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ORIGINAL RESEARCH

Low-Field Magnetic Resonance Imaging Findings in Children with Seizures in Ibadan, Nigeria

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Abstract

Background: Seizure is the most common neurological disorder in children and an important cause of paediatric hospital admission with the highest prevalence in the under-five age group. Magnetic Resonance Imaging (MRI) is the neuro-imaging technique of choice in the initial evaluation of children with epilepsy. High-field MRI is the ideal imaging modality for evaluating seizures but this is not readily available in developing countries.
Objective: To analyse the spectrum of MRI findings in children presenting with seizures using a low-field (0.36T) MRI.
Methods: Children aged ≤18years with seizures, with cranial MRI at the University College Hospital (UCH), Nigeria between January 2013 and June 2015 were retrospectively reviewed.
Results: There were a total of 134 patients with 53% as adolescents and most of them (85; 63.4%) had abnormal cranial MRI findings. More male children had abnormal findings (52; 61.2%) and most abnormal findings (42; 49.4%) were reported among adolescents. The most frequent abnormality was hydrocephalus (23.5%) from various causes followed by cerebral tumours (14.1%) and ischaemic cerebral infarcts (11.8%). In the adolescents, intracranial tumours (21.4%) were the most frequent abnormal findings, while hydrocephalus was commoner in children aged less than 10 years, accounting for 33.3% and 36.0% among the 1-5 years and 6-11 years age groups respectively.
Conclusion: Low-field MRI, which is more readily available, can provide substantial preliminary findings to aid the management of children with epilepsies. Improved access to high-field MRI through cost reduction and early MR imaging evaluation in the course of illness are desirable.

Keywords: Adolescents, Brain tumours, Children, Magnetic Resonance Imaging, Seizures.

Introduction

A seizure is a brief manifestation of signs and symptoms which result from disproportionate or synchronous neuronal activity in the brain. [1] It is a major public health problem, especially in resource-poor countries where it is associated with a high prevalence, social stigma and negative cultural beliefs resulting in potentially severe consequences. [2]

A seizure is the most common neurological disorder in children and an important cause of paediatric hospital admission with the highest prevalence in the under-five age group. [3] Up to 10% of children would have experienced at least one seizure before their sixteenth birthday while one-fifth of those with unprovoked seizure will progress to epilepsy. [4] Paediatric seizure has a global burden of 10.5 million, and about 90% of these children are found in developing countries. [5] The high proportion of seizures particularly in sub-Saharan Africa has been attributed to the high burden of prenatal and perinatal factors, predominantly birth asphyxia and central nervous system (CNS) infection. However, febrile convulsion is the commonest cause of seizures in the under-five age group. [6] Structural abnormalities due to congenital or vascular disorders, arteriovenous malformation, mesial temporal sclerosis, neoplasms, and malformations of cortical development could also be demonstrated in some cases. [7, 8] Many of these structural abnormalities could be cured and the patients become seizure-free.

Neuroimaging has revolutionized the management of seizure disorders. The evaluation of childhood seizure is dependent on the clinical manifestation, the age of the patient, associated disorders and the type of seizure.

Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) have significantly contributed to the understanding of the pathophysiologic mechanisms that underlie the development of epilepsy with MRI being the clinical imaging modality of choice globally [8-10] In many Low and Medium-Income Countries (LMICs), with limited funds and resources, the use of high-field MRI, PET or SPECT is greatly hindered. Ultrasound scan, which is cheap and widely available in these countries, has limited applicability beyond neonates and infants and useful only for the determination of pathologies like intracranial haemorrhage, intracerebral abscess, hydrocephalus and some congenital anomalies. [8]

