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**ORIGINAL RESEARCH**

# A study to evaluate the magnetic resonance imaging characteristics of epileptogenic substrates

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**Abstract**
**Background-** The present study is to review the efficacy of magnetic resonance imaging in the evaluation of patients with seizures.
**Material and methods-** The study was conducted on patients with magnetic resonance imaging reference for seizures in the Department of Radio diagnosis, Dr. S. N. MEDICAL COLLEGE and associated group of hospitals, JODHPUR. Imaging was done with ACHIEVA 1.5 TESLA MAGNETIC RESONANCE IMAGING equipment from PHILIPS
**Results-** Majority of patients who presented with seizures belonged to the first three decades of life with male preponderance. The proportion of patients presenting with partial seizures were higher than those with generalized seizures. The typical magnetic resonance signal intensity characteristics of epileptogenic substrates can be used to identify as well as diagnose the lesions specifically. Abnormalities were identified in 60 percent of the study population while 40 percent had normal magnetic resonance imaging. Mesial temporal sclerosis was the most commonly identified substrate in patients presenting with refractory partial seizures, followed by gliosis, which was followed by infections, tumours, developmental anomalies and vascular malformations in that order. The diagnostic yield from magnetic resonance imaging is high in patients with refractory partial seizures.
**Conclusion-**Magnetic resonance imaging should be considered in the initial evaluation of patients presenting with seizures, particularly with intractable partial seizures because of its high sensitivity for epileptogenic substrates, superior soft tissue contrast, multiplanar capability, lack of beam hardening artifact and lack of ionizing radiation.

## Introduction

With the discovery of X-rays by Sir Wilhelm Conrad Roentgen in 1895, began the era of diagnostic imaging which has with the development in technology has progressed through the various modalities like conventional radiography, ultrasound, computed tomography, magnetic resonance imaging, and nuclear medicine. In present day clinical practice, imaging plays an important role in the diagnostic work-up of patients, particularly neuroimaging with magnetic resonance in the evaluation of brain pathology.[1,2,3]

A seizure ( from Latin " to take possession of") is a paroxysmal alteration in neurologic function, resulting from abnormal excessive neuronal electrical activity arising in the gray matter of the cerebral cortex. Epilepsy is a chronic condition characterized by recurrent seizures unprovoked by an acute systemic or neurologic insult. Epilepsy usually requires long-term pharmacotherapy, or neurosurgical intervention in medically refractory cases.[4]

Computed tomography introduced in 1973, with its widespread availability at emergent care facilities, rapid scan time, high sensitivity in detecting major abnormalities is widely used for screening patients with new-onset seizures.Patients with new-onset seizures have abnormal computed tomographic scans and those with a cancer history, age greater than 40, current treatment with anticoagulants, head trauma, a focal neurologic deficit, or persistent alteration in mental status would benefit from computed tomographic imaging.Despite its utility in the acute setting, computed tomography has several drawbacks such as significant beam-hardening artifacts at the

skull base, poor sensitivity for subtle cortical and hippocampal abnormalities, which significantly limits its ability to characterize lesions. Hence, computed tomography has little role in the evaluation of chronic seizures.
Magnetic resonance imaging, the concept of which was introduced in 1936, and was initially used in basic science research, came into clinical practice with Lauterber's suggestion(1973), that position dependent encoding of magnetic resonance signal using gradients, can be used to generate images. With this the first magnetic imaging of human anatomy was done in 1976 and 1977 by two separate groups at Nottingham University. Since magnetic resonance imaging came into clinical practice in 1980s, it has been the preferred platform for evaluating diseases of the brain and spinal cord.
Its advantages over computed tomography include superior contrast resolution, multiplanar imaging, and absence of beam hardening artifacts and lack of ionizing radiation. These advantages result in better detection of small lesions, improved differentiation between gray and white matter structures and better visualization of hippocampus, all of which are critically important in imaging of seizures disorder.
Overall, magnetic resonance imaging is the preferred imaging tool for detecting the structural abnormalities that can result in seizure activity. The present study is to review the efficacy of magnetic resonance imaging in the evaluation of patients with seizures.

