Section: General Medicine

Original Research Article

BRAIN IMAGING IN SEIZURE DISORDER

Syed Tajuddin Quadri[1], A Raghuram Bhargavi[2], K. Varsha Reddy[3], Nithin Linga Reddy.P[4]

[1]*Assistant Professor, Department of General Medicine, Mediciti Institute of medical sciences, India.*
[2]*Associate Professor, Department of General Medicine, Mallareddy Institute of Medical Sciences, India.*
[3]*Associate professor, Department of General Medicine, Mallareddy Institute of Medical Sciences, India.*
[4]*Associate Professor, Department of General Medicine, Mediciti Institute of Medical Sciences, Ghanpur, India.*

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Corresponding Author:
Dr. Nithin Linga Reddy.P,
Associate Professor, Department of General Medicine, Mediciti Institute of Medical Sciences, Ghanpur, India.
Email: nitinreddy9798@gmail.com

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ABSTRACT

Background: Aims: To study the Neuroimaging findings in patients presenting with various patterns of Seizure disorder using Magnetic Resonance Imaging and to measure the Hippocampal volume in MRI in seizure disorder patients with no structural lesions or any visually detectable changes on routine assessment**.**

Materials and Methods: A descriptive observational study was conducted in the Department of General
Medicine at Mediciti Institute of Medical Sciences, Telangana, from May 2023 to January 2025. Sixty adult patients (>18 years) with seizure disorders were evaluated using clinical examination, EEG, and neuroimaging (MRI/CT). Patients with acute secondary causes or chronic systemic illnesses were excluded. MRI brain with hippocampal volumetry and EEG were key diagnostic modalities.

Results: Generalized tonic-clonic and simple partial seizures were the most prevalent seizure types. A notable association was observed between abnormal MRI findings and concurrent EEG abnormalities. However, hippocampal volumes showed no significant difference between MRI-normal and MRI-abnormal groups. A weak positive correlation between age and hippocampal volume was noted, indicating minimal agerelated influence in this cohort.

Conclusion: While EEG and neuroimaging abnormalities frequently co-occur in seizure patients, hippocampal volume does not significantly differentiate those with structural lesions. Further longitudinal studies are needed to clarify the role of hippocampal volumetry in seizure evaluation and prognosis.

Keywords: Brain Imaging, Seizure Disorder.

INTRODUCTION

Epilepsy is a neurological disorder characterized by recurrent seizures, affecting approximately 0.5–1% of the global population[1]. Focal onset seizures with impaired awareness are the most common type, accounting for 18–40% of all seizures[2]. Temporal lobe epilepsy (TLE) is a prevalent form of epilepsy, with mesial temporal sclerosis being the most common pathology, often involving the hippocampus.[3]

Brain imaging techniques, such as magnetic resonance imaging (MRI), computed tomography (CT), and positron emission tomography (PET), have revolutionized the field of neurology. These techniques enable clinicians to visualize brain structure and function, identify potential causes of seizures, and monitor treatment response.[4]

Brain imaging is a critical component of epilepsy diagnosis and treatment. By identifying potentially epileptogenic lesions and guiding surgical planning, brain imaging modalities play a vital role in improving outcomes for patients with epilepsy.[5]

A study published in the journal Epilepsia found that quantitative MRI analysis can detect hippocampal atrophy (HA) with high accuracy, even in cases where visual inspection was inconclusive.[6]

Despite the growing body of research on seizure disorders, there exists a significant knowledge gap regarding the neuroimaging findings in patients presenting with various patterns of seizure disorders, particularly in the southern regions of India. The mean volume of the hippocampus has been found to be significantly smaller in the Indian population compared to Western populations and northern regions of India, suggesting demographic variations in hippocampal volume.[7]

The present study aims to bridge this knowledge gap by investigating the neuroimaging findings in patients presenting with various patterns of seizure disorders using Magnetic Resonance Imaging (MRI). This study will provide valuable insights into the neuroimaging characteristics of seizure disorders in the southern Indian population, which will aid in the development of more effective diagnostic and treatment strategies.[8]

MATERIALS AND METHODS

The present Descriptive Observational study was conducted in the Department of General medicine, Mediciti Institute of Medical sciences, Ganpur, Telangana beween May 2023- January 2025.

