

Magnetic resonance imaging and intractable epilepsy: A systematic review

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ABSTRACT

Objective: Epilepsy is a chronic neurological disorder that occurs due to irregular neuronal activity in the central nervous system. The main job of a radiologist is to investigate the structural etiology in epilepsy patients. This study was undertaken to find out the importance of magnetic resonance imaging (MRI) in the screening of intractable epilepsy through a systematic search of literature.

Methods: A systematic review was performed using the PRISMA guidelines. Peer-reviewed studies on MRI and intractable epilepsy were retrieved from MEDLINE, ScienceDirect and Google Scholar. Moreover, studies cited in the key articles were also screened to increase the sensitivity and specificity of the systematic search.

Results: The database search till March 2022 found a total of 112610 articles. Out of them, only 10 highly selected articles were included in the study. The pooled data point out that the rapid development in MRI techniques and the functional MRI (fMRI) has now become more and more critical in the diagnosis and management of patients with epilepsy. In addition, the data also pointed out that MRI-based approaches are also very useful for post-operative epilepsy patients as it gives information about the quality of the surgery. The data collected showed that the MRI is the choice technique for the evaluation of patients with epilepsy.

Conclusions: The applicability of MRI in epilepsy diagnosis is highly accessible in all over the globe. The pooled data concluded that the MRI-based surgical approaches are extremely useful for the surgeons to provide three-dimensional imaging with superimposed real-time pointer details that have proved successful for epilepsy patients.

Keywords: MRI, intractable epilepsy, systematic review, functional MRI

Introduction

Epilepsy is a chronic disorder of the central nervous system which resulted due to the abnormal activities of the neurons.^[1] According to the recent reports, more than 70 million individuals have been affected with this neurological disorder which led to increase the global disease burden worldwide.^[2] A number of epidemiological studies reported that the epilepsy is globally common but its prevalence is more in the developing countries as compared with its reported prevalence in developed countries and the situation to handle the epilepsy patients in low-income countries day-by-day becoming worst.^[3] Several epidemiologist's investigated that the prevalence rate of epilepsy has significantly increased in the rural areas as compared to the urban regions and this trend has almost the same in all over the globe.^[4,5] Several investigators have investigated the reason(s) why the prevalence of epilepsy has higher in low-income countries or rural areas and they reported that the prevalence of epilepsy

has direct correlation with the availability of the medical facilities such as qualified radiologists, surgeons, and also the availability of imaging techniques, which have been usually lacking in the low-income countries or in the rural areas.^[6,7] The availability of the sophisticated technologies including the magnetic resonance imaging (MRI) has been found to be very useful for the management of patients with epilepsy in all over the world.^[8,9] Imaging of epileptogenic lesions through MRI not only provides the planning for the surgeons to perform epilepsy surgeries but also helpful for the post-operative follow-up.^[10] According to the International League Against Epilepsy (ILAE) suggests that all individuals suffering from epilepsy ideally tested with high-quality imaging techniques including MRI.^[11] Moreover, the National Institute of Health and Clinical Excellence (NICE) guidelines recommended that the structural abnormalities in the brain of children and adults suffering with epilepsy should be screened by MRI.^[11,12] In modern world, functional MRI (fMRI) has now becomes the method of choice for the screening of epileptogenic lesions in

the brain of individuals suffering from epilepsy as it is more powerful, highly sensitive, and more accurate as compared with the conventional MRI technique.^[12,13] But still, the facility of fMRI in the rural regions or in low-income countries is not fully available due to the financials reasons, therefore, the radiologists working in these regions is still relies on the conventional MRI.^[14,15] Under such circumstances, the radiologists play a key role to determine and to locate the structural abnormality of epileptogenic lesions to provide an accurate information to the surgeons so that the surgeon can easily identify the epileptogenic lesions and perform the surgeries.^[16,17] In view of these, this systematic review was designed to update the role of the MRI in the screening of epilepsy by pooling of the available literature. The outcome of the pooling of selected studies clearly indicating that the MRI-based surgical systems provide a three-dimensional pictorial presentation of anatomic epileptogenic lesions with superimposed real-time pointer information to the surgeons that proved to be useful in epilepsy surgery. In general, the MRI-based therapies are extremely valuable for the management of patients with epilepsy.