**Material and methods**
The study was conducted in the Department of Radio diagnosis, Dr. S. N. MEDICAL COLLEGE and associated group of hospitals, JODHPUR. Imaging was done with ACHIEVA 1.5 TESLA MAGNETIC RESONANCE IMAGING equipment from PHILIPS.

**Inclusion criteria**
All patients with magnetic resonance imaging reference for seizures at Dr. S. N. MEDICAL COLLEGE and associated group of hospitals were included in the study irrespective of age and sex.

**Exclusion criteria**
Patients with history of metabolic disturbances (hepatic / renal failure etc), pediatric patients with febrile seizures, were excluded from the study.
As per the "International League against Epilepsy Guidelines for Neuro-imaging in the Epilepsy patients (1997)" which recommends a dedicated epilepsy protocol magnetic resonance imaging for all patients with new onset seizure or newly diagnosed epilepsy in the non-emergent setting, the study group was imaged using EPILEPSY PROTOCOL, which consists of the following sequences:

- T2 AXIAL FAST SPIN ECHO (FSE)
- FLUID ATTENUATED INVERSION RECOVERY SEQUENCE(FLAIR) – AXIAL
- DIFFUSION WEIGHTED SEQUENCE (DWI)
- T1 INVERSION RECOVERY (IR) SEQUENCE – AXIAL
- T1 INVERSION RECOVERY (IR) CORONAL OBLIQUE – 3 MM SLICES
- T2 CORONAL OBLIQUE – 3MM SLICES
- T1 SPOILED GRADIENT RECALLED ECHO - CORONAL

[3D Magnetization Prepared Rapid Gradient Echo (MPRAGE)]
Gadolinium was used whenever indicated.
The magnetic resonance scans were reviewed and the findings were recorded in a Performa.

**Observations**
The present study was conducted in a study population of 150 patients, who presented with history of seizures and underwent magnetic resonance imaging. The magnetic resonance imaging was then evaluated to identify the abnormalities underlying seizures in our study group.
**Table 1: Distribution of patients on the basis of age**

| Age-Group (Yrs) | No. of Patients | Percentage Distribution |
|---|---|---|
| 0-10 | 31 | 21% |
| 11-20 | 43 | 28% |
| 21-30 | 28 | 19% |
| 31-40 | 19 | 13% |
| 41-50 | 19 | 13% |
| 51-60 | 5 | 3% |
| 61-70 | 5 | 3% |
| **Total** | **150** | **100%** |

In our study, majority of the patients were in the first three decades, the percentage of patients in the first decade being 21%, those in the second decade being 28% and 19% of patients belongs to third decade.

**Table 2: Distribution of patients according to sex**

| Sex | No. of patients | Percentage Distribution |
|---|---|---|
| Male | 85 | 56.66% |
| Female | 65 | 43.33% |
| **Total** | **150** | 100% |

In our study, the majority were male patients (56.66%).

**Table 3: Classification of patients on the basis of clinical presentation**

| Seizure type | No. of patients | Percentage Distribution |
|---|---|---|
| Partial seizure | 100 | 66.66% |
| Generalized seizure | 50 | 33.33% |
| **Total** | **150** | **100%** |

Patients with partial seizures constituted 66.6% of the study group.
Patients with generalized seizures constituted 33.3% of the study group.