Although Computed Tomography (CT) is relatively more widely available in some countries, its use is limited in the imaging of seizures in children because of its poor soft-tissue resolution and high radiation dose; these are of particular concern in children. [8] However, it is still the first imaging technique to be considered in emergencies and trauma-related seizures. [8] The global standard for imaging seizure disorders remains the high-field MR systems but these are not widely available in most developing nations due to prohibitive costs of acquisition and maintenance. [9] Most facilities in LMICs, therefore, rely on the use of low-field MR systems for seizure imaging as it serves as a good alternative and provides an opportunity to identify about 30-40% of epilepsy cases that are drug-resistant and may benefit from functional neurosurgery. The latter offers a potential cure through resection if the seizure focus can be localized. Therefore, imaging is critical to potentially identifying the aetiology of seizure activity and guiding therapy. [9-11]

This study describes the spectrum of abnormal MRI findings in paediatric seizure disorder using a low-field MRI system and highlights the relative usefulness of this procedure in paediatric seizure imaging, evaluation and management.

Methods

This is a retrospective study of paediatric patients aged between 0 and 18 years with seizures, who had cranial MRI at the Department of Radiology of the University College Hospital, Ibadan, Nigeria between January 2013 and June 2015. The MRI was performed using 0.36T Magnetic Resonance machine (MagSense 360, Mindray). Each examination was performed using a standard MRI protocol for seizures: 3mm axial

and coronal T1weighted (T1W), T2weighted (T2W), fluid attenuation recovery (FLAIR), inversion recovery sequences, diffusion-weighted (DW)/ apparent diffusion coefficient (ADC) and susceptibility-weighted (SW) sequences were obtained. All the patients provided written informed consent.

The age, sex and clinical presentation were obtained from the request cards. The patients were grouped into three categories based on their ages: 1-5 years, 6-11 years and 12-18 years. The following data were retrieved from the patients' individual MRI reports; the presence of tumours, hydrocephalus, white matter changes, cortical dysplasia, mesial temporal sclerosis, arteriovenous malformation, infarct, subdural collection, arachnoid cyst, porencephalic cyst, Dandy-Walker malformation and multiple lesions.

The data generated were analysed using the Statistical Package for Social Sciences (SPSS) software version 20 for Windows (SPSS Inc. Chicago, IL, USA.) IBM Corp. 2016 spreadsheet. Frequency tables, percentages and means ± standard deviation were used to present the results of the socio-demographic characteristics and MRI findings.

Results

A total of 134 paediatric patients presenting with seizures had cranial MRI during the study period. The male-to-female ratio was 1.5:1, most of the children (71, 53%) were adolescents in the 12-18 years age group. The lowest proportion was among under-five children who formed 17.9% (24/134) of the population as shown in Table I.

More than a third of the patients (53; 39.6%) had apparently normal MRI findings. Most abnormal findings (42; 49.4%) were reported in the 12-18 years age group, followed by the 6-11 years age group representing 29.4% (25/81) of the total abnormal findings. The under-five age group recorded the lowest proportion of abnormal findings (18; 21.2%). (Figure 1).

Most abnormal findings (52, 61.2%) were reported among male children while 33 (38.8%) of the abnormal findings were reported among females (Table II).

Table I: Age and sex distribution of children with seizures

Age group (Years)	*Sex*		
	Male (%)	*Female (%)*	*Total (%)*
0-5	18 (75.0)	6 (25.0)	24 (17.9)
6-11	19 (48.7)	20 (51.3)	39 (29.1)
12-18	44 (62.0)	27 (38.0)	71 (53.0)
Total	81 (60.4)	53(39.6)	134(100.0)