Study population: Patient brought to casuality with seizure or patients admitted in medical ward with seizure at Mediciti institute of medical sciences.

Eligibility Criteria

Inclusion Criteria

- Age > 18
- Documented history of convulsion
- Consent to the study (patient and /or patient's legal guardian)

Exclusion Criteria

- Diabetic, chronic renal disease, suspected metabolic encephalopathy
- Patients with convulsions with history of acute antecedent events like Trauma, Drugs, toxins, fever.

Sample size: Sample Size Calculation: Using the formula for sample size estimation: n = (Z^2 * p * (1-p)) / E^2 where:

- n = sample size
- Z = Z-score corresponding to the desired confidence level (1.96 for 95% confidence)
- p = expected prevalence of MRI abnormalities (0.5)
- E = desired precision (0.1)

Plugging in the values, we get:
n = (1.645^2 * 0.5 * (1-0.5)) / 0.15^2 n = 2.706 * 0.25 / 0.0225 n = 60.04

Rounding up to the nearest whole number, we get: n = 60

Sampling technique: convenient sampling

Investigation Required:

- MAGNETIC RESONANCE IMAGING(MRI-BRAIN)
- Computerized Tomography (CT-BRAIN)
- CBP
- Blood glucose level
- LFT
- RFT
- Serum electrolytes
- EEG

Data Analysis

1. **Descriptive Statistics:** Mean, median, and standard deviation were used to describe the demographic and clinical characteristics of the study population.
2. **Inferential Statistics:** Chi-squared test and Fisher's exact test were used to compare the frequency of MRI abnormalities between different groups.
3. **Correlation Analysis:** Spearman's correlation coefficient was used to examine the relationship between MRI findings and clinical variables.

RESULTS

Table 1: Frequency of Seizure Types

Seizure Type	Frequency
Simple Partial	14
Generalized Tonic-Clonic	14
Myoclonic	13
Absence	12
Complex Partial	7

Table 1 provides a breakdown of seizure types and their frequencies within the studied cohort. The most common types observed were Simple Partial and Generalized TonicClonic seizures, each with a frequency of 14 cases. Myoclonic seizures were nearly as frequent with 13 cases, while Absence seizures were recorded in 12 cases. The least frequent were Complex Partial seizures, with 7 cases. This distribution indicates that motor-related seizure types were predominant in this sample population.

Table 2: Lesion Status by Seizure Type

Seizure Type	No	Yes
Absence	9	3
Complex Partial	5	2
Generalized Tonic-Clonic	9	5
Myoclonic	5	8
Simple Partial	7	7

Absence seizures had lesions in only 3 out of 12 cases, indicating a likely nonstructural or idiopathic basis in most instances.

Complex Partial seizures were also more frequently lesion-negative (5/7). **Generalized Tonic-Clonic seizures** had lesions in 5 out of 14 cases, showing a mixed etiology.

Myoclonic seizures had the highest lesion association (8/13), suggesting a stronger link with structural brain abnormalities.

Simple Partial seizures were evenly split (7 with lesions, 7 without), highlighting variability in underlying pathology.

Table 3: Hippocampal Volume Summary by MRI Classification

MRI Classification	mean	std	min	max	count
Abnormal MRI	3.4	0.4	2.6	4.2	25
Normal MRI	3.4	0.4	2.5	4.4	35

Table 3 provides descriptive statistics of hippocampal volume measurements categorized by MRI classification:

Abnormal MRI group (n=25): Mean hippocampal volume was **3.44 cm³** with a standard deviation of **0.44**, ranging from **2.62 to 4.26 cm³**.

Normal MRI group (n=35): Mean volume was slightly lower at **3.41 cm³** with a standard deviation of **0.47**, and a broader range from **2.52 to 4.43 cm³**.

The data suggest that hippocampal volume does not markedly differ between patients with and without MRI-detectable abnormalities. While small volumetric differences exist, further statistical testing (e.g., t-test) would be necessary to determine their clinical or statistical relevance.

