Original Research Paper

Volume - 13 | Issue - 03 | March - 2023 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Radio-Diagnosis

ROLE OF DIFFUSION WEIGHTED MR IMAGING AND APPARENT DIFFUSION COEFFICIENT FOR THE EVALUATION OF INTRACRANIAL MASS LESIONS

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ABSTRACT **INTRODUCTION:** A conventional magnetic resonance imaging (MRI)examination allows for visualization of a mass lesion, and provides us with information on mass location, its homogeneity and signal intensity however, DWIs and mass lesion apparent diffusion coefficient (ADC) could provide additional useful information in the differential diagnosis of patient with brain mass lesions. **Objectives:** To study the appearance and differentiation of various intracranial mass lesions of brain and on DWI and ADC. **METHODS:** In all patients detected to have intracranial mass lesions on MRI of the brain, at the Department of Radiodiagnosis, MMC&RI. The DWI findings will be noted and correlated with ADC and T2, FLAIR images. For evaluation of the brain, MRI will be performed using a 1.5 Tesla MRI scanner (GE medical systems). **RESULTS:** All cases (100%) of epidermoid and medulloblastomas showed true diffusion restriction. 100% GBM cases showed true restricted diffusion while none of the low-grade tumours showed diffusion restriction. All cases of arachnoid cysts showed low signal on DWI. And none of benign meningioma and schwannoma showed restriction diffusion. Positive correlation was found in the comparison of mean ADC values for high-grade gliomas (1.19×10-3 mm2/s±0.2) and metastasis (0.833×10-3 mm2/s±0.2), low-grade gliomas (1.34 × 10-3 mm2/s ± 0.2), and medulloblastomas (0.68×10-3 mm2/s ± 0.075). **CONCLUSION:** DWI and ADC is useful in the differentiation of various brain mass lesions, in grading brain tumours. The combination of routine image interpretation and ADC had a higher predictive value. The ADCs of glioma, metastasis, and meningioma are related to tumour cellularity. We believe that DWIs and ADCs can provide information useful to diagnose brain mass lesions that cannot be obtained with conventional MRI alone.

KEYWORDS : Diffusion Weighted Imaging; Apparent Diffusion Coefficient; Magnetic Resonance Imaging; Diffusion restriction; T2 shine through infarct, abscess, epidermoid, meningioma.

INTRODUCTION:

Diffusion magnetic resonance imaging (MR) utilizes the Brownian motion of molecules to derive images. In acute stroke, Diffusion weighted imaging (DWI) demonstrates decreased diffusion in a vascular territory affected by ischemia.

Similarly, decreased diffusion is present in the centre of pyogenic abscesses and aids in the MR diagnosis of a ring-enhancing cerebral mass. In addition, tumours such as lymphoma and primitive neuroectodermal tumour (PNET) also demonstrate decreasing diffusion, adding valuable information to the radiologist when formulating a differential diagnosis of a cerebral mass lesion. There are also growing applications in differentiating tumours such as glioblastoma primary cerebral lymphoma, and metastasis.3

A conventional magnetic resonance imaging (MRI) examination allows for visualization of a mass lesion, and provides us with information on mass location, its homogeneity and signal intensity, the presence of perilesional oedema, and degree of contrast enhancement. Among brain mass lesions, differentiation between low and high-grade are very difficult. Traditional tumours of high-grade are very heterogeneous, which results from the presence of necrotic and or haemorrhagic regions, an extensive vascular oedema, strong enhancement, and mass effect. However, these signs are not always present. Sometimes, low-grade tumours show features typical for more malignant tumours. Similarly, differentiation between intracerebral necrotic tumours and cerebral abscesses is frequently impossible with conventional magnetic resonance imaging (MRI).4

Our hypothesis was that DWIs and mass lesion apparent diffusion coefficient (ADC) could provide additional useful information in the differential diagnosis of brain mass lesions

MATERIALS AND METHOD:

In all patients detected to have intracranial mass lesions on MRI of the brain, at the Department of Radiodiagnosis ,Mysore medical college and re from November 2017 to April 2019.

