Section: Radiodiagnosis

Original Research Article

DIAGNOSTIC ACCURACY OF MRI IN THE EVALUATION OF BRAIN LESIONS IN PATIENTS PRESENTING WITH SEIZURES

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ABSTRACT

Background: MRI is a key imaging modality in evaluating seizures, but conventional protocols may miss subtle lesions like focal cortical dysplasia or hippocampal gliosis. This study assessed the diagnostic accuracy of MRI in detecting brain lesions in seizure patients.

Materials and Methods: A prospective observational study was conducted on 80 patients with seizures who underwent standard MRI brain imaging. MRI findings were compared with final clinical diagnoses derived from EEG, clinical data, follow-up, and histopathology where available. Sensitivity, specificity, and accuracy were calculated.

Results: MRI detected abnormalities in 52 patients (65.0%), with mesial temporal sclerosis (17.5%) and focal cortical dysplasia (15.0%) being most common. MRI was negative in 28 cases, including 8 later diagnosed with subtle pathology. MRI showed sensitivity of 85.7%, specificity of 83.3%, and diagnostic accuracy of 85.0%.

Conclusion: MRI is effective in seizure evaluation but may miss subtle lesions. Incorporating advanced imaging sequences can enhance detection and guide better management.

Keywords: Seizure, MRI, diagnostic accuracy, temporal sclerosis, cortical dysplasia.

INTRODUCTION

Seizures are a common neurological manifestation resulting from abnormal neuronal activity and may occur secondary to a wide range of underlying structural brain abnormalities. Identification of epileptogenic lesions is crucial for accurate diagnosis, appropriate medical therapy, prognostication, and selection of patients for surgical intervention, particularly in refractory epilepsy.

Magnetic resonance imaging (MRI) is the preferred neuroimaging modality in patients presenting with seizures due to its superior soft-tissue contrast and ability to detect subtle cortical and subcortical abnormalities. MRI plays a central role in identifying seizure-related pathologies such as mesial temporal sclerosis, focal cortical dysplasia (FCD), neoplasms, vascular malformations, and gliotic or inflammatory lesions. However, several studies have demonstrated that standard MRI protocols may be inadequate, especially in patients with refractory focal epilepsy, resulting in a subset of patients classified as having MRI-negative epilepsy.[1-3]

The diagnostic limitations of routine MRI are particularly evident in detecting subtle malformations of cortical development, especially focal cortical dysplasia. Studies have reported a significant proportion of patients with drug-resistant epilepsy who exhibit no visible lesion on conventional MRI despite histopathological abnormalities.[1-3] Advances in epilepsy-dedicated imaging protocols and high-resolution MRI have improved lesion detection, especially in presurgical evaluation, yet challenges remain in routine clinical practice.[4,5]

Focal cortical dysplasia is one of the most common pathological substrates underlying refractory focal epilepsy. The International League Against Epilepsy (ILAE) has refined the classification of FCD, emphasizing the importance of correlating imaging findings with histopathological features.[6-9] The developmental organization of the cerebral cortex

and microstructural abnormalities, such as gray–white matter blurring and hippocampal sclerosis, contribute significantly to epileptogenesis and may be difficult to detect on standard imaging.[10-13]

Despite the widespread use of MRI, there is a need to systematically evaluate its diagnostic accuracy in patients presenting with seizures. Assessing the sensitivity and specificity of MRI in detecting brain lesions associated with seizures is essential for optimizing diagnostic strategies and improving patient outcomes. Therefore, the present study aimed to evaluate the diagnostic accuracy of MRI in the detection of brain lesions in patients presenting with seizures.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based observational diagnostic accuracy study was conducted in the Department of Radiodiagnosis

Study Population

A total of 80 consecutive patients presenting with seizures and referred for MRI brain evaluation were included in the study during the study period. Written informed consent was obtained from all participants or from guardians in paediatric cases.

Inclusion Criteria

- Patients of any age presenting with new-onset or recurrent seizures
- Patients referred for MRI brain as part of seizure evaluation
- Patients who consented to participate in the study

Exclusion Criteria

- Patients with contraindications to MRI
- Patients with seizures secondary to acute head trauma
- Patients with prior neurosurgical intervention for epilepsy
- Poor-quality or incomplete MRI examinations

MRI Acquisition Protocol

- All patients underwent MRI brain examination using a dedicated epilepsy protocol on a high-field strength MRI scanner. The protocol included:
- Axial and coronal T1-weighted images
- Axial and coronal T2-weighted images
- Fluid-attenuated inversion recovery (FLAIR) sequences
- Diffusion-weighted imaging (DWI) with ADC maps
- Susceptibility-weighted imaging (SWI) / Gradient echo sequences

Additional sequences were obtained when clinically indicated.