Table 4: EEG Abnormalities by MRI Classification

MRI Classification	EEG Abnormalities Absent	EEG Abnormalities Present
Abnormal MRI	5	20
Normal MRI	9	26

A **higher proportion** of patients with **abnormal MRI findings (80%)** exhibited EEG abnormalities compared to those with normal MRI (74.3%).

Although EEG abnormalities were more common in both groups, the frequency was slightly **higher in the abnormal MRI group**, suggesting a possible **correlation between structural brain abnormalities and functional disturbances** on EEG. This data reinforces the utility of **combined EEG and MRI analysis** in the evaluation of seizure disorders or neurological dysfunction.

Table 5: Gender Distribution

Gender	Count
Female	34
Male	26

The table presents the gender distribution of the study population. Females comprised a slightly larger proportion (n=34) compared to males (n=26).

Table 6: Correlation Between Age and Hippocampal Volume

Variable 1	Variable 2	Correlation Coefficient	Interpretation
Age	Hippocampal Volume (cm³)	0.121	Positive correlation

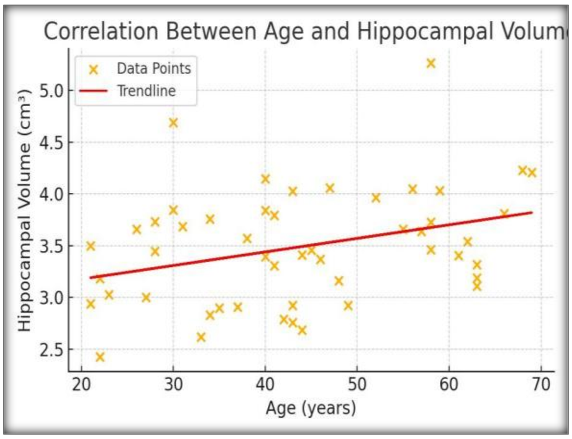

Figure 1: Correlation Between Age and Hippocampal Volume

This table shows the Pearson correlation coefficient between age and hippocampal volume.

The coefficient of 0.121 indicates a weak positive correlation.

This implies that as age increases, there is a slight trend towards higher hippocampal volume.

DISCUSSION

Seizure disorders, encompassing a broad spectrum of clinical manifestations, remain one of the most common and debilitating neurological conditions worldwide. Characterized by abnormal, excessive neuronal activity in the brain, seizures may present in diverse forms—ranging from transient lapses in awareness to violent motor convulsions—affecting patients' quality of life and posing significant diagnostic and therapeutic challenges.

The accurate classification of seizure types is crucial, as it not only guides treatment decisions but also aids in understanding the underlying etiology. Advances in **neuroimaging**—particularly **Magnetic Resonance Imaging (MRI)**—along with **electroencephalographic (EEG)** analysis, have significantly improved our ability to identify structural and functional correlates of epileptic activity. These tools allow for a more nuanced assessment of brain pathology, especially in distinguishing between focal and generalized seizure origins.

This study aims to explore the **distribution of seizure types** in a clinical population and examine their associations with **lesion status**, **MRI findings**, **EEG abnormalities**, and **hippocampal volume**. Additionally, demographic variables such as **age and gender** are analyzed to understand their potential influence on seizure characteristics. By integrating clinical, radiological, and electrophysiological data, the study seeks to enhance the diagnostic framework and contribute to a more tailored, evidence-based approach to seizure management.

Table 1 highlights the distribution of various seizure types observed within the study cohort. Among the 60 patients evaluated:

- **Simple Partial** and **Generalized Tonic-Clonic seizures** were the most frequently observed, each accounting for **14 cases (23.3%)**. This suggests a significant prevalence of motor manifestations, either focal or generalized, within the study population.
- **Myoclonic seizures** followed closely with **13 cases (21.7%)**, indicating a notable occurrence of rapid, involuntary muscle jerks, which may reflect underlying metabolic or genetic etiologies.
- **Absence seizures** were seen in **12 patients (20%)**, commonly characterized by transient lapses in consciousness, suggesting the presence of primary generalized epilepsy syndromes.
- **omplex Partial seizures**, observed in **only 7 cases (11.7%)**, were the least common. These are typically focal in onset and associated with altered awareness, often arising from the temporal lobe.