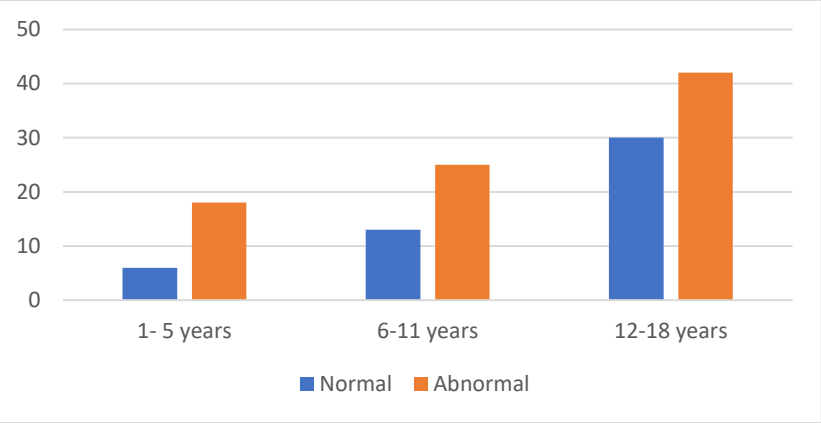

Figure 1: Proportion of children in the different age groups with normal and abnormal MRI findings

Table II: Gender distribution of the MRI findings

Sex	*MRI Findings*		
	Normal (%)	*Abnormal (%)*	*Total*
Male	29(59.2)	52 (61.2)	81 (60.4)
Female	20 (40.8)	33 (38.8)	53 (39.6)
Total	49 (100.0)	85(100.0)	134(100.0)

The most frequent abnormality on MRI was hydrocephalus (20/85; 23.5%) followed by intracranial tumours and cerebral infarcts representing 14.1% and 11.8% respectively. Focal cortical defects and arachnoid cysts (Figure 2) were the least common findings, representing 1.2% each of the total abnormal findings (Table III).

In the adolescent group (12-18 years), intracranial tumours (Figures 3) were the most frequent abnormal finding (9; 21.4%) cases. This was followed by hydrocephalus, periventricular leukomalacia and cerebral infarct with 11.9% each (Table IV). In the 6-11 years age group, hydrocephalus was the most frequent disorder (9; 36%), followed by ischaemic infarcts (3; 12.9%), intracranial tumours and cerebral abscess in 8.0% each (Table IV, Figures 3 and 4). The most frequent abnormal finding in the under-five age group was hydrocephalus (6; 33%), followed by encephalomalacia (2; 11.1%) and cerebral infarcts (2; 8.0%) (Table IV).

Discussion

In this facility-based, retrospective study, childhood seizures were more common among males by a third. This finding was in concordance with reports by Amisalat, *et al.* [12] Anand, *et al.* [13] and Ndubuisi, *et al.* [10] in Iran, India and Nigeria respectively. However, it was at variance with the study by Kim, *et al* [14] in Korea, where a female preponderance with a male-to-female ratio of 1: 1.75 was reported. Kalnin, *et al.* [15] Mung'Ala-Odeha, [6] and Aaberg, *et al.* [5] did not record any sex difference in their studies. The reason for the higher proportion of boys in this study remains unclear.

The incidence of seizures is consistently reported to be highest in the first year of life and declines to adult levels by the end of the first decade. [6,12] This is supported by the findings from the study of Aaberg, *et al* [5] and Anand, *et al* [13] who recorded the highest frequency in children in their first year of life and the 0-3year age group respectively. However, most of the children with

seizures in this study were in the adolescent group while the least number was found in the 0-5 years age group, similar to the findings of Ndubuisi, *et al* [10] in a similar population, Kim, *et al* [14] and Chaurasia, *et al* [16], with the highest frequency found in the age groups above 10 years.

Table **III: Pattern of abnormal cranial MRI findings in children with seizures**

Abnormal Findings	*Frequency*	*Percentage*
Hydrocephalus	20	23.5
Tumour	12	14.1
Cerebral Infarct	10	11.8
Periventricular leucomalacia	7	8.2
Encephalomalacia	6	7.1
Encephalitis	5	5.9
Brain abscess	5	5.9
Porencephaly	4	3.5
Arnold Chiari malformation	2	2.4
Subdural Collection	2	2.4
Arteriovenous Malformation	2	1.2
Brain atrophy	2	1.2
Focal cortical dysplasia	1	1.2
Arachnoid cyst	1	1.2
Multiple lesions	6	7.1
Total	85	100