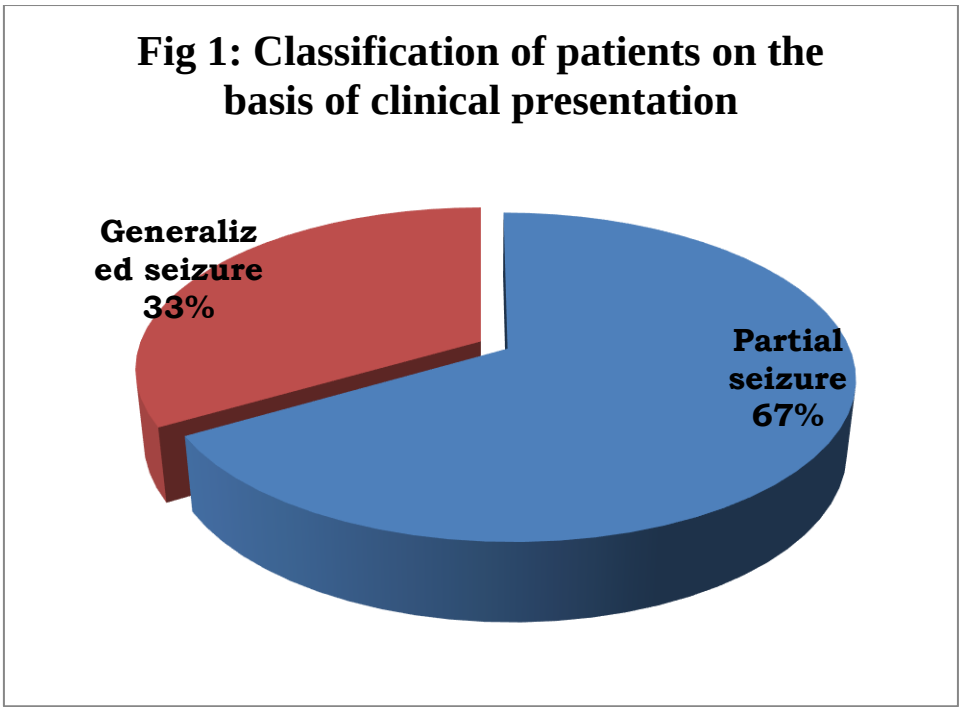



**Table 4: MRI findings associated with epileptogenic substrates**

| T1- W image | T2- W image | FLAIR | IR | SPGR | Post contrast | Epileptogenic substrate |
|---|---|---|---|---|---|---|
| Hypointense signal in hippocampus | Hyperintense signal in hippocampus | Hyperintense signal in hippocampus | Loss of architecture in hippocampus | | | Hippocampal sclerosis |
| Volume loss in hippocampus | Volume loss in hippocampus | | | | | |
| Hypointense | Hyperinense | Hypointense | | | | Gliosis |
| Hypo-to-isointense | Hypointense with edema | | | | Ring enhancement | Tuberculoma |
| Hypo/hyperintense | Hyperintense with edema | | | | Ring enhancement, scolex seen | Neurocysticercosis |
| Hypo-to-isointense | Homogenous high signal / variable signal | | | | Variable/ irregular enhancement | Low grade glioma |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Cleft dimple complex | | Focal cortical dysplasia |
| Focal round, linear, serpentine flow voids seen | Focal round, linear, serpentine flow voids seen | | | | Nidus/venous side of the lesion enhances | Arteriovenous malformation |
| Focal central heterogeneity with hypointense rim | Focal central heterogeneity with hypointense rim | | | | Enhancement seen | Cavernous angioma |

The epileptogenic substrates were identified on the basis of the signal intensities and morphological abnormalities seen on magnetic resonance imaging.

**Table 5: Epileptogenic substrates**

| Epileptogenic substrate | No. of patients | Percentage Distribution |
|---|---|---|
| Mesial temporal sclerosis | 26 | 29% |
| Gliosis | 24 | 27% |
| Infectious etiology | 19 | 21% |
| Tumours | 12 | 13% |
| Malformations of cortical development | 7 | 8% |
| Vascular malformation | 2 | 2% |
| **Total** | **90** | |

In our study, mesial temporal sclerosis was the most common abnormality identified in 29% of the study group, followed by gliosis seen in 27% of the seizure patients.1n 60 patients MR imaging did not reveals any structural abnormality.