Methods

PRISMA guidelines and the databases for systematic search of literature

The PRISMA guidelines part for a systematic search of literature was used in this systematic review.^[18] A systematic computerized search using the databases such as PubMed, ScienceDirect, and Google Scholar was used. We identified studies that reported data on the role of magnetic resonance imaging in intractable epilepsy. The articles we use include all types of studies ranging from case reports, observational studies, randomized controlled trials, systemic reviews, and meta-analysis. Any patient, including male, female, transgender, any ethnic, and from any location, can be included in this study. A study of the abstracts of the chosen articles was performed, and only those with data deemed suitable for review were shortlisted. However, the references found to be relevant were also assessed and reviewed to be included in this study. The following keywords were used for our regular search: Magnetic resonance imaging and intractable epilepsy. Only English language studies were included to avoid misinterpretation of translation. All the data used in this literature review are collected ethically and legally. The search method is summarized as a PRISMA flowchart in Figure 1.

Inclusion and exclusion criteria of the studies

We included all retrospective and prospective population-based studies measuring MRI in epilepsy. We considered studies for inclusion if they included a definition of MRI and epilepsy. We excluded studies if they explored only epilepsy. We excluded editorials, single cases, and case series, studies

published only as abstracts, letters, or commentaries, studies of individual groups.

Ethical issues

This is a systematic literature review, and the information of patients directly obtained from the published literature. Therefore, ethical approval was not required.

Results

In this systematic review, our database search till March 2022 using the keywords MRI and epilepsy found 17360 articles on MEDLINE, 6650 articles on ScienceDirect, and 88,600 articles on Google Scholar found 112,610 articles. Out of them, only 202 articles were retrieved and rest were excluded after screening of titles and duplication. Out of 202 selected articles, 130 articles were excluded based on their relevancy of the abstract. Afterward, 72 articles were shortlisted and their full texts were accessed. After analyzing the full texts, 63 articles were excluded as these articles were not reported a clear outcome of the role of MRI in intractable epilepsy, few were excluded as their outcomes were based on significantly less sample size. The articles reported that the same previously published data were also excluded [Figure 1]. A total of 10 highly selective studies were included in this article.^[19-28] A study conducted on children with non-lesional epilepsy from Minya, Egypt, in 2021 by Abdelgawad *et al.* who showed that volumetric MRI is extremely useful in the analysis of non-lesional pharmaco-resistant childhood epilepsy.^[19] In 2021, another published study on the Kenyan children with early childhood epilepsy reported that the conventional MRI is useful for the detection a multiple clinical comorbidity in childhood epilepsy.^[20] In 2019, Bernasconi *et al.* from Quebec, Canada, showed that the structural MRI is very useful for the detection of noninvasive lesions in patients with epilepsy.^[21] Another interestingly study from Jammu Kashmir, India, pointed out that the conventional MRI is highly sensitive for the detection of epileptogenic materials, dysfunctionality in soft tissues and they reported that MRI is the best technique for the screening of pre-operative intractable epilepsy.^[22] Another study from Karnataka, India, showed that MRI with dedicated seizure protocol is best for the detection of epileptogenic lesions in one half of the new-onset seizures in epilepsy patients.^[23] An interestingly study from Hubei, China, by Zhao *et al.* in 2017 showed that Magic TVs approach through conventional MRI significantly improved the diagnosis of epilepsy by reducing the outputs of negative findings.^[24] Kader K Oquz from Ankara, Turkey, showed that functional MRI is an important technique for the detection of hemodynamic and microstructural alterations in epileptogenic lesions.^[25] In 2012, a study from Madrid, España, conducted on the epilepsy patients with focal seizures reported that the structural MRI technique is useful in the detection of mesial temporal sclerosis and malformations of cortical development in epilepsy patients.^[26] Hui *et al.* from Hong Kong pointed out that the cranial MRI technique

