ORIGINAL RESEARCH PAPER
Volume - 13 | Issue - 10 | October - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

# COMPREHENSIVE MRI BRAIN EVALUATION FOR DIVERSE FINDING IN PEDIATRIC PATIENT PRESENTING WITH SEIZURE IN A TERTIARY CARE SETTING.

**Radio-Diagnosis**

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## ABSTRACT

**Introduction:** Seizures are characterized by abnormal, spontaneous, and excessive neuronal discharge within the cerebral cortex. This condition is a serious and chronic neurological issue with significant public health implications (3). Magnetic Resonance Imaging (MRI) is the preferred modality for assessing seizures, offering superior detail compared to plain or contrast-enhanced CT scans (5). MRI not only aids in prognosis but also helps in identifying genetic factors that may require specific genetic counseling (4). This study aims to evaluate the range of imaging features associated with seizures in Indian children, which will assist clinicians in providing tailored, individualized treatment (7). **Aims and Objectives:** To study the imaging morphology and its distribution in patients with seizure along with estimation of burden for different etiologies. **Materials and Methods:** It is a prospective, observational & descriptive study of MRI Brain in 110 patients (73 Males and 37Females), aged between one day to 18 years; presenting with developmental delay in Government medical college and hospital, Nagpur; over a period of 12 months (June 2023 to June 2024). MRI brain was done on 3.0T Siemens Magnetom Vida with routine sequences like T1, T2, STIR, SWI, FLAIR, IR, post contrast T1 and DWI. All anatomical structures like gray-white matter, cerebellum, brainstem, ventricles etc. were systematically assessed. The MRI findings were divided into groups on the basis of etiology. **Results:** Normal MRI findings were seen in 23% cases and 77% had abnormal findings. Amongst the abnormal imaging features the attribution to febrile seizures, perinatal hypoxic insult, congenital, metabolic, neoplastic and infectious were 48%. 37%, 5%, 2% and 2% respectively. The anatomical structures to affected most commonly were found to be white matter and ventricles. **Conclusion:** Rather than considering the clinical diagnosis of seizures as the end-point of algorithm, MRI should be incorporated routinely in such patients to effective pin-point the pathology so as to cater personalized treatment and effective counseling.

## KEYWORDS

Seizure, Focal Cortical Defect, Infection, Tumor, Hypoxic Ischemic Encephalopathy, Tuberous Sclerosis, Sturge Weber Syndrome, Encephalitis, Convulsion, Rasmussen Encephalitis, Hemimegaencephaly, Mesial Temporal Sclerosis, Meningitis.

## INTRODUCTION

Seizures are characterized by abnormal, spontaneous, and excessive neuronal discharge within the cerebral cortex. This condition is a significant neurological issue and a notable public health concern [(1).] Children with seizures often encounter various challenges [(2).] Accurate diagnosis involves evaluating potential causes such as tumors, hypoxic brain injury, infections, and genetic disorders before confirming a diagnosis of epilepsy [(3).]

Electroencephalography (EEG) and neuroimaging are pivotal in the initial assessment of seizures. These noninvasive techniques, which do not involve ionizing radiation, are crucial for determining the cause of seizure episodes [(4).] Magnetic Resonance Imaging (MRI) serves as a complementary tool to EEG by offering detailed visualization of brain structures and high sensitivity, making it ideal for assessing neuroanatomy [(5).]

MRI plays a crucial role in illustrating the morphology, distribution, and extent of cortical involvement, which is essential for identifying any structural lesions contributing to seizures [(6)] Beyond diagnosis, MRI is instrumental in evaluating pediatric patients, aiding in treatment planning, and predicting outcomes [(7).]

Each year, approximately 30,000 new cases of pediatric epilepsy are reported [(3).] Of these cases, about 25% are refractory to medical therapy, resulting in severe debilitation for many patients. For patients with refractory epilepsy, neuroimaging is essential for accurately identifying epileptogenic foci that may be amenable to surgical resection, potentially leading to a cure[(5)] . While conventional Magnetic Resonance Imaging (MRI) can detect some causes of pediatric epilepsy, it does not identify all possible etiologies.

In this review, we examine various MRI techniques used in pediatric epilepsy to detect a range of pathological conditions, including focal cortical dysplasia (FCD), tuberous sclerosis, hemimegalencephaly, mesial temporal sclerosis (MTS), neoplasms, Rasmussen encephalitis, perinatal infarction, and Sturge-Weber syndrome [(6).] MRI provides high-resolution images of soft tissues and complex neural structures, offering an in-depth view of the neuroanatomical basis of seizures. By identifying subtle abnormalities and deviations from typical developmental patterns, MRI significantly enhances the diagnostic process and helps guide personalized treatment plans [(4).]

