

Original Research Article

A clinical study to evaluate the association between clinical features, electroencephalographic changes, and neuroimaging in paediatric seizure disorders

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Received: 24 April 2025

Revised: 17 May 2025

Accepted: 22 May 2025

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ABSTRACT

Background: Seizure disorders in children are a significant cause of morbidity and present a diagnostic challenge due to varied clinical presentations and underlying aetiologies. Electroencephalography (EEG) and magnetic resonance imaging (MRI) are essential tools in evaluating these patients. This study aimed to analyse the association between clinical features, EEG findings, and MRI changes in paediatric patients presenting with seizures and to evaluate the diagnostic correlation among these modalities.

Methods: A prospective observational study was conducted on 60 paediatric patients presenting with seizures over an 18-month period at a tertiary care centre in Pune, Maharashtra. Detailed history, clinical examination, EEG, and MRI brain findings were collected and analysed for statistical significance.

Results: Generalized seizures were more common than focal seizures, with generalized tonic-clonic seizures (GTC) being the predominant type (73%). EEG abnormalities were found in 52% of cases, with generalized spike-wave discharges and focal spikes with generalization being most frequent. Temporal lobe involvement was the most common localization on EEG. MRI abnormalities were seen in 43% of cases, with periventricular white matter lesions being the most common (20%). Statistically significant associations were found between type of seizure and EEG abnormality ($p < 0.01$), and between EEG and precipitating factors ($p = 0.02$). However, no significant correlation was found between EEG and MRI localization ($p > 0.05$).

Conclusions: EEG and MRI are crucial complementary tools in the evaluation of paediatric seizures. While EEG abnormalities were more common in complex partial seizures, MRI was more likely to show abnormalities in cases with focal neurological signs. Routine use of both EEG and MRI is recommended in the initial evaluation of paediatric seizure disorders to improve diagnostic accuracy.

Keywords: Seizure disorder, Electroencephalogram, MRI brain, Paediatric epilepsy, Neuroimaging

INTRODUCTION

A seizure is a transient occurrence of signs and or symptoms resulting from abnormal excessive or synchronous neuronal activity in the brain.¹

Approximately 30% of patients who have a first afebrile seizure have 20% chance of developing the epilepsy at later life even if the neurologic examination, EEG and neuroimaging findings show no significant abnormality.¹

Epilepsy is a disorder of the brain characterized by an enduring predisposition to generate seizures and by the neuro-biologic, cognitive psychological and social consequences of this condition. The clinical diagnosis of epilepsy usually requires at least one unprovoked epileptic seizure with either a second such seizure or enough EEG and clinical information to convincingly demonstrate an enduring predisposition to develop recurrences.¹ Seizure disorder is a general term that is usually used include any one of the several disorders, including epilepsy, febrile seizures, and possibly, single seizures and symptomatic seizures secondary to metabolic, infectious or other etiologies (e. g., hypocalcemia, meningitis).¹

Children who had seizures or have been suffering from Epilepsy forms a big chunk of paediatric practice. Seizures being a complex symptom of underlying disease, a detailed workup is generally required for the evaluation of this cases. The introduction of EEG and neuroimaging has really helped to sort out the cause of epilepsy. The evaluation of cases of seizures includes a detailed history, clinical examination, EEG and advanced neuroimaging.² Seizures are an important cause of morbidity and mortality in childhood. Approximately 30% of patients who have a first afebrile seizure later develop epilepsy. It is therefore important to establish accurate diagnosis of seizures its aetiologies to appropriately manage such patients.³

In view of the above facts, we conducted a study in children presenting with seizure disorder to determine various clinical presentations and EEG changes and neuroimaging changes and to determine correlation between clinical data, EEG changes and MRI brain changes.

The purposes of this study were to describe the frequency of EEG and MRI abnormalities and explore relationships between MRI and EEG findings to determine their relevance in the assessment of children with new-onset seizures.

METHODS

This prospective observational study was carried out in the department of paediatrics at a tertiary care private hospital (Noble hospital) in Pune. A total of 60 children aged 1 month to 12 years who presented with seizures were enrolled over an 18-month period starting October 2013. Ethical clearance was obtained from the institutional ethics committee, and written informed consent was taken from all guardians.

Inclusion criteria

Children presenting with a first or recurrent seizure, age 1 month to 12 years and informed consent from parents/guardians were included in study.

Exclusion criteria

Neonatal seizures and known neurodevelopmental syndromes unrelated to epilepsy were excluded.