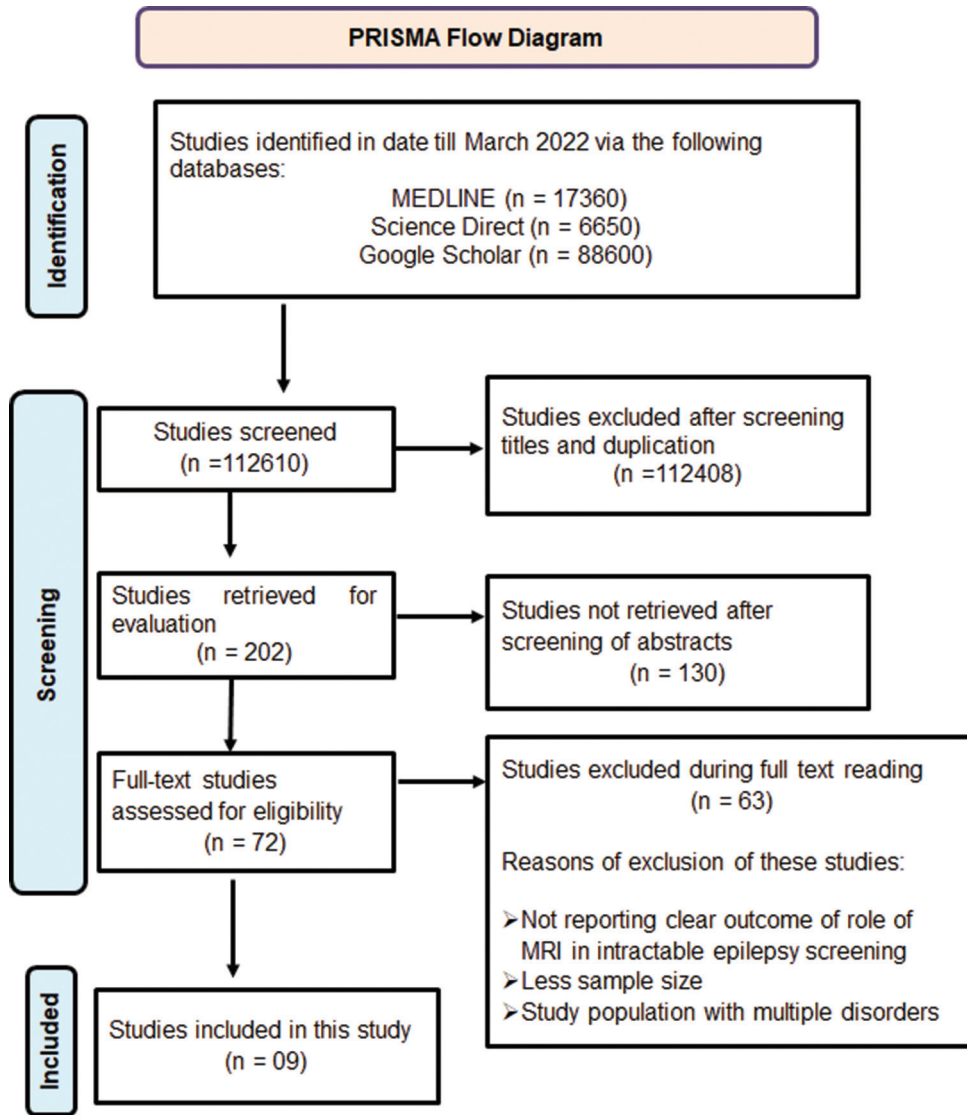


Figure 1: PRISMA flowchart for systematic literature search

is useful to show electroencephalographic results in patients with pre-operative epilepsy.^[27] A study from Washington DC, USA, by Jabbari *et al.* investigated that the conventional MRI has potential to detect focal ictal discharges in up to 85% of epilepsy patients with scalp electroencephalograms.^[28] The detailed characteristics with their outcomes are summarized in Table 1. In short, the applicability of MRI in epilepsy diagnosis is highly accessible to most of the population in developed economies. With the rapid development of MRI, exceptionally functional MRI (fMRI) is becoming more and more critical in the diagnosis and management of patients with epilepsy. The outcomes of this systematic review clearly point out that the MRI is choice technique for the evaluation of patients with epilepsy.