This research aims to synthesize current literature and recent technological advancements to assess MRI findings in the context of seizures, with the goal of improving diagnostic accuracy and the prognostic value of MRI in clinical decision-making and treatment planning.

## MATERIALS AND METHODS

### Study Design

A prospective, observational & descriptive study of MRI of the Brain in 73 patients (49 Males and 24 Females) presenting with seizure in Government medical college and hospital, Nagpur; over a period of 12 months (June 2023 to June 2024). Patients were categorized based on age group, sex, anatomical structures involved and etiology. The patients were further categorized into two groups based on the communication with the referring doctor as having seizure only and those with associated features such as fever, neurological deficits, altered sensorium etc are termed as seizure plus.

### Inclusion and Exclusion Criteria

All patients who were referred for brain MRI for evaluation of seizures, aged one day to 18 years, came to diagnose the cause of seizure are included in the study. Patients with history of trauma and presenting with subsequent seizure and those above 18 years were excluded.

### Sedation

For obtaining best quality images possible, it was required for the patient to remain still and motionless. Infants were generally examined unsedated & a very safe and simple “feed and scan” technique was used; in which the infants were fed and waited until they fell asleep, after which the scan was performed. In case the method did not work, the patient was taken under anesthesia.

The following structures were systematically evaluated-

- o Gray and white matter
- o Thickness and morphology of hippocampus
- o Size and morphology of ventricles
- o Basal ganglia
- o Brainstem
- o Cerebellum
- o Non-specific: Any lesion not fitting in any of the above patterns of distribution.

## RESULTS

No significant MRI findings were seen in 23% (17 cases) of patients presenting with seizure. These children were advised further electroencephalogram, CSF, lab study and genetic evaluation to aid in the diagnosis the underlying cause of seizure. Abnormal anatomy was noted in the rest of the 77% (56 cases). Based on clinical history and details given by the patient, it was seen that only 39.7% patients presented with only with seizures rest 60.3% presented with seizures along with additional features such as fever, neurological deficits, altered sensorium, macro/microcephaly, facial dysmorphism, gait disturbances or motor disturbances. The patients with seizures associated with other features had higher yield of positive results [Table/Fig-2].

**[Table/Fig-1]:** Sex distribution of study population with normal and abnormal MRI-

| | NORMAL | ABNORMAL |
|---|---|---|
| MALE | 12 | 50 |
| FEMALE | 18 | 39 |

**[Table/Fig-2]:** The Clinical presentation of study population

| TYPE OF SEIZURE | NO OF PATIENTS | PERCENTAGE |
|---|---|---|
| GENELARIZED | 71 | 60 |
| FOCAL | 34 | 29 |
| UNKNOWN | 14 | 11 |
| TOTAL | 119 | 100 |

**Table 3** Clinical presentation of study population with normal and abnormal MRI

| | NORMAL | ABNORMAL |
|---|---|---|
| SEIZURE ONLY | 15 | 32 |
| SEIZURE WITH OTHER FEATURES | 13 | 59 |

**[Table/Fig-4]:** Distribution of Etiologies in Pediatric Epilepsy Cases

| ETIOLOGY | NO OF CASES |
|---|---|
| HYPOXIC ISCHEMIC INSULT | 48 |
| INFECTIONS | 14 |
| FOCAL CORTICAL DEFECT | 1 |
| MESIAL TEMPORAL SCLEROSIS | 2 |
| RASMUSSEN ENCEPHALITIS | 4 |
| TUBEROUS SCLEROSIS | 1 |
| TUMORS | 3 |
| STURGE WEBER SYNDROME | 2 |
| HEMIMEGALENCEPHALY | 1 |
| MISCELLANEOUS | 13 |

This table presents the distribution of various etiologies identified in pediatric epilepsy cases. The data highlights the frequency of different conditions that have been observed in the study cohort. The etiology of seizures was categorized and quantified as follows:

