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Diagnostic yield of magnetic resonance (MRI) imaging and treatment outcomes in patients with spinal cord trauma in, Nigeria: A single centre study

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Abstract
Background: Spinal cord trauma (SCT) is a devastating condition that can lead to significant neurological impairment and reduced quality of life. Magnetic Resonance Imaging (MRI) has been playing an increasingly important role in the management of spinal trauma patients. This study was designed to determine diagnostic yield of magnetic resonance imaging and the relationship between MRI findings and treatment outcomes in patients with trauma to the spinal cord.
Materials and Method: A total of 245 patients who meet the inclusion criteria had their records and MRI findings evaluated retrospectively using convenience sampling method. The quantitative parameters that were used included: maximum spinal cord compression (MSCC), maximum canal compromise (MCC) and length of lesion while the qualitative parameters used are; intramedullary haemorrhage, cord oedema, cord swelling, disc herniation and soft tissue injury. Data such as cause of injury, anatomical level of injury, associated injury, and time of presentation, neurological/clinical presentation, and patterns of treatment, duration of hospitalization, ASIA classification and treatment outcome were collected.
Results: The majority 53.47% (n = 131) had cervical spine involvement. Greater proportion 61.22 % (n=150) of spinal cord injuries were caused by road traffic accident (RTA). Most of the patients 33.06% (n=81) had only haemorrhage. Majority 51.02% (n = 125) had ASIA A and the least 4.49% (n = 11) had ASIA E classification. Among ASIA A patients, 21.63% (n = 53) had only haemorrhage while 29.39% (n= 72) had both haemorrhage and Oedema. Out of 53 ASIA A patients that had only haemorrhage, 21.57% (n = 11) of the ASIA A patients had incomplete recovery while 78.43% (n = 42) had no recovery. Out of the 72 ASIA A patients that had both haemorrhage and oedema, 18.06% (n = 13) had incomplete recovery while 81.94% (n = 59) had no recovery.
Conclusion: The majority of the patients had cervical spine cord injuries and RTA was the most common causes of spinal cord injuries. Most of the patients had ASIA a classes of spinal cord injuries with more of them having only haemorrhage. The patients' recovery rate was very poor across all the various classes of ASIA and MRI has shown to be good prognostic tools for the evaluation of spinal cord injuries.

Keywords: Haemorrhage, magnetic resonance imaging, spinal cord, trauma

Introduction
Spinal cord trauma (SCT) is a devastating condition that can lead to significant neurological impairment and reduced quality of life. Despite advancements in our understanding of the pathophysiology and secondary trauma mechanisms involved in spinal cord trauma, there are currently very few effective treatments for this condition. Spinal cord trauma mainly affects young people mostly males [1] causing significant morbidity with huge human and economic losses. It is estimated that there are forty thousand patients in the United Kingdom with spinal cord trauma giving a prevalence of one in one Thousand, Five Hundred [0.7%]. There are about Eight Hundred new patients presenting with spinal cord trauma annually in the UK whereas, in the United States, Ten Thousand to Twelve Thousand, Five Hundred new cases per year are recorded [2]. There is paucity of comparative epidemiological data on the incidence and prevalence of SCI in Nigeria because mainly of lack of 'case' registers at local, state and federal levels. Also, census figures in Nigeria are always controversial [1].

Depending on the extent of damage, spinal injuries can be classified into complete and incomplete. Complete when there is absence of sensory and motor functions in the lowest sacral segments and incomplete when there is preservation of sensory or motor functions below the level of trauma including the lowest sacral segments [3]. In the past twenty years, imaging technology has revolutionized medical care, establishing radiologic evaluation as a vital part of patient management. General practitioners, as well as medical and surgical subspecialist now rely heavily on imaging to establish and confirm diagnoses and plan treatments [4].

Magnetic resonance imaging (MRI) is an essential imaging modality of choice for the evaluation, diagnosis and management of patients with spinal trauma injuries. Notably MRI is the modality of choice for evaluation of ligamentous and other soft tissue structures, disc, spinal cord, and occult osseous injuries [5]. Standard structural MRI sequences including T1 and T2 weighted spin-echo and fast spin-echo (spoiled), gradient echo and contrast-enhanced images provide the majority of information required for detecting and characterizing spinal pathology and achieving a differential diagnosis.