Table **IV: Distribution of abnormal cranial MRI findings according to age groups**

Abnormal findings	*Age groups (Years)*		
	0-5	***6-11***	***12-18***
	n (%)	***n (%)***	***n (%)***
Hydrocephalus	6 (33.3)	9 (36.0)	5 (11.9)
Tumour	1 (5.6)	2 (8.0)	9 (21.4)
Ischaemic Infarct	2 (11.1)	3 (12.0)	5 (11.9)
Periventricular leucomalacia	1 (5.6)	1 (4.0)	5 (11.9)
Encephalomalacia	2 (11.1)	1 (4.0)	3 (7.1)
Encephalitis	1 (5.6)	1 (4.0)	3 (7.1)
Brain abscess	1 (5.6)	2 (8.0)	2 (4.8)
Porencephaly	0 (0.0)	1 (4.0)	3 (7.1)
Arnold Chiari malformation	0 (0.0)	1 (4.0)	1 (0.7)
Subdural Collection	1 (5.6)	0 (0.0)	1 (2.4)
Arteriovenous Malformation	0 (0.0)	1 (4.0)	1 (2.4)
Brain atrophy	0 (0.0)	1 (4.0)	1 (2.4)
Focal cortical dysplasia	0 (0.0)	0 (0.0)	1 (2.4)
Arachnoid cyst	0 (0.0)	0 (0.0)	1 (2.4)
Multiple lesions	3 (16.7)	2 (8.0)	1 (2.4)
Total	18 (100)	25 (100)	42 (100)

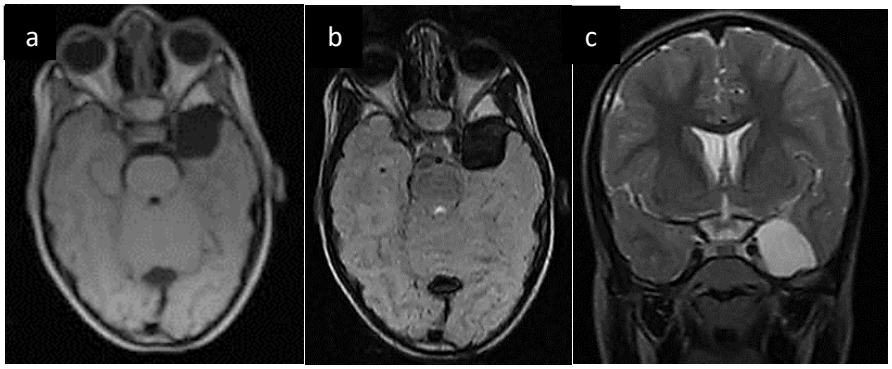

Figure 2: A 13-year-old boy presenting with simple partial seizures from the age of 1 year 5 months. MRI shows a cystic mass in the left temporal lobe consistent with an Arachnoid Cyst. (a) Axial T1W MRI sequence and (b) Axial FLAIR images showing the cyst with fluid intensity (c) Coronal T2W MRI sequence of the brain shows the lesion as hyperintense.