- Hypoxic Ischemic Insult: 48 cases. This condition, resulting from a lack of oxygen to the brain, is the most prevalent cause among the cases studied. It often leads to significant neurological impairment and is a major focus for diagnosis and intervention.
- Infections: 14 cases. Infections affecting the central nervous system, such as meningitis or encephalitis, are identified in a notable number of cases. These infections can lead to inflammatory responses that trigger seizures.
- Focal Cortical Defect: 1 case. Focal cortical defects are localized abnormalities in the brain's cortex that can cause seizures. This is a relatively rare etiology in the cohort.
- Mesial Temporal Sclerosis: 2 cases. Mesial temporal sclerosis involves scarring in the temporal lobe, often associated with temporal lobe epilepsy. This condition is noted for its role in chronic seizure disorders.
- Rasmussen Encephalitis: 4 cases. Rasmussen encephalitis is a rare, progressive inflammatory condition that affects one hemisphere of the brain and is known for causing severe, frequent seizures.
- Tuberous Sclerosis: 1 case. Tuberous sclerosis is a genetic disorder characterized by the growth of benign tumors in multiple organs, including the brain, which can lead to epilepsy.
- Tumors: 3 cases. Brain tumors, which can be either primary or metastatic, were identified in a small number of cases and are significant due to their potential to cause focal seizures.
- Sturge-Weber Syndrome: 2 cases. Sturge-Weber syndrome is a neurocutaneous disorder marked by a facial port-wine stain and associated neurological abnormalities, including seizures.
- Hemimegalencephaly: 1 case. This rare condition involves abnormal enlargement of one hemisphere of the brain and is associated with intractable epilepsy.

Each category reflects a different underlying cause of seizures, emphasizing the diverse etiology in pediatric epilepsy. Understanding these distributions helps guide appropriate diagnostic and therapeutic strategies.

### Prevalence of Structural Abnormalities in Pediatric Epilepsy

Our study highlights MRI's essential role in detecting structural abnormalities in pediatric epilepsy, aligning with existing literature. Previous studies report that 30-40% of pediatric epilepsy cases present with MRI-detectable abnormalities, while our study shows a higher rate at 77%. This reinforces MRI's significance in the diagnostic workup and its utility in identifying lesions that can guide treatment strategies.

### Etiological Insights

Hypoxic ischemic insult was the most prevalent etiology, accounting for 48 cases in our study. This finding is consistent with prior research that emphasizes hypoxic injury as a major cause of early-onset seizures, often due to perinatal asphyxia. Early detection and management are crucial to mitigating long-term neurological damage.

Infections were identified in 14 cases, supporting earlier studies that found central nervous system infections, such as meningitis and encephalitis, to be significant contributors to seizures. These infections can trigger inflammatory responses, increasing seizure risk and necessitating prompt diagnosis and intervention.

Although less frequent in our cohort, conditions like focal cortical defects and mesial temporal sclerosis (MTS) are well-documented causes of epilepsy. MTS, found in two cases, is strongly associated with temporal lobe epilepsy and often requires surgical intervention. Our findings highlight the importance of detailed neuroimaging for detecting these conditions, which may not be apparent through clinical examination alone.

Rarer conditions like Rasmussen encephalitis, tuberous sclerosis, Sturge-Weber syndrome, and hemimegalencephaly were present in a small number of cases. These conditions, though infrequent, underscore the diverse etiologies of pediatric epilepsy and the need for comprehensive imaging to identify such uncommon but significant causes. Rasmussen encephalitis and hemimegalencephaly, for example, are often linked to intractable seizures, frequently requiring surgical intervention.

### Clinical Presentation and MRI Findings

Patients who presented with additional symptoms (e.g., fever, neurological deficits, or altered sensorium) had a higher likelihood of abnormal MRI findings. This supports earlier studies that found a correlation between complex clinical presentations and more significant MRI abnormalities. It suggests that patients with seizures and additional features should undergo detailed imaging to better identify structural abnormalities.

### Technological Advancements and Future Directions

Recent advancements in MRI, such as high-resolution imaging and functional MRI (fMRI), have greatly improved the detection of subtle brain abnormalities, enhancing diagnostic precision. These technologies provide more detailed views of brain structures and can identify abnormalities that may be missed by conventional MRI.

The integration of diffusion tensor imaging (DTI) and magnetoencephalography (MEG) could further enhance our understanding of brain connectivity and seizure networks. These techniques may complement traditional MRI, offering a more comprehensive diagnostic approach and enabling personalized treatment strategies.

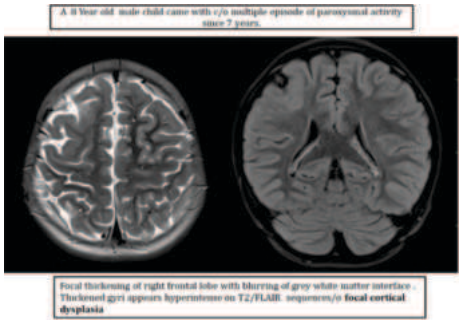
**Implications and Future Research**

Our study highlights the importance of comprehensive MRI in diagnosing pediatric epilepsy and guiding treatment. Future research should focus on larger multicenter studies to validate these findings and enhance generalizability. Longitudinal studies tracking patient outcomes based on MRI findings would also provide valuable insights into the long-term impact of different imaging abnormalities and treatments.