In Nigeria, according to National Bureau of Statistics (NBS) and Federal Road Safety Corps (FRSC) report of Quarter two (Q2) in 2020, there is an increase in the rate of road traffic accident [6]. This has led to increased number of patients with trauma to the spinal cord. However, there are inadequate documented research findings on the relationship between MRI investigations and treatment outcomes in patients with spinal cord injury in our setting. The aim of this study was to establish the diagnostic yield of magnetic resonance imaging (MRI) and the relationship between MRI findings and treatment outcomes in patients with trauma to the spinal cord in our setting.

Materials and Methods

Study Design and population

This retrospective study was conducted to include patients' records with spinal cord trauma in a tertiary hospital in Nigeria. Cases of spinal cord injuries diagnosed with MRI from 2015 to 2021 were retrieved from medical records. Permission for the collection of data was obtained from the management of the study centre.

Sample size determination and sampling method

Preliminary review into medical records of patients with trauma to the spinal cord from 2015 to 2021 in the study centre indicates that an average total of 638 patients had MRI investigations for SCT and were subsequently admitted. The sample size was deduced from Taro Yamane's formula cited by in Uko *et al* [7] study as below

$n=N/1+N\ (e)^{2}$ where n= sample size; N= Total population of the area under study; e= error limit or margin of error, it is usually accepted at 5% or 0.05 {i.e confidence level at 95% (0.05)}.

For this study, N= 638.

$n= 638/1+638\ (0.05)^{2}$

$n= 638/1+638\ (0.0025)$

$n=638/1+1.60$

$n=638/2.60$

n= 245

Therefore, a sample size of 245 was used for this study. The patients' data were selected using convenience sampling having met the selection criteria for the research. Patients admitted in the hospital were selected. The data were collected by retrieving patient treatment folders, their MRI reports and archived images.

Inclusion and exclusion Criteria

The inclusion criteria are patients with spinal cord trauma, patients who had MRI examinations to assess the spinal cord injury, patients whose cases occurred within 2015 and 2021, patients who were admitted and given adequate treatment, patients whose recovery patterns within 3months was clearly understood, patients who had follow-ups after recovery. The following were the exclusion criteria; patients who had trauma to the spinal cord but did not undertake MRI investigation, patients admitted earlier than 2015, patients whose pattern of treatments could not be verified, patients whose recovery patterns after 3months could not be assessed, patients whose time of recovery was not specified

Instruments and procedures for data collection

Data for the study were collected from two different sources

1. MRI reports from patients images.
2. Treatment folders of same patients.

Method of data collection

A total of 245 patients who met the inclusion criteria had their records and MRI findings evaluated. Data were collected by retrieving patients' records and MRI reports from their folders at medical records department. The quantitative parameters that were used include: maximum spinal cord compression (MSCC), maximum canal compromise (MCC) and length of lesion while the qualitative parameters used are; intramedullary haemorrhage, cord oedema, cord swelling, disc herniation and soft tissue injury. The following useful information were retrieved from the patient's folder: cause of injury, anatomical level of injury, associated injury, and time of presentation, neurological/clinical presentation, and patterns of treatment, duration of hospitalization, ASIA classification and treatment outcome. Recovery will be classified as either complete recovery or incomplete recovery.

Method of data analysis

The data from MRI reports showed 3 quantitative imaging parameters and 5 qualitative parameters for diagnosis and assessment of patient conditions.

Quantitative parameters included

1. Maximum spinal cord compression (MSCC)
2. Maximum canal compromise (MCC)
3. Length of lesion.

Qualitative measures included

1. Intramedullary haemorrhage
2. Cord oedema
3. Cord swelling
4. Disc herniation
5. Soft tissue injury

However, this study was limited to using intramedullary haemorrhage and cord oedema as vital MRI findings in order to avoid ambiguity because of ease of understanding of the diagnostic value of these two parameters.

The following data was useful from the patient's treatment folder

1. Cause of injury
2. Level of injury
3. Associated injury
4. Time of presentation
5. Neurological/ clinical presentations
6. Patterns of treatments
7. Duration of hospitalization
8. Outcome of treatment

On admission, patients were put on neurological functionality test. This enabled the following classifications based on ASIA (American Spinal cord Injury Association) classification for spinal injury.