Image Interpretation

MRI scans were independently evaluated by experienced radiologists blinded to clinical and EEG findings. Imaging was assessed for the presence, location, and nature of seizure-related brain lesions such as mesial temporal sclerosis, focal cortical dysplasia, neoplasms, vascular malformations, and gliotic or inflammatory changes. MRI findings were categorized as lesion positive or lesion negative.

Reference Standard

MRI findings were correlated with the final clinical diagnosis, based on a combination of clinical assessment, EEG findings, laboratory investigations, follow-up imaging, and histopathology where available. This composite diagnosis served as the reference standard.

Outcome Measures

The primary outcome was the diagnostic accuracy of MRI in detecting brain lesions in patients presenting with seizures. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 25 statistical software. Categorical variables were expressed as frequencies and percentages. Diagnostic accuracy indices were calculated by comparing MRI findings with the reference standard. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 80 patients presenting with seizures were included in the present study. The demographic and clinical characteristics of the study population are summarized in Table 1. The age distribution showed that the majority of patients belonged to the 21–40 years age group, accounting for 50 patients (62.5%), followed by 18 patients (22.5%) aged more than 40 years. Only 12 patients (15.0%) were aged 20 years or younger. The mean age of the study population was 32.6 ± 14.8 years, indicating a predominance of young and middle aged adults. With respect to sex distribution, 45 patients (56.2%) were males and 35 patients (43.8%) were females, showing a slight male predominance. Regarding seizure characteristics, generalized seizures were the most common presentation and were observed in 57 patients (71.2%), while focal seizures were noted in 23 patients (28.8%). In terms of seizure onset, 49 patients (61.2%) had a history of recurrent seizures, whereas 31 patients (38.8%) presented with new onset seizures. These baseline demographic and clinical details are depicted in Table 1. Magnetic resonance imaging findings of the study population are detailed in Table 2. MRI of the brain revealed abnormal findings in 52 patients (65.0%), while 28 patients (35.0%) showed no detectable abnormalities on MRI and were categorized as MRI negative. Among the MRI positive cases, mesial temporal sclerosis (MTS) was the most frequently detected lesion, identified in 14 patients (17.5%). Focal cortical dysplasia (FCD) was the second most common abnormality and was observed in 12 patients (15.0%). Other MRI abnormalities included post

ischemic gliosis or encephalomalacia in 9 patients (11.2%), infective granulomas such as neurocysticercosis or tuberculomas in 7 patients (8.8%), space occupying lesions (tumors) in 6 patients (7.5%), and vascular malformations in 4 patients (5.0%). The complete distribution of MRI findings is presented in Table 2. The MRI findings were correlated with the final clinical diagnosis, which was established using a composite reference standard comprising clinical evaluation, EEG findings, follow up imaging, and histopathological confirmation where available. Based on this reference standard, 56 patients (70.0%) were confirmed to have structural brain lesions, while 24 patients (30.0%) were diagnosed with non lesional epilepsy.

MRI correctly detected structural abnormalities in 48 out of the 56 patients with confirmed lesions. Additionally, MRI correctly demonstrated the absence of lesions in 20 out of 24 patients who were ultimately classified as having non lesional epilepsy. However, 8 patients with MRI negative findings were later found to have subtle epileptogenic abnormalities on follow up imaging or histopathological examination. The diagnostic performance of MRI in detecting brain lesions in patients presenting with seizures is summarized in Table 3. When compared with the final clinical diagnosis, MRI demonstrated a sensitivity of 85.7% and a specificity of 83.3%. The positive predictive value (PPV) was 92.3%, indicating a high likelihood of true lesion detection when MRI findings were positive. The negative predictive value (NPV) was 71.4%, reflecting the presence of a subset of patients with MRI negative but clinically significant lesions. The overall diagnostic accuracy of MRI in the present study was 85.0%, as shown in Table 3. Among the 28 MRI negative patients, 8 patients were subsequently diagnosed with subtle epileptogenic lesions, including focal cortical dysplasia and hippocampal abnormalities, during follow up or histopathological evaluation.

