,0%
Catenoix et al, 2008 (**)	Mixed series	Yes	28 (2)	Retrospective	RF-TC	SEEG-guided	19 (67.9%)	48.7%	3.8%
Chandra et al, 2021	Pediatric only	Yes	6 (2)	Retrospective	Hemispherotomies	Stereotactic	6 (100%)	100%	83.3%
Chipaux et al, 2019	Pediatric only	No	46 (46)	Prospective & Retrospective		SEEG-guided	33 (71.7%)	73.9%	56.5%
Contento et al, 2021	Mixed series	No	38	Retrospective	Epileptogenicity after RF-TC	SEEG-guided	32 (84.2%)	50%	21,0%
Cossu et al, 2015(**)	Mixed series	No	89 (22)	Retrospective	RF-TC	SEEG-guided	43 (48.3%)	28%	10.1%
Cossu et al, 2013(**)	Mixed series	Yes	5 (2)	Retrospective	RF-TC in PVNH	SEEG-guided	5 (100%)	80%	60,0%
Dai et al, 2022	Mixed series	Yes	10 (2)	Retrospective	RF-TC in insular epilepsy	SEEG-guided	2 (20%)	100%	70,0%
Deveaux et al, 2008 (**)	Mixed series	No	6	Retrospective	Surgery in Functional/eloquent areas	Stereotactic	NA	NA	NA
Dimova et al, 2017 (**)	Mixed series	Yes	23 (10)	Retrospective	RF-TC	SEEG-guided	8 (34.8%)	30.4%	4.3%
Fan et al, 2019	Mixed series	Yes	21 (2)	Retrospective	RF-TC in mTLE	SEEG-guided	21 (100%)	100%	76.2%
Gao et al, 2020	Mixed series	Yes	35 (17)	Retrospective	MEG in RF-TC for MRI-negative epilepsy	SEEG-guided	15 (42.9%)	NA	25-30%
Guenot et al, 2011 (**)	Mixed series	Yes	42 (5)	Retrospective	RF-TC	SEEG-guided	28 (68.3%)	51.2%	2.4%
Guenot et al, 2004 (**)	Mixed series	No	20	Retrospective	RF-TC	SEEG-guided	18 (90%)	65%	15,0%
Jayapaul et al, 2022	Mixed series	No	4	Retrospective	insular surgery	Stereotactic	NA	NA	NA
Liu et al, 2020	Mixed series	Yes	4 (2)	Retrospective	Orbito-Frontal epilepsy	SEEG-guided	0	100%	100,0%
Luo et al, 2022	Pediatric only	Yes	9 (9)	Prospective	RF-TC in TSC	SEEG-guided	9 (100%)	100%	77.8%
Ma et al, 2021	Pediatric only	Yes	1 (1)	Retrospective	RF-TC in Insular epilepsy	SEEG-guided	0	100%	100,0%
Mereaux et al, 2020	Mixed series	No	8	Retrospective	SEEG	SEEG-guided	20 (43%)	87.5%	37.5%
Mirandola et al, 2017 (**)	Mixed series	No	20	Retrospective	RF-TC in PVNH	SEEG-guided	17 (100%)	76.5%	76.5%
Moles et al, 2018(**)	Mixed series	Yes	21 (2)	Retrospective	RF-TC in TLE	SEEG-guided	16 (76.2%)	47.6%	0,0%
Mullatti et al, 2019	Mixed series	Yes	19 (6)	Retrospective	RF-TC in insular epilepsy	SEEG-guided	4 (21%)	74%	53,0%
Neuberger et al, 2022	Mixed series	Yes	2 (1)	Retrospective	MEG	SEEG-guided	NA	NA	NA
Patil et al, 1995	Mixed series	Yes	9 (3)	Retrospective	RF-TC	Stereotactic	NA	100%	56,0%
Takayama et al, 2022	Pediatric only	Yes	2 (2)	Retrospective	RF-TC	Stereotactic	2 (100%)	100%	100,0%
Wang et al, 2022	Mixed series	Yes	3 (1)	Retrospective	callosotomy	Stereotactic	2 (66.7%)	100%	66.7%
Wu et al, 2014	Mixed series	No	7	Retrospective	Robot-assisted RF-TC in TLE	SEEG-guided	7 (100%)	85.7%	57,0%
Xu et al, 2022	Mixed series	Yes	15 (4)	Retrospective	RF-TC in motor cortex	SEEG-guided	13 (86.7%)	80%	60,0%
Yanming et al, 2021	Pediatric only	Yes	1 (1)	Retrospective	base of sulcus FCD	SEEG-guided	1 (100%)	100%	100,0%
Yu et al, 2018	Pediatric only	Yes	1 (1)	Retrospective	Semiology in Insular epilepsy	SEEG-guided	0	100%	100,0%
Zhao et al, 2020	Pediatric only	Yes	6 (6)	Retrospective	Frameless Robot-assisted SEEG	SEEG-guided	7 (100%)	100%	50,0%
Zhao el al, 2017	Mixed series	Yes	12 (1)	Retrospective	RF-TC in Bilateral TLE	SEEG-guided	2 (16.7%)	83.3%	41.7%