The DWI findings were noted and correlated with ADC and T2 FLAIR images. For evaluation of the brain, MRI will be performed using a 1.5 Tesla MRI scanner (GE medical systems). The following sequences will be acquired:

- Sagittal and axial T1 weighte
- Sagittal and axial T2 weighted
- T 2 weighted FLAIR
- Diffusion weighted images with ADC will be taken.
- ADC was measured with a manual placement of region of interests (ROIs) in the centre part of the lesion. Additional histopathological findings were given where ever possible.

Inclusion criteria

All patients who were detected to have intracranial mass lesions on MRI brain.

Exclusion criteria

Patients who were detected to have:

- Intracranial bleed
- Stroke
- Metabolic or toxic insults to the brain
- Demyelinating disorders
- Post-operative patients.

STATISTICAL ANALYSIS

The results of the study were tabulated and evaluated descriptively by Microsoft excel 2016. Also the results were presented in figures, tables, frequency graphs and pie charts.

RESULTS:

Age wise distribution of intracranial lesions

The age of the patients with intra cranial lesions studied ranged from 1 year to 67 years. The patients involved in the study were divided into 7 age groups viz. 1-10 years, 11-20 years, 21-30 years, 31-40 years, 41-50 years, 51-60 years and 61-70 years. There were five patients (10%) in 1-10 year age group, four (8%) in 11-20 year age group, six patients (12%) in 21-30 year age group, thirteen (13%) in 31-40 year age group, ten (20%) in 41-50 year age group, eight (16%) in 51-60 year age group, four (8%) in 61-70 year age group, as given in table 3.

Sex distribution of lesions

Of the 50 patients studied 22 (44%) were females and 28 (56%) were males. The mean age among females was 42.6 years and the mean age among males was 46.4 years as given in table 4.

Spectrum of intracranial lesions

Of the total cases included in this study, Meningioma were the majority which constituted 9 (18%) cases. The cases of tumours of which 15 (30%) were intraaxial and 27(54%) were extra axial tumours, 3 (6%) infective and 5(10%) cases of intracerebral metastases as given in table 5.

Imaging characteristics of intracranial lesions

Infections

The study included 3 infective conditions of which 2 (66.66%) were tubercular Granulomas and 1 (33.33%) were NCC granulomas. No true diffusion restriction noted. T2 shine through was seen in both Tubercular and NCC granuloma as given in table 6.

Tumours

Intra axial tumours

There were 15 cases of intra axial tumours in this study. There were 3 females and 12 males. This included 2 cases of anaplastic astrocytoma, 3 cases of glioblastoma multiforme, 3 oligodendroglioma, 2 ganglioglioma, 1 medulloblastomas, 3 diffuse astrocytoma. 6 cases showed true diffusion restriction. Of these were 3 were GBM, 2 were Anaplastic astrocytoma and 1 was medulloblastomas as given in table 7.

Extra axial Tumours

27 cases of extra axial tumours were included in this study. Of these 14 were females and 13 were males. These were 9 cases of Meningioma, 4 cases Schwannoma, 1 Hemangiopericytoma, 2 Dermoid, 1 Epidermoid, 1 Arachnoid cyst, 1 colloid cyst, 7 Pituitary macroadenoma, 1 craniopharyngioma and 1 colloid cyst. True restricted diffusion was noted in 4(14.8%) cases. This included the all the 2(100%) cases of epidermoid cyst and two case of meningioma (22.22%). In rest 7 cases of meningiomas (77.77%) no change was noted. 4(100%) case of schwannoma showed no diffusion restriction as given in table 8.

ADC VALUES OF GLIOMA

Low grade gliomas [Grade I and Grade II gliomas] In our study, the mean ADC of eight cases of histologically proven low-grade gliomas [1 grade-I glioma, 7 grade-II gliomas] was 1.536 x 10-3 mm2/s. High grade gliomas [grade-III and grade-IV gliomas] In our study, the mean ADC of five cases of histologically proven high-grade gliomas [all cases were grade-IV gliomas] was 1.106 x10-3 mm2/s as given in table 9.

DISCUSSION

MR diffusion imaging had been used to study water mobility in normal brain tissue, cerebral infarction, multiple sclerosis, gliomas, and brain abscesses, and to differentiate between arachnoid cysts and epidermoid cysts and other diseases.41,42 Preoperative differentiation of brain mass lesions is very important, due to different therapeutical approaches and prognosis.

In this study 50 patients with intracranial mass lesions detected on MRI of the brain were included. It was found that DW MRI provides adjunctive information for intracranial mass lesions including infections, intraxial and extra axial lesions in conjunction with conventional MRI.