Table 1: Demographic and Clinical Profile of the Study Population (n = 80)

Variable	Category	n (%)
Age (years)	≤ 20	12 (15.0)
	21–40	50 (62.5)
	> 40	18 (22.5)
Mean age ± SD (years)	—	32.6 ± 14.8
Sex	Male	45 (56.2)
	Female	35 (43.8)
Seizure type	Generalized	57 (71.2)
	Focal	23 (28.8)
Seizure onset	New-onset	31 (38.8)
	Recurrent	49 (61.2)

Table 2: MRI Findings in Patients Presenting with Seizures (n = 80)

MRI Finding	n (%)
Mesial temporal sclerosis	14 (17.5)
Focal cortical dysplasia	12 (15.0)
Gliosis / encephalomalacia	9 (11.2)
Infective granulomas	7 (8.8)
Tumors	6 (7.5)
Vascular malformations	4 (5.0)
MRI positive	**52 (65.0)**
MRI negative	**28 (35.0)**

Table 3: Diagnostic Performance of MRI Compared with Final Clinical Diagnosis

Parameter	Value
True positives	48
False positives	4
False negatives	8
True negatives	20
Sensitivity (%)	85.7
Specificity (%)	83.3
Positive predictive value (%)	92.3
Negative predictive value (%)	71.4
Overall diagnostic accuracy (%)	**85.0**

DISCUSSION

In the present study of 80 seizure patients, MRI demonstrated abnormalities in 65.0% of cases. The diagnostic accuracy was 85.0%, with sensitivity and specificity of 85.7% and 83.3%, respectively. These results underscore MRI's strong role as a first-line modality in seizure evaluation. However, 35.0% of patients were MRI-negative, reflecting the known limitations of conventional MRI in detecting microstructural or subtle lesions—particularly in cases of focal epilepsy. Mesial temporal sclerosis (MTS) was the most frequently identified lesion in our study, seen in 17.5% of patients. Urbach et al. (2014),[14] showed that high-resolution MRI with volumetric and FLAIR analysis can distinguish the

type and extent of hippocampal sclerosis, correlating with Wyler grading on histopathology. They highlighted that volume loss and T2/FLAIR hyperintensity were measurable even in early-stage disease, enhancing lesion visibility—suggesting that the detection rate in our study could potentially increase with quantitative protocols.

Several MRI-negative patients in our study were later found to have histopathological evidence of gliosis or subtle temporal lobe abnormalities. This is supported by Hattingen et al. (2018),[15] who described "gliosis only" as a distinct entity with minimal volume loss and subtle signal changes, often missed on routine MRI. In their cohort, only 25% of gliosis-only cases showed signal hyperintensity, compared to 74% in classic hippocampal sclerosis—explaining under-detection in our standard protocol.

Focal cortical dysplasia (FCD) was detected in 15.0% of our MRI-positive patients, but likely underestimated due to the subtlety of imaging features. Chen et al. (2018),[16] introduced the FLAWS sequence, which significantly improved detection of FCD by enhancing contrast at the gray–white matter interface. Sun et al. (2021),[17] extended this, combining FLAWS with voxel-based morphometry, reporting improved detection in MRI-negative epilepsy, especially in FCD type I.Several studies emphasize the value of advanced 3D and morphometric imaging. Middlebrooks et al. (2020),[18] demonstrated that the 3D-EDGE MRI sequence improved FCD detection by enhancing cortical junction contrast, aiding in visualization of previously occult lesions. Likewise, Demerath et al. (2020),[19] used MP2RAGE-based morphometric analysis and found it superior in detecting subtle dysplasias compared to conventional MRI sequences.These findings support the need for advanced MRI sequences and post-processing in epilepsy protocols—especially in patients like ours who were MRI-negative but had confirmed pathology on follow-up.

CONCLUSION

MRI demonstrated good diagnostic accuracy (85.0%) in detecting brain lesions in seizure patients, with a lesion detection rate of 65.0%. Mesial temporal sclerosis and focal cortical dysplasia were the most common findings. However, 35.0% of cases remained MRI-negative, underscoring limitations of standard imaging. Incorporating advanced MRI techniques may enhance lesion detection and guide better management.

Limitations of the Study

The study was limited by a modest sample size (n = 80) and use of routine MRI protocols without advanced imaging sequences. Subtle lesions like focal cortical dysplasia or gliosis-only may have been under-detected. Histopathological correlation was not available for all cases. Being a single-center study, findings may not be generalizable.

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