A structured proforma was used to collect data including demographics, clinical history, seizure type, risk factors, neurological examination, EEG findings, and MRI results. EEG was performed using the standard 21-electrode system in a quiet setting during the interictal phase. Each EEG was interpreted by a certified neurophysiologist. MRI scans were interpreted by a neuroradiologist blinded to the clinical and EEG data. MRI protocols included T1, T2, FLAIR, and DWI sequences to enhance the sensitivity of lesion detection.

Statistical analysis

All data were compiled and analysed using SPSS software version 20. Descriptive statistics such as mean, standard deviation, and percentages were used to summarize the demographic and clinical characteristics.

Associations between categorical variables were evaluated using chi-square test or Fisher's exact test where appropriate. A $p < 0.05$ was considered statistically significant for all comparisons.

RESULTS

Among the 60 children studied, 31 (52%) were male and 29 (48%) were female. The mean age of presentation was 4.6 years, with the majority of children falling in the 1 to 5 years age group (46.7%), followed by those under 1 year (35%) and 6 to 12 years (18.3%) (Table 1).

Precipitating factors

Fever was the most common precipitating factor, present in 29 children (48.3%). This was followed by unprovoked seizures in 22 children (36.7%), breakthrough seizures in 8 children (13.3%), and hypocalcaemia in one child (1.7%).

Seizure types

GTC were the most prevalent seizure type in the study (73.3%), followed by complex partial seizures (23.3%), while absence and myoclonic seizures were rare.

Symptomatology

The most common presenting symptoms included loss of consciousness (93.3%), tonic-clonic movements (96.7%), frothing from the mouth (78.3%), post-ictal unconsciousness (86.7%), and post-ictal ataxia (46.7%).

Less common symptoms included urinary incontinence, bowel incontinence, and aura.

EEG findings

The 48.3% patients had normal EEG; 51.7% patients had abnormal EEG. Out of abnormal EEG, 52% had generalized changes while 48% cases had focal EEG changes. In generalized changes, generalized spike waves were most common (15% of all cases) while in focal changes, focal spikes with generalization were most common (18% of total study population).

EEG localization

Among those with localized findings: temporal lobe: 9 (29%), parietal lobe: 4 (13%), frontal and occipital lobes: 1 case each (3%), diffuse changes/ no localization: 48%.

MRI findings

In our study, 57% cases had normal MRI scan while 43% cases had abnormal MRI scan. White matter lesions were most common findings (20%) of total study population, gliotic changes (10% cases) and cerebral atrophy in 7% cases.

MRI localization

The 15% cases had diffused localization and 85% cases showed focal lesions. Out of focal changes, 50% of cases with abnormal MRI scan had periventricular white matter lesions, 12% cases had frontal lobe localization.

Association between EEG and clinical parameters

Statistically significant association was found between seizure type and EEG abnormality ($p < 0.01$). CPS (complex partial seizure) was more likely to show abnormal EEGs (86%) compared to GTC seizures (39%).

Statistically significant association was found between clinical seizure type and specific EEG abnormalities, with focal spikes and generalized discharges more prevalent in complex partial seizures. Notably, absence and myoclonic seizures showed distinctive EEG patterns such as spike and wave complexes.

Precipitating factors and EEG abnormalities

A statistically significant association was found between seizure precipitating factors and EEG findings ($p = 0.02$), with breakthrough and unprovoked seizures showing a higher proportion of EEG abnormalities compared to fever-triggered seizures, which were more often associated with normal EEGs.

Association between EEG and MRI findings

Of the 31 patients with abnormal EEGs, 17 had abnormal MRIs. In contrast, 14 patients with abnormal EEGs had normal MRIs. No statistically significant association was found between EEG and MRI abnormalities ($p = 0.11$).

Table 1: Demographic parameters, (n=60).

Demographic parameters	N (%)
Age group (in years)	
<1	9
1 to 3	21
3 to 6	12
6 to 9	12
9 to 12	6
Gender distribution	
Females	29 (48.3)
Males	31 (51.7)
Precipitating factors	
Fever	29 (48.3)
Breakthrough	8 (13.3)
Hypocalcaemia	1 (1.7)
Unprovoked	22 (36.7)
Symptoms distribution	
History of aura	2 (3.3)
Loss of consciousness	56 (93.3)
Uprolling of eyes	18 (30)
Tonic clonic movements	58 (96.7)
Frothing from mouth	47 (78.3)
Urinary incontinence	12 (20.0)
Bowel incontinence	4 (6.7)
Post-ictal ataxia	28 (46.7)
Post- ictal unconsciousness	52 (86.7)
Risk factor for seizures	
Febrile seizures	29 (48.3)
Birth history	15 (25.0)
Developmental delay	13 (21.7)
Family history	1 (1.7)
No identifiable risk factors	22 (36.7)
Clinical seizure types	
Primary generalised seizures	
GTC	44 (73.3)
Absence	1 (1.7)
Myoclonic	1 (1.7)
Complex partial seizures	
Complex partial seizures with secondary generalization	14 (23.3)

Table 2: EEG findings.