(**) Risk of cases overlap.
(*) Own series.

months (SD ± 26.6) Complication rates were low, transient neurological deficits were reported in 18 cases (19.4%). No deaths were associated with RF-TC. Mean number of contacts were RF-TC was applied was 17 (SD ± 14.2). Though seldomly reported, volume of ablation was 4.3 cm^3 (SD ± 2.9) and the most frequent location was in the frontal lobe (35.5%), followed by the insula (31.2%). In terms of laterality, right-hemisphere RF-TC procedures were in the frontal lobe (12 cases), temporal (9 cases), parietal (8 cases) and insular (7 cases). Conversely, in left-hemispheric procedures, ablations occurred in the insula (22 cases), frontal (21), temporal (9), parietal (8). Bilateral procedures occurred in the centromedian nucleus (2 cases), amygdalohippocampal complex (1) and corpus callosum (2) (Fig. 3). Outcomes between right and left were almost identical: 71.4% responders, 40% seizure freedom for right-sided procedures vs. 70.9% and 47.3%, respectively for left-sided lesions. When dividing into MRI-positive and MRI-negative cases, no significant differences were found in terms of seizure

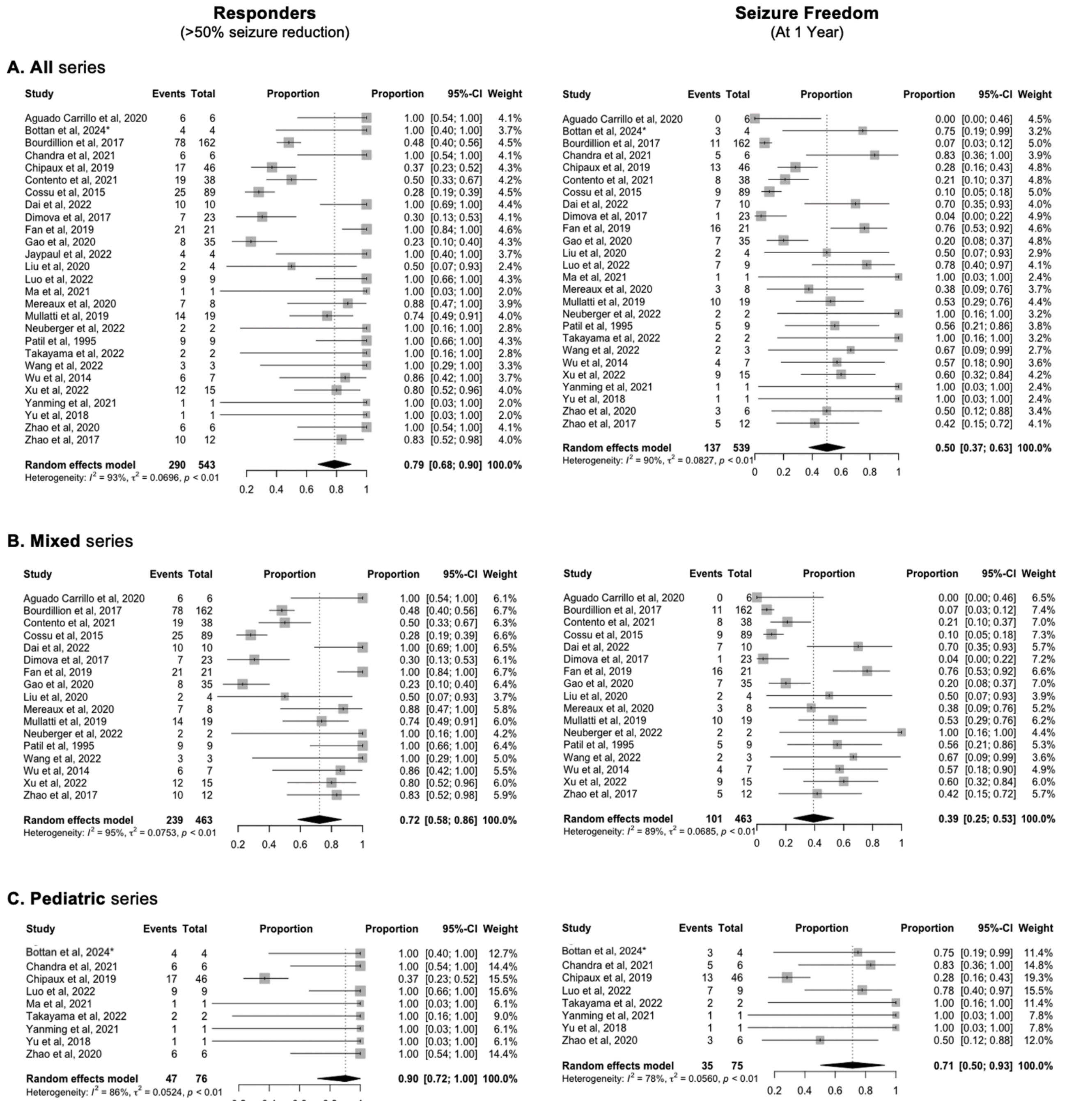