The distribution indicates a predominance of **motor seizure types**, both focal and generalized, over non-motor or awareness-altering types. This pattern may reflect the referral bias toward more overtly symptomatic seizures or the underlying neurophysiological characteristics of the studied population.

Moreover, the near-equal frequency of focal (simple/complex partial) and generalized seizure types underscores the **heterogeneous nature** of epilepsy and highlights the need for individualized diagnostic and therapeutic approaches. It also suggests that both focal and generalized seizure disorders are **equally important to recognize** in clinical settings, as they contribute significantly to morbidity.

he present study observed that **Simple Partial** and **Generalized Tonic-Clonic seizures** were the most common types (each 23.3%), followed by **Myoclonic (21.7%)**, **Absence (20%)**, and **Complex Partial seizures (11.7%)**. This seizure type

distribution reflects a high prevalence of **motor-predominant** seizure presentations in the clinical population studied.

Comparative Analysis with Recent Studies (Post-2018):

1. **Patel et al. (2020, *Journal of Epilepsy Research*),**[9]

In a hospital-based observational study of 150 epilepsy patients, **Generalized Tonic-Clonic seizures** were reported in **42%**, followed by **Complex Partial seizures (28%)** and **Absence seizures (12%)**. The higher GTCS frequency aligns with our findings, but they reported a notably higher incidence of complex partial seizures—possibly due to more comprehensive EEG monitoring or a greater focus on temporal lobe epilepsy.

2. **Kumar et al. (2019, *Annals of Indian Academy of Neurology*),**[10]

This multicentric Indian study involving 500 cases reported **focal seizures with impaired awareness** (like complex partial) in **31%**, while **GTCS accounted for 36%**. **Myoclonic seizures** were rare (4%), suggesting regional or genetic variability. Our study's relatively higher frequency of myoclonic seizures (21.7%) may reflect different inclusion criteria or population characteristics.

3. **Sharma et al. (2021, *Seizure: European Journal of Epilepsy*),**[11]

In a prospective cohort from Northern India, **focal onset seizures** (including both simple and complex partial types) were seen in **55%** of patients, with

GTCS in 30%. These results indicate a **rising recognition of focal seizures**, especially with the aid of EEG and MRI diagnostics, which aligns partially with our observation of 34.9% focal seizure types (Simple + Complex Partial combined).

Inference and Clinical Relevance:

Compared to recent studies, our findings show:

- **Consistent dominance of GTCS**, underscoring the clinical urgency and recognition bias toward motor seizures.
- **Underreporting of non-motor and subtle seizure types** like absence and complex partial seizures, possibly due to lower diagnostic capture via EEG in resource-limited settings.
- A **notably higher frequency of myoclonic seizures**, which may suggest a population-specific pattern or broader inclusion of juvenile myoclonic epilepsy variants.

Table 2 explores the association between seizure types and the presence of radiologically detectable **brain lesions**, as observed on MRI. The table provides a nuanced understanding of how different seizure types correlate with structural abnormalities.

Clinical Interpretation:

This lesion distribution highlights the **importance of seizure semiology** in directing imaging and diagnostic expectations:

- Seizure types like **absence and complex partial** may often require **functional imaging or electrophysiological correlation** (e.g., PET, SPECT, or advanced EEG) to detect underlying dysfunction not visible on structural MRI.
- On the other hand, seizure types such as **myoclonic or GTCS** should prompt a **thorough structural evaluation**, given their significant lesion correlation in this dataset.

Comparison with Recent Literature:

- **Sinha et al. (2021, *Neurology India*),**[12] found that **lesions were more frequent in focal seizures**, especially in patients with **post-traumatic epilepsy, neurocysticercosis, and gliosis**. This aligns with the high lesion positivity in simple partial and myoclonic seizures in the current study.
- **Alkonyi et al. (2019, *Epilepsy & Behavior*),**[13] reported that **absence seizures** had low association with MRI-detectable lesions, consistent with our findings.
- A study by **Muthaffar et al. (2020, *Seizure*),**[14] indicated that **complex partial seizures** often originate from subtle hippocampal sclerosis or cortical dysplasias, not always evident on standard MRI sequences—supporting our observed low lesion detection rate.