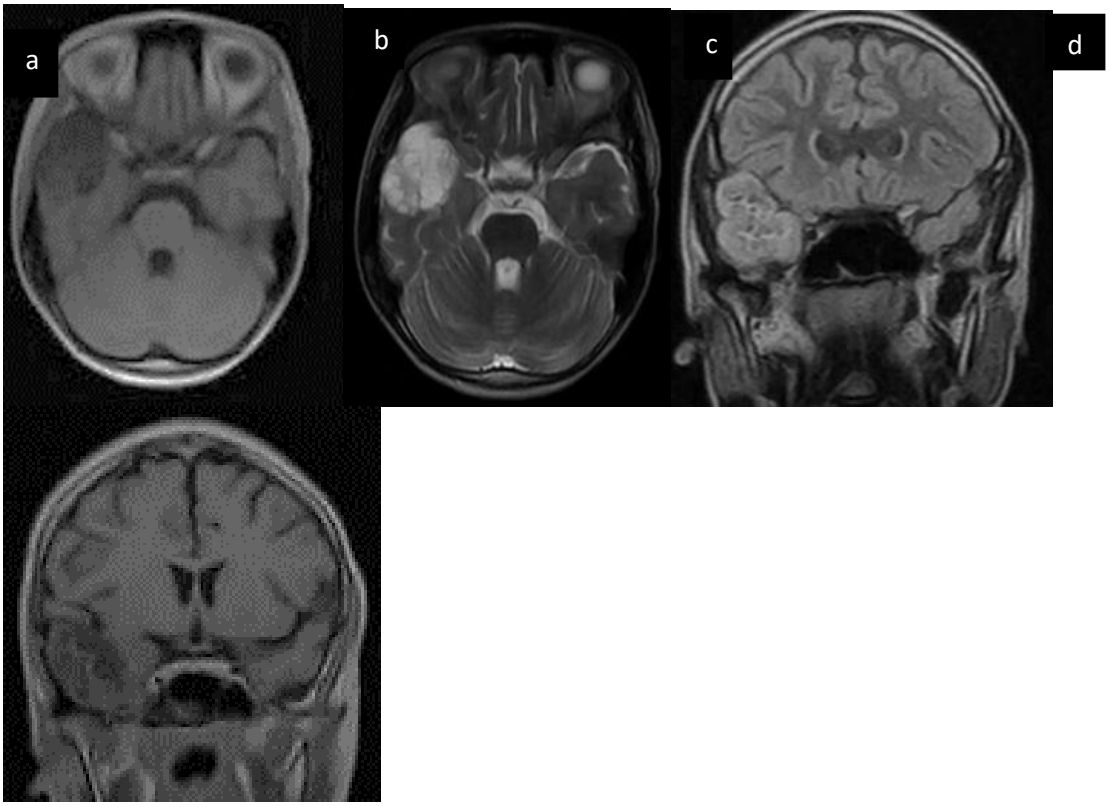

Figure 3: A 12-year-old female who presented with recurrent partial seizures of 4-year duration. MRI shows a heterogeneously enhancing bubbly cystic lesion in the right temporal lobe with features suggestive of Dysembryoplastic Neuroepithelial Tumour (DNET). (a) Axial T1W MRI- A hypointense lesion in the right temporal lobe. (b) Axial T2W MRI- The mass is heterogeneous but mostly hyperintense. (c) Coronal FLAIR it appears isointense to the brain (d) Post-contrast coronal T1W. The mass shows heterogeneous enhancement.