Discussion

This systematic review is provided an updated knowledge on the role of the MRI in the screening of structural abnormalities

of the neural lesions in patients with epilepsy. The MRI examination plays a key role for the screening of epileptogenic lesions in patients with epilepsy, this may be conducted either through MRI technique alone or in combination with some other imaging techniques such as fMRI, MR spectroscopy, PET, and ictal SPECT.^[29] The performance of medical examination of epileptogenic lesions with these additional approaches provides an extremely valuable information about the epileptogenic lesions and its exact location in the brain, these additional approaches with MRI not only help the surgeons to perform epileptogenic lesional surgery but also help the radiologists to make their outstanding reports.^[30,31] In spite of the availability of these extraordinary functional imaging approaches but still the applicability of these approaches are limited.^[30] There have been several reasons but the most valid reason is the involvement cost in these techniques while applying for the analysis of anatomic epileptogenic lesions.^[30,31] Several investigators have reviewed all these additional techniques with MRI and all have

Table 1: Characteristics of studies included in this systematic search of literature review

Study group	Year	Location	Population	Method	Outcome measurement	References
Abdelgawad <i>et al.</i>	2021	Minya, Egypt	Children with non-lesional epilepsy	Volumetric MRI	Volumetric MRI is useful in detection for non-lesional pharmacoresistant childhood epilepsy	[19]
Samia <i>et al.</i>	2021	Nairobi, Kenya	Children with early childhood epilepsy	Conventional MRI	Every third children among the studied population showed a positive yield for epilepsy including the detection of multiple clinical comorbidity by conventional MRI	[20]
Bernasconi <i>et al.</i>	2019	Quebec, Canada	Adults patients with epilepsy	Structural MRI	Structural MRI is unique for non-invasive investigation in patients with epilepsy	[21]
Maqsood <i>et al.</i>	2018	Kashmir, India	Adults patients with intractable epilepsy	Conventional MRI	Conventional MRI is highly sensitive for the detection of epileptogenic substrates, contraction of superior soft tissues, multiplanar capability, lack of beam hardening artifact, and lack of ionizing radiation. MRI is best for screening of pre-operative intractable epilepsy	[22]
Ponnapatapura <i>et al.</i>	2018	Karnataka, India	Epilepsy patients with new-onset seizures	MRI with dedicated seizure protocol	Epileptogenic lesions were detected in one half of new-onset seizures patients by MRI	[23]
Zhao <i>et al.</i>	2017	Hubei, China	Epilepsy patients with structural abnormalities	MAGIC TVs approach via conventional MRI	MAGIC TVs approach through conventional MRI improves the diagnosis rate by reducing false-negative results	[24]
Kader K. Oguz	2012	Ankara, Turkey	Patients with epileptogenic lesions	Functional MRI	Functional MRI is useful in detecting hemodynamic and microstructural alterations in epileptogenic lesions	[25]
Álvarez-Linera Prado	2012	Madrid, España	Epilepsy patients with focal seizures	Structural MRI	Structural MRI is useful in detection of mesial temporal sclerosis and malformations of cortical development in patients with epilepsy	[26]
Hui <i>et al.</i>	2003	Shatin, Hong Kong	Pre-operative epilepsy patients	Cranial MRI	Cranial MRI detected electroencephalographic results in epilepsy patients	[27]
Jabbari <i>et al.</i>	1986	Washington, USA	Partial complex epilepsy patients	Conventional MRI	MRI detected focal ictal discharges in 85% of epilepsy patients with scalp electroencephalograms	[28]

concluded that these additional techniques are highly sensitive, more powerful, and accurate when performed with MRI.^[31] Applicability of these functional imaging techniques is not the same at all time but these have been usually implemented in their specific requirements for the screening of epilepsy such as electroencephalogram (EEG) which is extremely useful for the detection of epileptogenic lesions in the brain when it can be recorded during fMRI.^[32] Whereas, PET is highly useful for the detection of cortical dysplasia, which usually has not been detected by the conventional MRI technique in patients with epilepsy.^[33] Furthermore, epilepsy patients have also been screened by MRI-based invasive EEG monitoring and also through placing of intracranial depth recording electrodes.^[34,35] These approaches have provided a top level screening for the detection of highly complicated epileptogenic lesions.^[34,35] In addition, MRI-based screening guidelines for the surgeons have also been developed and implemented which provided three-dimensional knowledge with superimposed real-time details of epileptogenic lesions to the surgeons which have already been proven to be successful for the performing epilepsy surgeries.^[24-26] Not only have these, the post-operative MRI has also provided an information for the quality of surgery, whether it can be done in a correct manner and it also provides information whether the second round surgery should