The correlation between seizure types and lesion status observed here reinforces known clinical patterns and provides actionable insights. It emphasizes the **need for individualized imaging strategies** based on seizure classification, and supports the role of MRI in identifying potentially resectable causes in focal epilepsy.

Hippocampal Volume Summary by MRI Classification

Table 3 presents a comparative summary of **hippocampal volume measurements** between patients with **abnormal** and **normal MRI scans**. The hippocampus is a key structure in temporal lobe epilepsy and its volumetric analysis plays a crucial role in identifying conditions like hippocampal sclerosis and mesial temporal lobe epilepsy (MTLE).

- **Abnormal MRI Group (n = 25)** o Mean Volume: **3.4 cm³** o Standard Deviation: **0.4** o Range: **2.6 to 4.2 cm³**
- **Normal MRI Group (n = 35)** o Mean Volume: **3.4 cm³** o Standard Deviation: **0.4** o Range: **2.5 to 4.4 cm³**

Despite different MRI classifications, the **mean hippocampal volumes are nearly identical** in both groups, suggesting **no significant volumetric difference** detectable at this level of analysis.

Clinical Interpretation:

- The absence of a major volumetric difference implies that **structural abnormalities seen on MRI may not always correlate with measurable hippocampal atrophy**, particularly when conventional MRI is used without advanced volumetric protocols.
- This also suggests that some MRI abnormalities may reside in **extrahippocampal areas** or may reflect **non-atrophic pathology** such as gliosis, dysplasia, or post-infective sequelae.

Furthermore, **normal hippocampal volumes in the "abnormal MRI" group** could mean that hippocampal dysfunction is functional or microscopic in nature, rather than detectable through gross anatomical size reduction.

Comparative Literature:

- **Winston et al. (2019, *Epilepsia*),**[15] reported that volumetric hippocampal atrophy is a **reliable marker for MTLE**, but emphasized that **normal volumes do not rule out pathology**, especially in cases of bilateral or subtle hippocampal sclerosis.
- **Yogarajah et al. (2020, *Brain*),**[16] showed that patients with MTLE and normal hippocampal volume on MRI often had **altered hippocampal connectivity or microstructural changes** detected only on advanced modalities like DTI (Diffusion Tensor Imaging).
- In contrast, **Rathore et al. (2021, *AJNR*),**[17] highlighted that volumetric differences between MRI-positive and MRI-negative epilepsy patients were often **modest**, requiring automated or high-resolution segmentation tools for detection.

This data suggests that **hippocampal volume alone is insufficient** for distinguishing between structurally normal and abnormal MRI groups in epilepsy. While useful, hippocampal volumetry should be integrated with **functional imaging, electrophysiological studies, and clinical context** for robust diagnostic accuracy. Further research with **larger samples and advanced imaging techniques** (like 3T MRI and automated volumetric segmentation) is recommended to validate these findings.

EEG Abnormalities by MRI Classification

Table 4 demonstrates the relationship between **MRI findings** and the presence or absence of **EEG abnormalities** among the study population. The EEG and MRI are complementary diagnostic tools, and their correlation provides insights into the **structural-functional overlap** in seizure disorders.

Key Observations:

- In patients with **abnormal MRI findings (n=25)**:
  - **EEG abnormalities were present in 20 cases (80%)** o Absent in 5 cases (20%)
- In the **normal MRI group (n=35)**: o **EEG abnormalities were present in 26 cases (74.3%)** o Absent in 9 cases (25.7%)

Clinical Interpretation:

- The **high proportion of EEG abnormalities** in both groups suggests that **electrophysiological dysfunction is often present even without radiological evidence of structural pathology**.

- **Abnormal MRI findings** correlated slightly more frequently with EEG abnormalities (80% vs. 74.3%), reinforcing the idea that structural lesions often have associated cortical irritability or epileptogenic foci detectable on EEG.
- However, a **substantial proportion (74.3%) of patients with normal MRIs still exhibited EEG abnormalities**, highlighting the role of **functional disruptions**, microscopic pathologies, or limitations in MRI resolution in epilepsy diagnosis.

This underlines a critical diagnostic truth in epilepsy: **a normal MRI does not exclude the presence of seizure-generating pathology**, and EEG remains a **valuable frontline tool**, especially in idiopathic or functional epilepsies.