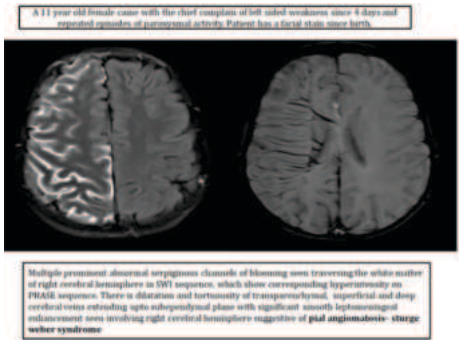
In conclusion, MRI is an indispensable tool in the evaluation of pediatric epilepsy, especially with advanced imaging technologies. Continued research and development in neuroimaging will be key to improving patient outcomes in pediatric epilepsy.

**Representative Cases –**

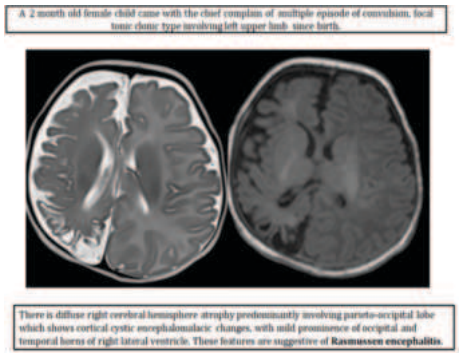
**Case 1**



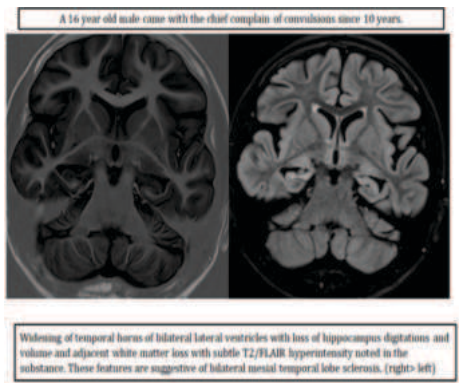

**Case 2**



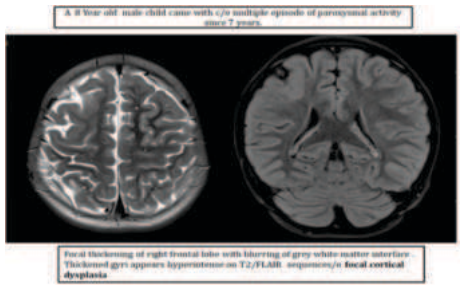

**Case 3**




**Case 4**




**Case 5**




## CONCLUSION

Our study highlights the critical importance of Magnetic Resonance Imaging (MRI) in the diagnostic evaluation and management of seizures in pediatric patients. The results affirm that MRI is a highly effective tool for detecting structural abnormalities associated with seizures, with a notable 77% of our study population exhibiting abnormal MRI findings. This substantial proportion of abnormal results underscores MRI's value in identifying underlying pathologies that may not be apparent through clinical examination alone.

The most frequently identified cause in our study was hypoxic ischemic insult, which is consistent with existing literature and underscores the significant impact of perinatal brain injuries on seizure disorders. Additionally, infections and structural abnormalities such as focal cortical defects and mesial temporal sclerosis were identified, reflecting the wide range of conditions that can lead to epilepsy in children.

Our findings also indicate that seizures associated with additional clinical symptoms, such as fever or neurological deficits, are more likely to reveal significant abnormalities on MRI. This observation emphasizes the need for a comprehensive approach to interpreting MRI results, particularly when seizures are accompanied by complex clinical presentations.

The advancement of MRI technologies, including high-resolution imaging and emerging techniques like diffusion tensor imaging (DTI) and functional MRI (fMRI), offers the potential for enhanced diagnostic precision and treatment planning. These technological innovations may improve our ability to detect subtle abnormalities and tailor treatment strategies more effectively.

In summary, our study supports the routine use of MRI in the evaluation of pediatric seizures. By revealing structural abnormalities, MRI plays a crucial role in accurate diagnosis, guiding treatment decisions, and improving patient management. Future research should focus on larger, multicenter studies to validate these findings and further explore the benefits of advanced imaging technologies in optimizing outcomes for children with epilepsy.

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