1. ASIA A- No sensory and/ or motor functions.
2. ASIA B-Sensory functions only.
3. ASIA C-Some sensory and motor functions observed with $^{3}/_{5}$ graded functionality in ½ muscles evaluated.
4. ASIA D-More than $^{3}/_{5}$ graded functionality in ½ of muscles evaluated.
5. ASIA E- Normal sensory and motor functions.

The study was able to use this pattern of data analysis to arrive at a presentation that will compare the classification based on MRI findings and neurological presentation first independently and then combined.

Classification of recovery (based on prognosis) was grouped into

1. Complete recovery
2. Incomplete recovery
3. Slow or fast recovery
4. No recovery

Data collected was analysed using the statistical package for social sciences (SPSS) version 22. Results were presented in frequency tables. Statistical inferences were drawn at $p< 0.05$.

Results

Demographic variable of the patients

Most of the patients 35.10% (n = 86) were within the age group of 38-47 years, followed by age group 48 – 57 years 15.51% (n = 38) and the least were within age group 28 – 37 years and 58 – 67 years, which was 10.20% (n = 25) each respectively (Table 1). Out of 245 patients, male accounted for 68.98% (n = 169) while the remainder were females 31.02% (n = 76) (Figure 1).

Magnetic resonance imaging findings in patients with trauma to the spinal cord

From Table 2, out of 245 patients, the majority 53.47% (n = 131) had cervical spine involvement and the least 21.22% (n = 52) had thoracic spine involvement. Out of 245 cases of spinal cord injuries, greater proportion 61.22 % (n=150) were caused by road traffic accident (RTA) and the least 6.13% (n = 15) of the spinal cord were caused by gunshot (Table 3).The occurrence of haemorrhage and oedema was evaluated and the results revealed that most of the patients 33.06% (n=81) had only haemorrhage and the least 2.04% (n=5) neither had hemorrhage nor oedema (Table 4).

Based on ASIA classification pre-treatment, out of 245 patients, majority 51.02% (n = 125) had ASIA A and the least 4.49% (n = 11) had ASIA E classification (Table 5). With regards to the diagnostic yield of MRI (findings) of the different ASIA classifications, among ASIA A patients 21.63% (n = 53) had only haemorrhage while 29.39% (n= 72) had both haemorrhage and Oedema. Among ASIA B patients, 7.35% (n = 35) had only haemorrhage (Table 6).

Patient's treatment outcomes based on MRI findings and ASIA classification, results showed that out of 53 ASIA A patients that had only haemorrhage, 21.57% (n = 11) of the ASIA A patients had incomplete recovery while 78.43% (n = 42) hand no recovery. Out of the 72 ASIA A patients that had both haemorrhage and oedema, 18.06% (n = 13) had incomplete recovery while 81.94% (n = 59) had no recovery. Among 18 ASIA B patients that had only haemorrhage, 33.33% (n = 18) of the patients had complete recovery while 66.67% (D = 12) of patients had no recovery at all. Among the seven ASIA B patients that had both haemorrhage and edema, 100% (n=7) of them had incomplete recovery (Table 7).

The results of treatment outcomes and recovery of the patients in table 4.8, showed that out of 245 patents, the majority 46.12% (n = 113) of the patients did not recover while the least 18.78% (n = 46) of the patients had incomplete recovery (Table 8).

The result of ASIA classification of the patients after treatment revealed that, out of 245 patients, the majority 41.63% (n = 102) of the patients did not recovered (ASIAA) and the least (1.23% (n = 3) of the patients had ASIA D (Table 9).

Table 1: Age distribution of the patients

Age Range	Frequency	Percentage %
18-27	36	14.69%
28-37	25	10.20%
38-47	86	35.10%
48-57	38	15.51%
58-67	25	10.20%
68>	35	14.30%
Total	245	100%