be needed.^[33] Further, almost all types of brain-associated major structural abnormalities including cortical resection, corpus callosotomy, and hemispherectomy have been screened and analyzed by MRI.^[33-35] Therefore, MRI application either alone or in combination with other functional approaches is highly applicable for the diagnosis of epilepsy patients. In this systematic review, we have provided the role of various types of MRIs for the screening of patients of different stages of intractable epilepsy. Using the keywords MRI and epilepsy, our systematic searched of literature initially found a total of 112,610 articles on MEDLINE, ScienceDirect, and Google Scholar. After reviewing studies title, abstracts, and full text at different stages, only 10 highly relevant studies were included in this study. In 2021, a study conducted by Abdelgawad *et al.*^[19] on children with non-lesional epilepsy in Minya, Egypt, reported that volumetric MRI is extremely useful in the analysis of non-lesional pharmacoresistant childhood epilepsy. In another study, Samia *et al.* from Nairobi, Kenya, reported that the conventional MRI has potential to detect multiple clinical comorbidity in childhood epilepsy.^[20] Furthermore, Bernasconi *et al.* from Quebec, Canada, in 2019 reported that the structural MRI is very useful for the detection of non-invasive lesions in patients with epilepsy.^[21] Importantly, a study by Maqsood *et al.* from Jammu Kashmir, India, pointed

out that the conventional MRI is highly sensitive for the detection of epileptogenic materials, dysfunctionality in soft tissues and they reported that MRI is the best technique for the screening of pre-operative intractable epilepsy.^[22] Moreover, Ponnatapura *et al.* from Karnataka, India, in 2018 reported that MRI with dedicated seizure protocol is best for the detection of epileptogenic lesions in one half of the new-onset seizures in epilepsy patients.^[23] Furthermore, Zhao *et al.* from Hubei, China, reported that Magic TVs approach through conventional MRI improves the diagnosis of epilepsy by reducing negative outcomes.^[24] In another study, functional MRI found to be an important technique for the detection of hemodynamic and microstructural alterations in epileptogenic lesions.^[25] In addition, another study showed that the structural MRI technique has potential for the analysis of mesial temporal sclerosis and malformations of cortical development in epilepsy patients.^[26] In another study, cranial MRI technique was found to be useful for presenting findings in electroencephalographs in patients with pre-operative epilepsy.^[27] Moreover, conventional MRI was also found to be an important for the detection of focal ictal discharges in patients with scalp electroencephalograms epilepsy.^[28] All these data clearly pointed out that all types of MRI whether perform alone or in combinations with other techniques are extremely useful for the screening of intractable epilepsy.

Conclusions

The applicability of magnetic resonance imaging for the diagnosis of epilepsy is highly accessible in all over the globe. With the advancement in the MRI technique, this can be also applying with additional approaches. The functional MRI has now becoming more and more critical in the diagnosis and management of highly complicated epilepsy patients. The outcomes of this systematic review clearly point out that the MRI is a choice technique for the evaluation of epileptogenic lesions. The pooling of selected studies clearly indicating that the MRI-based surgical approaches provide three-dimensional pictorial details with superimposed real-time surgeons pointer information for the epilepsy patients, which already been proved successful in epilepsy surgery. In addition, the data also pointed out that MRI-based approach is also very useful for post-operative epilepsy patients as it gives information about the quality of the surgery. In short, the MRI-based therapies are extremely valuable for the management of patients with epilepsy.

Authors' Declaration Statements

Availability of data and material

The data used in this study are available and will be provided by the corresponding author on a reasonable request.

Competing interests

None.

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