Tumours

Intra axial tumours

MR imaging is the most sensitive method for detecting tumours of the brain. It is however not specific enough to determine the histological nature of most tumours.

DWI can differentiate between tumour and infection and can provide information about the cellularity of tumours thereby helping in characterization and grading of tumors.48 Cruz CH et al43 showed that highly cellular tumours such as high-grade gliomas and lymphomas can have low ADC values and show restricted diffusion. It was also shown that medulloblastomas may be differentiated from other paediatric brain tumours by presence of diffusion restriction.

The findings of this study were similar. In this study, 100% of GBM and Medulloblastoma showed true diffusion restriction with mean ADC values (0.009101) and (0.00081). None of the low-grade gliomas or showed restricted diffusion.

We found that ADC values cannot be used in individual cases to differentiate tumour types reliably. The combination of routine image interpretation and ADC had a higher predictive value. In our study Low grade glioma has higher ADC (Mean 0.0015) and High-grade glioma lower ADC (Mean 0.0011) values.

Yamasaki et al44 suggested inverse relationships between mean ADC and the grades of astrocytic tumours [WHO grades II– IV].

Niloufar Sadeghi et al45 reviewed 19 patients with gliomas and found that the mean ADC [0.93 x 10-3 mm2/s] of the high-grade glial tumours were significantly lower than the mean ADC [1.23 x 10-3 mm2/s] of the low-grade glial tumours. Our finding of decreasing ADC with increasing glioma grade [WHO grade II-IV gliomas] correlates well with this study, but the mean ADC in our study and their study did not correlate.

Extra axial tumours

Diffusion weighted MR plays a key role in differentiating arachnoid from epidermoid cysts. Schaefer et al24 showed that conventional MR cannot be reliably used to differentiate these two lesions as both have CSF like signal intensity on conventional MR sequences. However, on DWI epidermoid cyst shows restricted diffusion while arachnoid cyst shows CSF like intensity. This was also demonstrated in a study by Cruz et al,43 in which epidermoid cysts had ADC values similar to brain parenchyma while arachnoid cysts had ADC values similar to CSF.

In this study arachnoid cyst had signal similar to CSF on DWI and ADC images. The epidermoid noted in this study had restricted diffusion.

Correlation between ADC values and tumour cellularity in both gliomas and meningiomas as study conducted by Kono et al, 2001.46

In our study 9 cases of meningiomas, 2 cases showed areas restriction within the lesion with less mean ADC values (0.6x 10-3) proved to be aggressive meningioma. Schwannomas showed no restricted diffusion reflecting lack of high cellularity on comparison of vestibular Schwannomas and meningiomas, signal intensity on T2W is higher in vestibular Schwannomas than in meningiomas. Signal heterogenicity is common in vestibular Schwannomas than in meningiomas. On DWI vestibular Schwannomas were iso to hypointense to cortex with ADC values ranging from 1.2 -1.9 (mean 1.1 x 10-3) where as meningiomas were iso to hyperintense to cortex with ADC values ranging from 0.8 - 1.4 (1.18x 10-3). Study comprised 7 cases of pituitary macroadenoma showed no diffusion restriction with mean ADC value 0.76 x 10-3.

Study included 5 primary proved Metastases (3 cases of lung carcinoma and 2 cases of carcinoma breast) out of 4 metastases showed true diffusion restriction with mean ADC value 1.316 x 10-3. However, we found that there is no correlation between the metastasis showing restricted diffusion and primary pathology.

LIMITATIONS OF STUDY

Large patient populations must be studied to evaluate the applicability of the ADC for obtaining a differential diagnosis of craniopharyngiomas, epidermoid tumours, and dermoid. Our series included only a few patients with rare tumours. Further studies are necessary to determine the usefulness of the ADC for differentiating these tumours.

CONCLUSION

Diffusion weighted MRI is a valuable technique that provides unique information about the physiological state of brain tissue. The current study comprised 50 patients evaluated in MMC&RI Mysore, who underwent DW MRI of the brain when they were referred for suspected intracranial lesions. All the MRI scans in this study were performed using 1.5T MRI scanner.