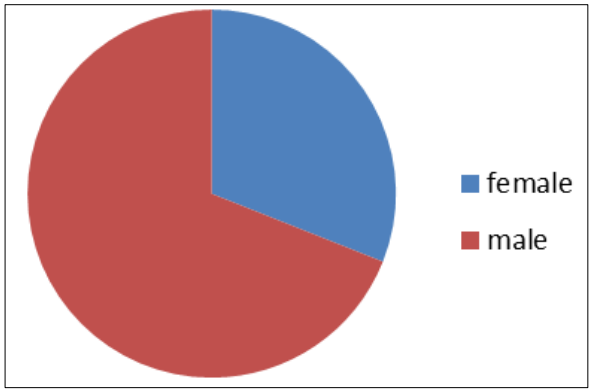

Fig 1: Sex distribution of the patients

Table 2: Frequency Distribution of the Spinal Segment

Spinal Segment	Frequency	Percentage (%)
Cervical	131	53.47
Thoracic	52	21.22
Lumbar	62	25.31
Total	245	100

Table 3: Causes of Spinal Cord Injuries

Cause	Frequency	Percentage (%)
RTA	150	61.22
Fall	49	20
Gunshot	15	6.13
Others	31	12.65
Total	245	100

Table 4: Total of occurrence of haemorrhage and Oedema based on MR1 findings

Qualitative parameter	Number of patients	Percentage (%)
Haemorrhage only	73	29.80%
Oedema only	81	33.06%
Haemorrhage + Oedema	86	35.10%
No Haemorrhage nor Oedema	5	2.04%
Total	245	100%

Table 5: ASIA classification pre- treatment

classification	frequency	percentage %
ASIA A	125	51.02%
ASIA B	60	24.49%
ASIA C	20	8.16%
ASIA D	29	11.84%
ASIA E	11	4.49%
TOTAL	245	100%

Table 6: Diagnostic yield of MR1 (Findings) of the different ASIA classifications

Classification	Haemorrhage only		Oedema		Haemorrhage +oedema		No haemorrhage +No oedema	
	No of Patients	%	No of patient	%	No of Patients	%	No of Patient	%
ASIA A	53	21.63%	-	-	72	29.39%	-	
ASIA B	18	7.35%	35	14.29%	7	2.85%	-	
ASIA C	-	-	20	8.16%	-	-	-	4.49%
ASIA D	-	-	29	11.84%	-	-	-	
ASIA E	-	-	-	-	-	-	11	
TOTAL	71	28.98%	84	34.29%	79	32.24%	11	4.49%

Table 7: Patient treatment outcomes (patients recovery) based on MR1 finding and ASIA classifications

	Haemorrhage	Oedema		Haemorrhage + Oedema			No Habior Rhage+ Oedema			
	Recovery	Recovery		Recovery			Recovery			
Class	Complete	In complete	No recovery	complete	In complete	No recovery	complete	In complete	No recovery	Complete
ASIA A	-	11	42		-	-	-	13	59	-
ASIA B	6		12	22	13	-		7	-	
ASIA C	-	•	-	IS	2	-		-	-	
ASIA D	-	-		29	-	-	-	-		
ASIA E	-	-				-			-	11
Total	6	11	5I	69	15	-	-	20	59	11

Table 8: Total outcome of treatment of the patients

MR1 Findings		Recovery		
	No of patients	Complete	In complete	No recovery
1. Haemorrhage	71	6	11	54
2. Oedema	84	69	15	-
3. Haemorrhage + Oedema	79	-	20	59
4. Neither haemorrhage nor oedema	11	11	-	-
Total	245	86	46	113

Table 9: ASIA classification after treatment of the patients

Classification	Number of patients	percentage
ASIA A	11	46.12%
ASIA B	25	10.20%
ASIA C	18	7.35%
ASIA D	3	1.23%
ASIA E	86	35.10%
Total 245 100%		

Discussion

In this study, majority of the patients were young adults and males formed the greater proportion of the sample size studied. These findings could be ascribed to the fact that young adults and males constitutes the active unit of every society and involved in strenuous jobs, which exposes them the major causes of spinal cord injuries such driving, carpentering and militancy activities[8]. The different aspects of these findings are in agreement with of the findings of the studies conducted by Obalum *et al* [1], Kawu [9], Haar *et al* [10] and Nwadinigwe *et al* [11]. In Obalum *et al* [1] study, which was carried out retrospectively in Lagos State, Nigeria to evaluate the pattern and outcomes of spinal cord injuries, reported that your g adults were commonly affected with spinal cord injuries. Similar study by Kawu [9], reported that young adults with mean age of 38.9 ± 11.4 years and, males were commonly affected with spinal cord injuries. In Haar *et al* [10] study, which evaluated whether the qualitative and quantitative MRI assessment after acute traumatic cervical spinal cord injuries correlate with the patients neurological status, reported that out of 88 patients, 77 were males while 11 were females. Similarly, N wadigwe *et al* [11] in their study conducted in Enugu State, Nigeria, also reported higher male preponderance of spinal cord injuries. A greater number of the patients had cervical spinal cord injuries. This finding could be attributed to the fact that adults were most highly affected age group, which are usually active and involved in activities that pre-disposes them to spinal cord injuries. The finding is consistent with the findings of previous studies by N wadigwe *et al* [11] and Kawa [9], which also reported cervical spinal cord injuries to be the most prevalent cord injuries.