EEG findings	N	%
Normal	29	48.3
Abnormal	31	51.7
Generalised	Spike wave	9 15.0
	Sharp wave	1 1.7
	Spike and waves complexes	3 5.0
	Poly spike and waves complexes	1 1.7
	Polymorphic slowing	2 3.3
	Focal slowing	4 6.7
Focal	Focal spike with generalisation	11 18.3
Total	60	100

Table 3: MRI study localization.

MRI study localization	N	Percentage (%)
B/L periventricular leucomalacia (White-matter lesions)	12	20
Gliotic changes	6	10
Cerebral atrophy (volume loss)	4	7
Meningeal involvement with diffuse cerebral oedema	2	3
Encephalomalacic changes	1	2
Medulloblastoma (space occupying lesion)	1	2
Ventricular dilatation	1	2
Encephalitis (cortical lesion)	2	3
No significant abnormality	34	57
Total	60	100

Table 4: Localisation of MRI.

Localisation of MRI	Right	Left	Bilateral	Total	
				N	%
Nonlocalised/diffused				4	15.4
Temporal	1	0	0	1	3.8
Parietal	0	1	0	1	3.8
Frontal	0	1	2	3	11.5
Occipital	0	0	1	1	3.8
Brain Stem				1	3.8
Meninges				2	7.7
Periventricular white matter				13	50

Table 5: Association between clinical type and EEG in study group.

Type of seizures	EEG		Total	P value
	Abnormal	Normal		
GTC	17 39%	27 61%	44	<0.01
Myoclonic	1 100.0%	0 0.0%	1	0.97
CPS	12 86%	2 14%	14	<0.01
Absence	1 100.0%	0 0.0%	1	0.97
Total	31 51.7%	29 48.3%	60 100%	0.01

Table 6: Association between clinical type and type of EEG changes.

EEG findings		Type of seizures				Total		P value
		A	CPS	GTC	M	N	%	
Normal		0	2	27	0	29	48.3	<0.01
Abnormal		1	12	17	1	31	51.7	
Generalised	Spike wave	0	1	8	0	9	15.0	0.71
	Sharp wave	0	0	1	0	1	1.7	0.96
	Spike and waves complexes	1	0	1	1	3	5.0	<0.01
	Poly spike and waves complexes	0	0	1	0	1	1.7	0.94
	Polymorphic slowing	0	0	2	0	2	3.3	0.86
Focal	Focal slowing	0	3	1	0	4	6.7	0.09
	Focal spike with generalisation	0	8	3	0	11	18.3	<0.01
Total		1	14	44	1	60	100	

Table 7: Association between precipitating factors and EEG.

Precipitating factor	EEG		Total
	Abnormal	Normal	
Fever	10 32.3%	19 65.5%	29 48.3%
Unprovoked	14 45.2%	8 27.6%	22 36.7%
Break through	7 22.6%	1 3.4%	8 13.3%
Hypocalcaemia	0 0.0%	1 3.4%	1 1.7%
Total	31 100.0%	29 100.0%	60 100.0%
P value=0.02			

DISCUSSION

In our study maximum number of patients presenting with generalized seizures were in 1 to 3 years and 3 to 6 yrs age group with mean age of 4.6 years (Table 1). Lowest prevalence was noted in 9-12 years age group. As found in many other studies like Ramya et al prevalence of seizures is observed to be high among age group 1-5 years and low among 9-12 years.⁴ Our findings were consistent with age specific prevalence of seizures in developing countries.

In our study, 52 % were male and 48% were female (Table 1) indicating prevalence of seizure more in males as compared to females which is similar to studies conducted by Mac et al and other by Udani et al.^{5,6}

Previous studies by Bartolemei et al, Da Silva Sousa et al and Nakken et al have reported seizure precipitants in 53 to 92% of patients.⁷⁻¹⁰ In our study, fever was the precipitating factor in 48 % children while 37% children presented as unprovoked seizure with no precipitating factor (Table 1).