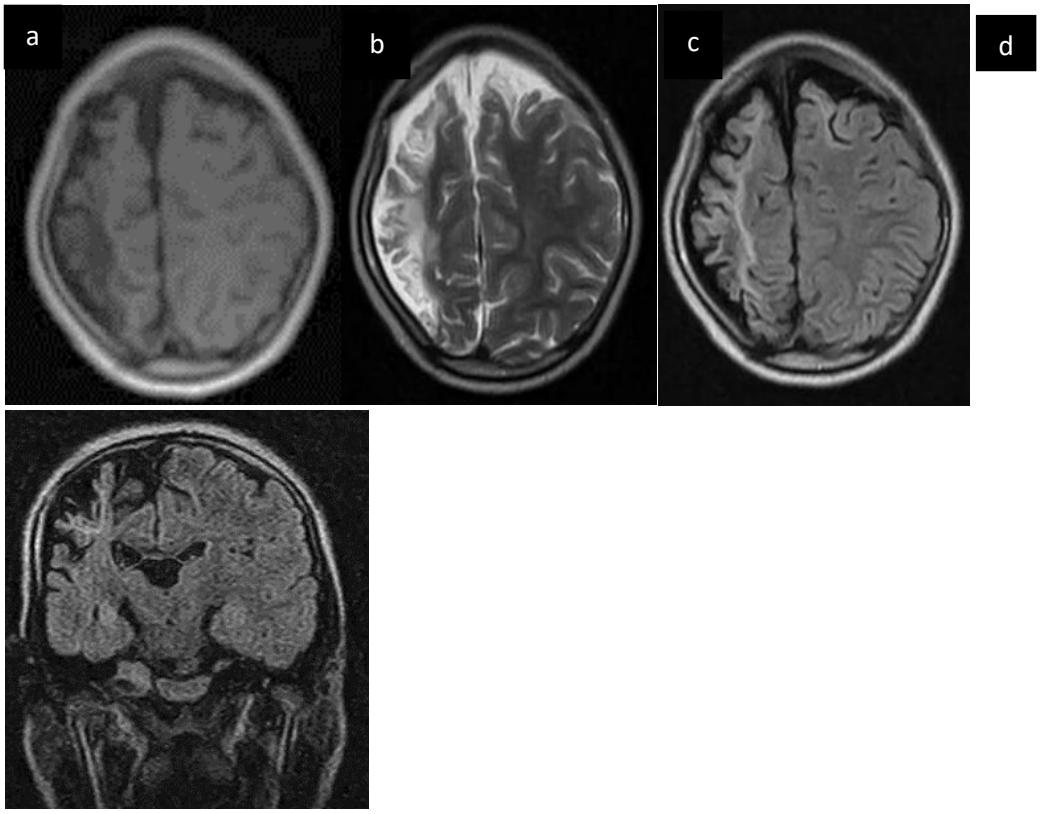

Figure 4: A 9-year-old male child presented with recurrent seizures with associated left hemiparesis of 8-year duration. MRI showed generalized cerebral atrophy (right more than left) likely due to ischaemic insult involving the right Internal Carotid Artery. (a) Axial T1W MRI (b)Axial T2W MRI (c) Axial FLAIR and (d) Coronal flair sequences of the brain, all showing generalized cerebral atrophy evidenced by a generalized widening of the CSF spaces and prominence of the sulci, more severe on the right.

The higher frequency in the adolescents in the present study may be due to late presentations to the hospital. This could be related to the high cost of investigations such as MRI in the study setting since most people make out-of-pocket payment for health services, hence affordability may be a major challenge.

In the evaluation of paediatric patients with a seizure disorder, it is important to arrive at an accurate diagnosis to enable proper management of the patient. Even though MRI is the gold standard neuroimaging modality in seizure management, it has a limitation in the fact that between 10% and 40% of subtle epileptogenic structural abnormalities might still be missed on MRI. [17,18] It has been reported that the inability to detect a lesion on MRI is a strong predictor of worse treatment response. This is because some of the leading causes of medically refractory or cryptogenic and surgically correctable epilepsy in children and adults are focal cortical defect (FCD) and mesial temporal sclerosis (MTS), which are more often than not detectable only on higher field strength MR (≥1.5T). [18-20] This was observed in previous studies where findings on 3-Tesla MRI was compared to those on 1.5-Tesla MRI.[18, 21-24] Low-field strength MRI such as the one used for the present study is not able to detect subtle abnormalities like MTS and FCD, but obvious pathologies such as tumours, cerebral ischaemia, congenital malformations and infections can be still diagnosed. This is well demonstrated in the present study. Also, low-

field MRI is more sensitive than CT in the evaluation of patients for structural abnormalities, but in the absence of MRI, CT may detect gross structural pathologies. [9, 11]

