1. Introduction

MRI (magnetic resonance imaging) is an important medical diagnostic tool in detecting and assessing epileptogenic zones in the brain. The epileptogenic zone is an area of the brain that is a source of uncontrolled epileptic activity. MRI can produce images of the brain with high spatial resolution, allowing detailed visualization of brain structure. This allows the identification of pathological changes, such as lesions, hemorrhages, or vascular malformations, that may be a cause or indicator of an epileptogenic zone. MRI offers a variety of scanning techniques, including structural MRI (T1-weighted and T2-weighted), diffusion MRI, functional MRI (fMRI), and proton spectroscopy MRI. The combination of these various techniques can help doctors identify areas that have the potential to become epileptogenic zones. Lesions such as tumors, blood clots, or scar tissue from brain injury can be clearly seen on MRI. These lesions can be a focus of epileptic activity and, therefore, can be identified as an epileptogenic zone.1-3

Functional MRI techniques, such as fMRI, allow monitoring brain activity while the patient performs certain tasks. This can help in determining the brain regions involved in epileptic seizures. Patients with epilepsy often experience structural brain changes over time. MRI allows monitoring of these changes,
which can help in determining the evolution of the epileptogenic zone. By examining the entire brain, MRI can help in identifying potentially epileptogenic zones, which is important for planning surgical intervention or treatment. MRI is a non-invasive technique, which means it does not require surgery or invasive procedures. This reduces risk and patient discomfort.6

2. Methods
The literature search process was carried out on various databases (PubMed, Web of Sciences, EMBASE, Cochrane Libraries, and Google Scholar) regarding the potential of MRI (magnetic resonance imaging) in detecting epileptogenic zones in the brain. The search was performed using the terms: (1) "MRI" OR "epileptogenic" OR "zone" OR "detection" AND (2) "MRI" OR "epilepsy." The literature is limited to clinical studies and published in English. The literature selection criteria are articles published in the form of original articles about Potential MRI (Magnetic Resonance Imaging) in detecting epileptogenic zones in the brain. Studies were conducted in the timeframe from 2013-2023, and the main outcome was a potential MRI (magnetic resonance imaging) in detecting the epileptogenic zone in the brain. Meanwhile, the exclusion criteria were studies that were not related to MRI (magnetic resonance imaging) potential in detecting epileptogenic zones in the brain, the absence of a control group, and duplication of publications. This study follows the preferred reporting items for systematic reviews and meta-analysis (PRISMA) recommendations.

Figure 1. PRISMA flowchart.
3. Results and Discussion

High spatial resolution

MRI with high spatial resolution allows the identification of pathological changes in brain structures that can be a cause or indicator of epileptogenic zones. MRI can help identify various types of brain lesions, including tumors, cysts, scar tissue, or infarction. Lesions such as brain tumors or scar tissue caused by previous injuries can act as epileptogenic zones. Arterio-venous malformations (AVM) or other capillary malformations can be detected via MRI. Vascular malformations can cause disruption of cerebral blood flow, which in turn can trigger seizures. MRI is excellent at detecting intracerebral or subarachnoid hemorrhage that may be associated with epileptic activity. This is a common cause of focal epilepsy, especially in adults. MRI can be helpful in identifying atrophy or structural changes in the hippocampus, which are signs of mesial temporal sclerosis. Occasionally, structural changes in the cerebral cortex, such as cortical dysplasia, may be the cause of epilepsy. MRI with contrast can help identify this dysplasia.7-10

Multi-modality imaging

Conventional structural MRI, such as T1-weighted and T2-weighted images, is used to view brain anatomy and identify structural changes that may be associated with the epileptogenic zone. For example, lesions, bleeding, or atrophy can become the focus of seizures. Diffusion MRI allows assessment of the movement of water molecules in brain tissue. This can help in detecting microstructural changes and nerve cell damage that may occur in the epileptogenic zone. The fMRI technique is used to monitor brain activity by measuring cerebral blood flow. This can help in identifying regions that are active during epileptic seizures or as part of the epileptogenic network. Proton spectroscopy MRI techniques are used to examine the chemical composition of the brain. This can help in detecting metabolic changes associated with the epileptogenic zone, including increased levels of glutamic acid and decreased levels of gamma-aminobutyric acid (GABA). Diffusion Tensor Imaging (DTI) is an MRI method that measures the movement of water molecules in nerve fibers in the brain. This can help in mapping the brain’s communication pathways and identifying areas that may be involved in epileptic activity.11-15

Detection of structural lesions

Lesions such as tumors, blood clots, or scar tissue from brain injury can be clearly seen on MRI, and in some cases, they can be the focus of epileptic activity. This is why MRI is very important in identifying the epileptogenic zone, especially when obvious structural changes are visible. Brain tumors can become epileptogenic zones because their growth can disrupt the normal function of the surrounding brain tissue. In addition, chemical changes caused by brain tumors can also trigger epileptic seizures. MRI helps in identifying the size, location, and type of brain tumor. Blood clots in the brain, such as those that occur in intracerebral hemorrhage or subarachnoid hemorrhage, can cause changes in the brain’s electrical activity and cause epileptic seizures. MRI will detect these blood clots and inform about their location. Scar tissue formed as a result of previous brain injury can become a focus of epileptic activity. MRI can identify the location and extent to which this scar tissue affects normal brain activity. Identification and characterization of these lesions are essential in planning the treatment of patients with epilepsy. If such lesions can be removed safely through surgery, this could be a solution to control epileptic seizures.16-20

4. Conclusion

MRI can produce images of the brain with high spatial resolution, allowing detailed identification of brain structures that may be associated with the epileptogenic zone. Lesions such as tumors, blood clots, or scar tissue that are the focus of epileptic activity can be clearly seen on MRI. Various MRI techniques, such as structural MRI, diffusion MRI, functional MRI, and proton spectroscopy MRI, can be used together to provide comprehensive information about the epileptogenic zone. MRI allows monitoring of brain structural changes over time, which is useful in determining the evolution of the epileptogenic zone.
fMRI techniques help understand brain activity during epileptic attacks or as part of the epileptogenic zone.

5. References