Most common presentations of generalized seizures in our patients were loss of consciousness, tonic-clonic movements, frothing in mouth, post ictal unconsciousness and post ictal ataxia (Table 1). These are quite common findings in generalized tonic-clonic seizure as quoted in a textbook by Engel.¹¹

Febrile seizure (48%) was found to be the commonest risk factor in our study (Table 1) which is comparable to study carried out by Bharucha et al.¹²

EEG abnormalities (Inter ictal epileptiform discharges-IED) present in 52% of our patients (Table 2). This is comparable with different studies where IED seen in 20-55% of patients with epilepsy on a 1st "routine" EEG.¹³⁻¹⁷

In our study, 52% patients had abnormal EEG. Out of abnormal EEG, 52% had generalized changes while 48%

cases had focal EEG changes. In generalized changes, generalized spike waves were most common (15% of all cases) while in focal changes, focal spikes with generalization were most common (18% of total study population). These findings were Statistically significant ($p<0.01$) and comparable to other studies (Table 5 and 6).^{6,17}

Abnormalities were more common in left side as compared to right; temporal lobe was the commonest localization site. Nickels et al found that temporal lobe plays a vital role in epilepsy and is the most frequent lobe involved in focal onset seizures. It was determined that temporal lobe epilepsy was responsible for 8% of all paediatric epilepsy, and for 13% of all focal seizures in their cohort.¹⁸

In our study, 43% patients had neuroimaging abnormality. Periventricular white matter lesions were present in 50% of abnormal MRI findings. Non localized or diffuse neuroimaging changes were present in 15% of cases with abnormal MRI changes. Frontal lobe changes were seen in 11% cases, temporal, and parietal lobe changes in 4% cases each and meningeal involvement in 8% cases. Brainstem involvement was seen in 4 % cases. A study by Kalnin et al on neuroimaging in children with first recognized seizure showed white matter lesions as most common findings, while classical epileptogenic lesions involving cortex were less (Table 3 and 4).¹⁹

Unprovoked seizures and breakthrough seizures had statistically significant association ($p<0.05$) with occurrence of EEG abnormalities. Shinnar et al in their study concluded that Children with even a single unprovoked seizure have a high incidence of EEG abnormalities (Table 7).¹⁷

Patients with spike wave findings in EEG were mostly associated with GTC type seizures (89%), patients with EEG showing spike and wave complexes had statistically significant association with myoclonic seizures and Absence seizures ($p=0.01$), focal spikes with

generalisation waves were associated mostly with complex partial seizures (72%), these findings were statistically significant ($p < 0.01$) (Table 6).

In our study of 60 patients, 52% had abnormal EEG changes, 43% had neuroimaging abnormalities and 28% had abnormalities in both neuroimaging and EEG. When analysed bio statistically it showed no statistically significant association between EEG abnormality and MRI scan abnormality and also there is no statistically significant association between location of EEG changes and location of MRI changes. Our study has similar results with the study of Doescher et al.²⁰

Limitations

The study was limited to 60 children; a larger cohort would improve the generalizability of the findings. The study focused on initial presentation and did not include long-term follow-up to assess seizure recurrence, treatment response, or developmental outcomes. The study did not include advanced metabolic, genetic, or molecular testing, which could have helped identify underlying causes in cryptogenic or idiopathic cases. Conducted at a single tertiary care hospital, the findings may not be representative of the broader paediatric population, particularly those in rural or low-resource settings. Despite these limitations, the study highlights important trends in seizure evaluation and supports the integrated use of EEG and MRI in assessing paediatric seizure disorders.

CONCLUSION

The integration of clinical data, EEG findings, and MRI results provides a more comprehensive understanding of seizure ethology in children. While EEG is indispensable for classifying seizure types and identifying epileptogenic zones, MRI reveals structural lesions that can have long-term implications on treatment and prognosis.

An integrated diagnostic approach facilitates early diagnosis, better classification of epilepsy syndromes, and appropriate therapeutic strategies. Routine EEG and MRI should be considered standard in evaluating new-onset seizures, particularly those without identifiable triggers.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Thakur S, Mondal D, Pote P, Dey S, Mandal P. A clinical study to evaluate the association between clinical features, electroencephalographic changes, and neuroimaging in paediatric seizure disorders. *Int J Contemp Pediatr* 2025;12:1054-60.