Abnormal MRI findings were detected in 60.4% of the children in this study with only one case of FCD diagnosed but none of MTS., This pattern was attributed to the low-field strength (0.36T) used. Ndubuisi, *et al* [10] in a similar study conducted in Nigeria, detected abnormal findings on neuroimaging in 51.8% of the children, but no case of FCD or MTS was recorded. Anand, *et al.* [13] recorded a higher percentage of 84% with positive MR images and they were able to detect cortical defects in 13.1% of the children studied. Ahiuwalia, [24] *et al.* recorded abnormal MR findings in 48.1% of cases, of which MTS and FCD accounted for 13.65% and 5.73% respectively. The reason for this high rate of detection of FCD and MTS is no doubt due to the higher field strength (1.5T) used by the previous authors. On the contrary, Chaurasia, *et al* [16] found positive MRI in 70.4% cases but no case of FCD or MTS was reported. Although the strength of the magnetic field was not documented in the latter study, it is not entirely clear whether low-field MRI, when reviewed with EEG findings, could produce an increased yield of more positive findings. [25] Nevertheless, the use of higher field MR contributes to better diagnosis and outcomes. This is obvious in the western world where access to advanced tools is feasible. [26, 27]

Kalnin, *et al.* [15] who used 0.5-1.5T MR in their study recorded a lower proportion of positive MR findings of 31%, with no evidence of cortical defects, while Berg, *et al.* [28] found only 12.7% positive findings on MR. The reason for this low proportion might be because the patients presented after their first seizures. Some studies have reported that the presence of a lesion on MRI is associated with continuing seizures at follow-up. [15] Wellmer, *et al.* [29] in their study suggested that possible reasons for undetected epileptic lesions in standard out-patient MRI could be due to (1) insufficient clinical focus hypotheses from the referring neurologists, (2) the lack of optimization of "standard head" protocols for the spectrum of epileptogenic lesions and (3) unfamiliarity with the spectrum of epileptogenic lesions.

The most frequent anomalies in this study were hydrocephalus and tumours. This finding is similar to the report of Kalnin, *et al.* [15] who detected ventricular enlargement in 51% of the cases studied but followed by encephalomalacia rather than tumours. Ndubuisi, *et al.* [10] in Nigeria recorded tumours as the commonest finding and this was closely followed by vascular lesions. Chaurasia, *et al.* [16] and Anand, *et al*. [13] both from India, reported infections and infestations as their commonest findings, with tuberculosis and neurocysticercosis topping the list. Another study which was done earlier from our centre by Osuntokun, *et al*. [30] also reported infection as the commonest positive findings. This was attributed to poor sanitation and low socio-economic status that is still dominant in developing countries, especially in the tropics. Infections were found in only 11.8% of the cases in the present study. The reason for the few cases of infections in the present study is likely due to poor referral for MRI because of the cost implications to the patients who are most at risk of such infections and infestations.

Most of the positive findings in the present study were recorded among adolescents and the most frequent abnormality was brain tumour followed by cerebral infarction. Ndubuisi, *et al.* [10] also documented the highest rate of positive findings among adolescents, with tumours taking the lead among them. The commonest aetiology reported by Owolabi, *et al.* [31] from the same centre were cerebral infarction and brain tumours, even though that was a study done among adults. This shows that adolescents and adults may have

similar aetiologies for seizures in Ibadan, Nigeria. However, it is at variance with the report by Chaurasia, *et al.* [16] from India who recorded infections as the commonest aetiology in adolescence. The differences might be due to the peculiar characteristics of the studied population.

Conclusion

Access to high-field MRI in LMICs like Nigeria is a major challenge. Low-field MRI, which is generally more available, is capable of providing substantial preliminary findings to aid the management of children with epilepsy. Improved access through cost reduction and early evaluation using MR imaging in the course of illness may enhance clinical decision making for children with seizures in Nigeria, sub-Saharan Africa and other LMICs. While high-field MRI, PET and SPECT are the gold standards in the diagnosis and management of childhood seizures, low-field MRI still has a role to play in a resource-limited environment as many structural abnormalities can be detected and this may enhance clinical decision making for children with seizures in sub-Saharan Africa.

Authors' Contribution: AAJ and OGI conceived and designed the study. AAJ and FID did literature review while FID participated in data acquisition and analysis. All the authors participated in manuscript drafting and revision for sound intellectual content. All the authors approved the final version of the manuscript.
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