Fig. 2. Forest plots for the proportional meta-analysis. A) All series included in the present study. B) Adult and pediatric mixed series. C) Pediatric only series. Note: our own small case series is included as "Bottan et al, 2024".

Table 3
Summary of the results for the different groups of series. Series with risk of overlap of cases were removed.

Series	Total cases	MRI -positive (%)	Responders (%)	Sz free (%)	Mean FUP (Mo)	Transient deficits (%)	Permanent deficits
All	549	60.7	83.7	57	21.7 (±16.4)	7.6	1.5
Mixed	440	53.3	79.7	47.4	25.8 (±28.3)	7.3	1.4
Pediatric	76	78.6	96.7	80.3	12.4 (±8.5)	16.7	0.1
Pooled	93	57	74.2	42.5	25.2 (±26.6)	16.1	0

freedom or responder rates. Percentage of seizure reduction between the two groups was 87.6% and 59.4%, respectively (p = 0.0041). RF-TC was more frequent in frontal lobe lesions in the MRI-positive group (41.5%, p = 0.1929) whereas in the MRI-negative cases, lesioning occurred mainly in the insula (55%, p = 0.0001). The results for the pooled analysis are summarized in Tables 4A and 4B.

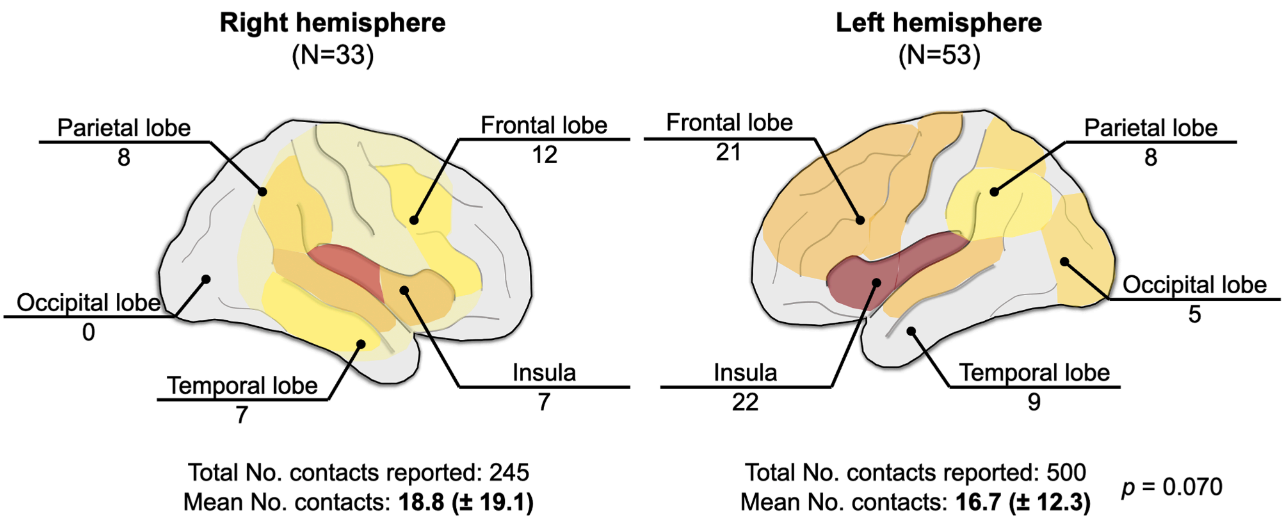

Fig. 3. Heat map illustrating the frequency of targeted lesions per hemisphere and brain region in the pooled cases.