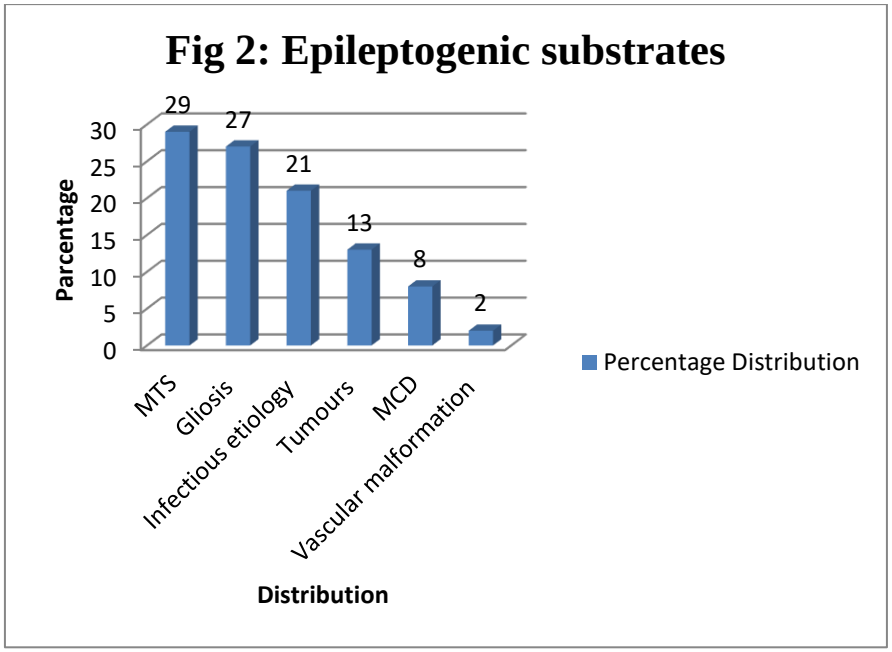



**Table -6: Findings in patients with partial and generalized seizures**

| MRI features | Partial seizure group | Generalized seizure group |
|---|---|---|
| MRI with findings | 68 | 23 |
| Normal MRI | 32 | 27 |
| **Total** | **100** | 50 |

Among 100 patients with partial seizures, 68 patients had lesions detected in magnetic resonance imaging. The diagnostic yield in the partial seizure group is 68%.
In the generalized seizure group, lesions were identified in 23(46%) patients among 50 patients.