The majority of the spinal cord injuries cases in this study were caused by RTA. This is so because most drivers of buses cars motorcycle tricycle drives without observing the road safety rules [8].

This finding is in harmony with the findings of the studies conducted by Kawu [9] and Nwadiniwe *et al* [11], which also reported that RTA accounted for the highest percentage cause of spinal cord injuries. In a study by Kawu [9], RTA accounted for 79.7% of the total causes of SCI.

We found that most of the patients had only haemorrhage when compared to those with oedema only or combined. This finding is inconsistent with the finding of the studies conducted by Andreoli *et al* [12], Ramon *et al* [13], Shimada and Tokioka [14], which summarizes the MRI signal patterns and the degree of neurological improvement as measured by ASIA, reported 67% patients that had oedema as against the 22% of the patients that had prognosis of oedema is greatly better than for those with haemorrhage [12, 14]. The discrepancies noted our studies could be assorted to the different sample size and geographical variations of the different studies. Among the different categories of the patients included in this study based on ASIA classifications, majority of the ASIA A patients that had only haemorrhage and those that had both haemorrhage and oedema did not received after treatment. This means that the recovery of the patients after treatment was not absolutely dependent on the occurence of haemorrhage and Oedema especially among ASIA A patients. This finding is in agreement with the studies in Lagos State, Nigeria by Obalum *et al* [1] and Haar *et al* [10].

In Obalum *et al* [1] study, ASIA a patients had the lowest recovery rates and also Haar *et al* [10] in their study, which retrospectively evaluate whether the qualitative and quantitative MRI assessment after acute traumatic cervical spinal cord injuries correlate with the patient's neurologic status, reported that ASIA A patients had the lowest

recovery rate after treatment. According to Kalu *et al* [15] haemorrhage into the spinal cord in event of trauma is graul, leading to permanent neurological and motor impartment and disability while cases of only cord oedema can achieve complete recovery of sensory and motor functions.

Among the ASIA B patients, those with only cord oedema had complete recovery. This finding is in harmony with the observations developed by Kalu *et al* [15] and Andreoli *et al* [12], Ramon *et al* [13], Shimada and Tokioka [14]. In Kalu *et al* [15] study, they reported that patients with only cord oedema can achieve complete recovery of neurological and motor function. According to the independent research carried out by Andreoli *et al* [12], Ramon *et al* [13], Shimada and Tokioka [14] reported that the prognosis of patients with oedema is greatly better than those with haemorrhage. They attributed their finding to the fact that more abnormalities on MRI are associated with more neurologic status.

In addition Andreoli *et al* [12] in their study, which was conducted to determine the role of emergency MRI in the diagnosis of acute spinal cord injuries and established a strong correlation between MRI appearances of traumatic spinal cord injuries in acute phase and long term recovery of motor and sensory functions. They also observed that patients with initial hemorrhage hard poor prognosis whereas those with spinal cord oedema had a better treatment outcome. According Andreoli *et al* [12] and Kalu *et al* [15], MRI is very important in the initial assessment of unconscious patients who cannot undergo a motor and neurological evaluation due to its prognostic value, which usually aid physician in making management and treatments decisions.

Conclusion

The majority of the patients had cervical spine cord injuries and RTA was the most common causes of spinal cord injuries. Most of the patients had ASIA a classes of spinal cord injuries with more of them having only haemorrhage. The patients' recovery rate was very poor across all the various classes of ASIA and MRI has shown to be good prognostic tools for the evaluation of spinal cord injuries.

Conflict of interest

None declared among the authors

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