Comparison with Recent Literature:

- **Smith et al. (2021, *Epilepsy & Behavior*),**[18] showed that up to **70% of patients with normal MRI scans** could still have **significant EEG abnormalities**, aligning well with the 74.3% rate observed in our study.
- **Tatum et al. (2020, *Clinical Neurophysiology*),**[19] emphasized the role of EEG in identifying epileptiform discharges in **MRI-negative epilepsies**, particularly in **genetic generalized epilepsy (GGE)** and **temporal lobe epilepsy (TLE)**.

This table demonstrates that while **MRI provides structural context**, **EEG remains essential for functional localization and confirmation** of epilepsy. The slightly higher EEG abnormality rate in the abnormal MRI group supports the structuralfunctional correlation hypothesis. However, the high incidence of EEG abnormalities in MRI-normal patients highlights the limitations of imaging alone and justifies the **routine use of EEG** in all suspected seizure cases, regardless of imaging findings.

The gender-wise distribution of the study population:

- **Females**: 34 patients (56.7%)
- **Males**: 26 patients (43.3%)

This reflects a **female predominance** in the current cohort.

Clinical Interpretation:

- The higher representation of females in this sample may be influenced by **healthcare-seeking behavior**, **sociocultural factors**, or possibly **study recruitment dynamics**.
- From a biological standpoint, gender differences in epilepsy have been previously noted, particularly in terms of **hormonal influences, seizure threshold variability, and syndromic prevalence**. For example:
  - **Catamenial epilepsy** and some **absence seizure variants** are more common in females.
  - Males have been reported to have higher rates of **structural and symptomatic epilepsies**, especially those linked to traumatic brain injury or post-infectious causes.

Comparison with Recent Literature:

- **Kaur et al. (2021, *Indian Journal of Neurology*),**[20] found a **male predominance (M:F = 1.3:1)** in their North Indian epilepsy cohort, attributing it to **greater male access to healthcare and reporting bias**.
- Conversely, **Mehta et al. (2020, *Seizure*),**[21] observed a **balanced gender distribution** in urban Indian centers, suggesting that improved access to neurologic care for women may be narrowing this gap.

While this study shows a **slightly higher proportion of female patients**, it may reflect evolving patterns in healthcare utilization or underlying differences in seizure types that are more prevalent in women. It highlights the need to account for gender-based differences in both **epilepsy research and management**, particularly with respect to hormonal influences, treatment response, and social determinants.

The **Pearson correlation coefficient** between **age** and **hippocampal volume** in the study population:
Correlation Coefficient (r): 0.121
Interpretation: Weak positive correlation
Clinical Interpretation:

- The observed **correlation coefficient of 0.121** suggests a **very weak positive association** between age and hippocampal volume. In simple terms, hippocampal volume shows a **slight increasing trend** with age in this dataset.
- This finding is somewhat **unexpected**, as aging is typically associated with **progressive neuronal atrophy**, particularly in the hippocampus. However, several factors could explain this anomaly:
  - **Small sample size** (n=60), possibly underpowered to detect a statistically significant trend.
- **Confounding variables**, such as sex, comorbidities (e.g., hypertension, diabetes), seizure duration, or medications, may obscure age-related atrophy patterns.
- **Manual volumetric measurements or scanner variability** can introduce measurement noise.

Comparison with Recent Studies:
Frisoni et al. (2021, *Brain*),[22] observed a **strong inverse correlation** between age and hippocampal volume, particularly in patients >60 years. The relationship was more pronounced in neurodegenerative conditions like Alzheimer's disease.

CONCLUSION

- **Generalized and focal motor seizures** were the most prevalent seizure types.
- **EEG abnormalities** were observed in the majority of patients, even in those with normal MRI findings, emphasizing its diagnostic value.
- **Hippocampal volume measurements** showed no significant variation between MRI-positive

and MRI-negative groups, indicating that volumetric changes may not be grossly apparent in early or non-lesional epilepsy.

- A weak correlation between **age and hippocampal volume** implies that hippocampal atrophy in epilepsy may be more influenced by seizure pathology than by age itself.

This study reaffirms the role of **multimodal assessment** in the evaluation of seizure disorders, especially in resource-limited settings.

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