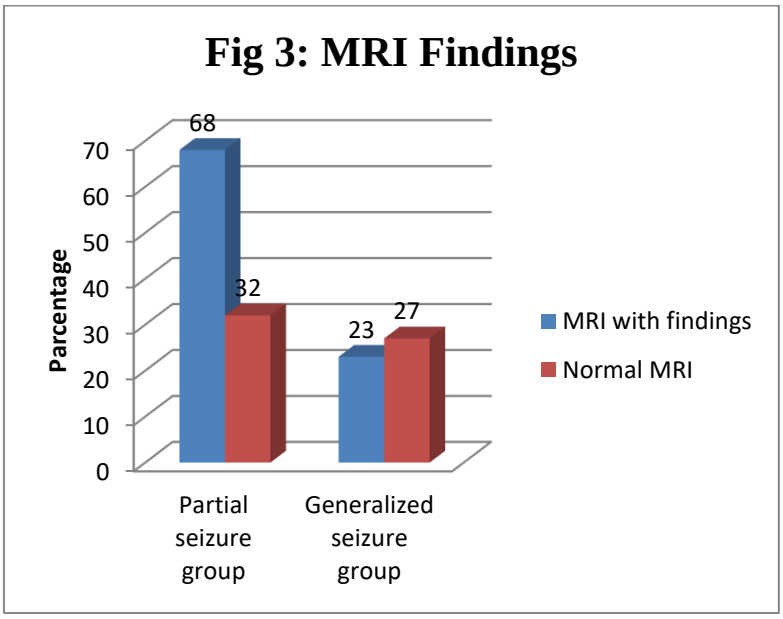
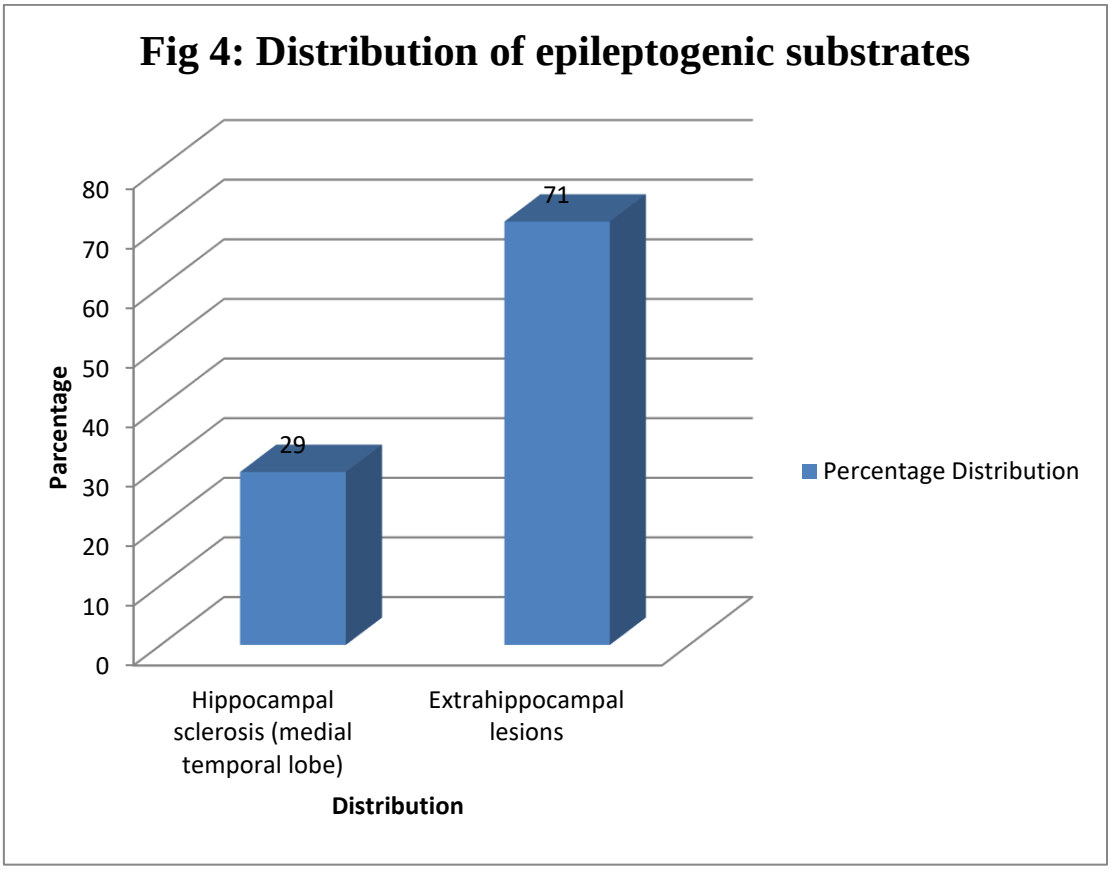



**Table – 7: Distribution of epileptogenic substrates**

| Distribution | No. of patients | Percentage distribution |
|---|---|---|
| Hippocampal sclerosis (medial temporal lobe) | 26 | 29% |
| Extrahippocampal lesions | 64 | 71% |
| Total | | |

In the total study group, 29% of patients had evidence of hippocampal sclerosis.




**Discussion**

Magnetic resonance imaging has become indispensable in the diagnostic work-up of epilepsy patients, who present with recurrent seizures, which is amenable to both medical and surgical treatment.About 15-30% of

patients with partial seizures are refractory to pharmacotherapy (Arroyo et al, [5] Kwan P et al,[6] Mattson R[7]), which mandates the need to evaluate these patients with imaging studies to identify possible structural abnormalities which may be responsible for seizures. Identification of a structural substrate on magnetic resonance imaging, guides further management, as the chance of being considered for surgical treatment is greatly enhanced when a structural abnormality is found on magnetic resonance imaging.(Engel,[8] Kuzniecky et al,[9] Jack et al[10]).Approximately, 60% of patients become seizure-free after surgery, the seizure-free surgical outcome being 67% for hippocampal sclerosis, 75% for neoplasms, and 58% for cortical dysplasia. (Spencer SS [11])