Table 4A
Main results of the pooled analysis of cases. RF-TC: radiofrequency thermocoagulation; MRI: magnetic resonance imaging; M: male; SEEG: stereo-electroencephalography; Vol: volume; Y: year; Sz: seizure; N: number. %: percentage.

	MRI-positive	mean (ST dev)	median (IQR)	MRI-negative	mean (ST dev)	Median (IQR)	P value
N=	53			40			
Age (Y)			10 (9.2)			13 (6)	
Sex (M)	29			19			
Sz freedom 1y	28(46)			20(32)			1.000
Responder rate	42(53)			27(40)			0.2360
FUP time	36		13 (11.75)			20 (28.5)	
% Sz reduction	39	87.6 (24.3)		21	59.4 (49.1)		0.0041
Location							
frontal	22			11			0.1929
temporal	9			10			0.4379
parietal	12			4			0.1651
insular	7			22			0.0001
occipital	5			1			0.2315
other	13			3			0.0500

Table 4B
MRI positive and negative cases in the pooled analysis. MRI: magnetic resonance imaging; %: percentage; M: male; N: number; SEEG: stereo-electroencephalography; Sz: seizure; Vol: volume; Y: year.

	MRI-positive	mean (ST dev)	median (IQR)	MRI-negative	mean (ST dev)	Median (IQR)	p
N=	53			40			
Sz freedom 1y	28(46)			20(32)			1.000
Responder rate	42(53)			27(40)			0.2360
FUP time	36		13 (11.75)			20 (28.5)	
% Sz reduction	39	87.6 (24.3)			59.4 (49.1)		
Location							
frontal	22			11			0.1929
temporal	9			10			0.4379
parietal	12			4			0.1651
insular	7			22			0.0001
occipital	5			1			0.2315
other	13			3			0.0500

4. Discussion

This systematic review identified that there are limited pediatric studies evaluating RF-TC to date. Safety and efficacy in children seem to be similar to that reported in larger adult series, although more studies are needed. Quality of evidence is low as most data comes from case reports and small series and is focused on SEEG-guided ablations. The proportional meta-analysis we conducted suggests that pediatric RF-TC may have comparable (or superior) results to adult cases, although prior reports suggested otherwise [5,13]. Most cases reviewed in the pooled analysis were extracted from heterogeneous adult and pediatric series and, not surprisingly, MRI-positive lesions had improved outcomes compared to MRI-negative cases [40].

Despite growing relevance of LITT in the pediatric literature there seems to be an increased interest in RF-TC, as the number of publications has increased in the last few years (Supplementary Appendix 4). Its feasibility when combined with SEEG is likely the reason for the growth in interest [7,41]. Evidently, patients that have already been implanted for phase III preoperative investigations undergo RF-TC almost routinely in some centers [8–10,13,20]. Applicability of RF-TC has expanded over the years.

The largest pediatric series reported on SEEG-guided RFTC in 2 European centers [13]. This study included 46 patients, with a responder rate (> 50% seizure reduction) of 69.6% at 1 month and 73.5% at 1 year, although only 15 children of the entire cohort were still available for follow up. Seizure freedom rates in this study were 43.5% and 26.7%, respectively. This study included a 72% MRI-positive cohort, most of which were FCD cases. Multivariate analysis found that older children responded better to RF-TC. Interestingly, this study reported on subsequent surgical results: The positive predictive value of RFTC at 1 month for Engel 1 outcome following subsequent resective surgery was 0.83. at the end of the follow up period.

The second largest study included 22 patients and was a subgroup from a mixed cohort published earlier by the authors [5,10]. Seizure freedom attained in 14% of patients with SEEG-guided RF-TC directly. Fourteen (63.3%) patients had subsequent surgery following RF-TC. A third study, included 9 patients with TSC [42]. The authors used a high-density array of depth electrodes for SEEG and further RF-TC. Follow-up ranged from 6 months to 3 years, with Engel I outcomes at the end of the reported follow up for 7 out of 9.