With this background, we evaluated the magnetic resonance imaging features of patients presenting with recurrent seizures either, focal or generalized, who underwent epilepsy protocol imaging, as the detection rate of abnormality is high with epilepsy protocol imaging**. (**Erasmoet al [12]**).**

Our study included one hundred and fifty patients who underwent epilepsy protocol magnetic resonance imaging. Out of the 150 patients, the majority of patients belonged to the first two decades, the percentage being 21% in the first decade and 28% in the second decade.

Bronen et al [13], has categorized the cause of epilepsy by the age of seizure onset, in which majority are in the first two decades, similar to our study.

About 85(56.66%) were males and65 (46.33%) were female patients.

Our study included 100 patients with partial seizures and 50 patients with generalized seizures.The epileptogenic substrates which include hippocampal sclerosis, gliosis, infections, tumours, developmental anomalies and vascular malformations were identified on the basis of the magnetic resonance imaging features typical for each of these lesions.Hippocampal sclerosis was diagnosed based on the principal findings of volume loss and abnormal signal in the hippocampus (Cendes et al.[14], Bronen et al [13], Kuzniecky[9]) with identification of loss of hippocampal architecture on inversion recovery sequence **(**JacksonGD[15]**).**

In the present study, hippocampal sclerosis was identified in 26(29%) patients. Similar results were shown by Lefkopoulos et al [84] in their study of 120 patients with refractory seizures.No single modality among these can definitively identify the seizure focus, especially those who are planned for epilepsy surgery, and hence a combination of these should be used. (Engel J. [8])

Computed tomography is widely available, very useful in the emergent setting, can detect major structural abnormalities and calcifications, but its sensitivity in the dectection and characterization of subtle cortical abnormalities, hippocampal lesions which is important in epilepsy imaging , and detection of posterior fossa lesions is low.Magnetic resonance imaging with its superior soft tissue contrast, multiplanar imaging capability, and lack of beam hardening artifact is more sensitive in picking up subtle cortical abnormalities, hippocampal lesions as well as characterizing lesions such as different types of tumours, infections with its advanced applications.

Functional magnetic resonance imaging, SPECT and PET also help to localize the seizure focus. They are complementary to magnetic resonance imaging (Bronen et al [13]). However, their availability restricts their routine usage , though they can be used in (1) patients with abnormal magnetic resonance imaging with non-localizing electroencephalography, (2) multifocal magnetic resonance imaging (tuberous sclerosis),(3) normal magnetic resonance imaging with abnormal electroencephalography. (Erasmo [12])

Finally in our study, we found that magnetic resonance imaging along with clinical history should be used in the initial assessment of patients who presents with seizures ,either focal or generalized and who are considered surgical candidates, since the presence of focal and, in particular, medial temporal lobe pathology increases the chances of progression to successful surgical treatment.

**Conclusion**

One hundred and fifty patients with clinical presentation of seizures, either partial or generalized were imaged using epilepsy protocol magnetic resonance imaging. From the observations we concluded thatMajority of patients who presented with seizures belonged to the first three decades of life with male preponderance.The proportion of patients presenting with partial seizures were higher than those with generalized seizures.The typical magnetic resonance signal intensity characteristics of epileptogenic substrates can be used to identify as well as diagnose the lesions specifically.

Abnormalities were identified in 60 percent of the study population while 40 percent had normal magnetic resonance imaging.Mesial temporal sclerosis was the most commonly identified substrate in patients presenting with refractory partial seizures.The second most common substrate identified was gliosis This was followed by infections, tumours, developmental anomalies and vascular malformations in that order. The diagnostic yield from magnetic resonance imaging is high in patients with refractory partial seizures.Thus, a combination of clinical information and magnetic resonance imaging should be considered in the initial evaluation of patients presenting with refractory partial seizures.

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