One study reported on 6 patients who underwent robot-assisted RF-TC hemispherotomies, 5 of which became seizure free [42]. Another study reported on 20 cases of robot-assisted depth electrode implantation, reporting on 6 patients (plus 1 with a hypothalamic hamartoma) with SEEG-guided RF-TC, with seizure freedom in three of them [35]. None of these studies had a control group and the heterogeneous nature of these small case series does not allow to extract conclusions about the true effect of RF-TC in pediatric cohorts. Thus, the need to further investigate by pooling individualized cases.

4.1. Pooled analysis of pediatric cases

We extracted data for 93 cases from 24 studies with the addition of our 4 unpublished cases. The results in the pooled cases confirm similar findings in adult and pediatric series: RF-TC had comparable responder rates and seizure freedom results, while showing low morbidity rates [5,8,14,43,44]. A similar proportion of transient deficits was reported, which is remarkably higher, ranging from 14.1 – 16.7% with a lower rate of permanent deficits (0-2.3%). Likely, owing to the incidence of post-ablation edema which usually resolves within weeks of the procedure [14,31,43]. Interestingly, the pooled analysis had a lower proportion of MRI-positive cases. This could explain why responder rates and seizure freedom results were lower than those reported in the pediatric series.

Despite the lack of high quality evidence, results seem to support the safe utilization of RF-TC in the pediatric population, and results ought not to be different from those observed in adults. Indeed, some of the studies included suggests that responders to thermocoagulation may have a better surgical prognosis when continuing to open surgery [5,8,10,13]. This further validates the interest shown in RF-TC, particularly in the setting of SEEG.

RF-TC’s main advantage seems to lay on the feasibility of performing it bedside at the end of an SEEG investigation and its lower costs compared to the higher equipment costs of LITT [45,46]. Notwithstanding its advantages, overall success rates are lower than those reported with surgery and LITT [47]. The volume of tissue that can be ablated is smaller and, furthermore, cannot be controlled by temperature monitoring and/or intraprocedural imaging such as with LITT. With these limitations, candidacy seems to be reduced. Patients with small, higher-risk surgical targets are ideal candidates for this procedure [7]. This may also explain the increased localization of ablations in the insula and central cortex.

Quality of evidence for RF-TC in pediatric population was low. Since most of studies included in the present work belonged to small case series and case reports, with the exception of 2 studies which included a control group [21,23].

This study has limitations. The most evident one is the low number of studies focusing on RF-TC, the majority of which are small case series or case reports. Single group studies can only provide low quality of evidence in this setting. We chose to perform a pooled analysis of cases to further evaluate the role of RF-TC in this population. Since larger series tend not to publish individualized patient data, most of the data for pooled analysis was extracted from smaller series, often dedicated to specific conditions, areas, or techniques. This implies a publication and selection bias, therefore, positive outcomes are likely overestimated. Larger, well designed pediatric series are necessary to adequately assess the true effect RF-TC in children with DRE.

5. Conclusion

There are few pediatric studies evaluating RF-TC. Safety and efficacy in children seem to be similar to that reported in larger adult series, although more studies are needed. Quality of evidence is low as most data comes from case reports and small series. Most cases reviewed where extracted from heterogeneous adult and pediatric series. Patients with small, high-risk surgical targets are ideal candidates for this procedure. Larger, well designed pediatric series are necessary to adequately assess the true effect RF-TC in children with DRE.

Patient consent

Patients’ parents included in this series consented appropriately.

Data availability statement

Data can be shared for revision upon request.

Ethical statement

We confirm that we have read the Journaĺs position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

CRediT authorship contribution statement

Juan S. Bottan: Conceptualization, Data curation, Formal analysis, Writing – original draft. **Fuad Almalki:** Data curation. **Maryam Nabavi Nouri:** Writing – review & editing. **Jonathan C. Lau:** Conceptualization, Writing – review & editing. **Alla Iansavichene:** Investigation, Methodology. **Greydon Gilmore:** Visualization, Writing – review & editing. **Michael Miller:** Methodology. **Sandrine de Ribaupierre:** Conceptualization, Writing – review & editing, Supervision. **Andrea V. Andrade:** Conceptualization, Writing – review & editing, Supervision.

Declaration of competing interest

None of the authors have any conflict of interest to disclose.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.seizure.2025.01.012.

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