Many different intracranial mass lesions were found. By using a combination of various MR sequences coupled with DWI and ADC images a valuable diagnosis maybe provided to the clinicians. In this study the signal characteristics of various lesions on DWI, ADC, T2 and FLAIR images were studied.

DWI and ADC can provide valuable information about tumour cellularity and help in the characterization of tumours and grading of tumours. The solid portion of high grade tumours may show restricted diffusion with low ADC values compared to low grade tumours. True restriction was not observed in low grade gliomas with high ADC values.

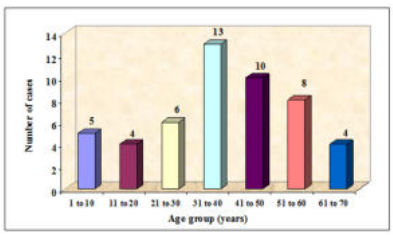
In the evaluation of extra axial cystic lesions, DWI plays an important role. While conventional MR sequences may be inconclusive in the differentiation of epidermoid cyst from arachnoid cyst, DWI shows restricted diffusion in the former and helps distinguishing the two.

There is no restriction of diffusion in Schwannomas. Two cases of proved aggressive meningioma showed restriction with low ADC values compared to benign meningiomas with no restriction. Thus, DW MRI helps in differentiating and characterizing intracranial mass lesions.

Tables and Graphs-

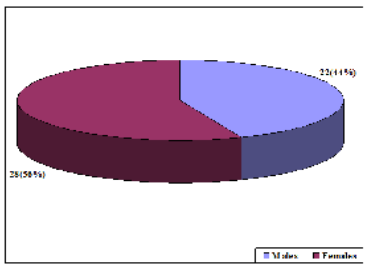
Table/Fig 1: Age distribution and type of intracranial lesion

Intracranial Lesion	Age range (years)							Total
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	
1. Infections								3
Tuberculoma			1	1				2
NCC					1			1
2. Intra Axial Lesions								15
GBM			1			1	1	3
Anaplastic astrocytoma				1	1			2
Oligodendroglioma		1				2		3
Ganglioglioma	1	1						2
Medulloblastoma	1							1
Diffuse astrocytoma	1		1			1		3
Subependymoma				1				1
3. Extra Axial Lesions								27
Meningioma			1	1	3	1	3	9
Hemangiopericytoma			1					1
Arachnoid Cyst	1							1
Epidermoid					1			1
Dermoid		1			1			2
Schwannoma			1	2	1			4
Pituitary macroadenoma		1		5		1		7
Colloid	1							1
Craniopharyngioma				1				1
4. Metastasis				1	2	2		5
Total	5	4	6	13	10	8	4	50



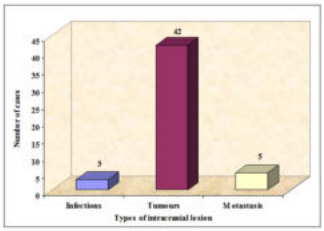
Table/Fig 2: Sex distribution of lesions

Sex	Number of cases	Percentage
Males	22	44
Females	28	56
Total	50	100



Table/Fig 3: Types of intracranial lesion

Types of intracranial lesion	Number
Infections	3
Tumours	42
Metastasis	5

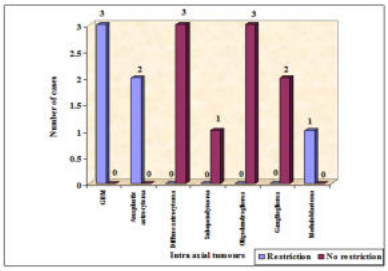


Table/Fig 4: Infective conditions on DW imaging

Infection	Restriction	
	Yes	No
Tuberculoma	0	2
NCC	0	1

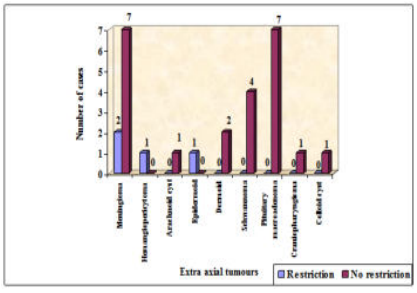
Table/Fig 5: Intra axial tumours

Intra axial tumours	Restriction	No restriction
GBM	3	0
Anaplastic astrocytoma	2	0
Diffuse astrocytoma	0	3
Subependymoma	0	1
Oligodendroglioma	0	3
Ganglioglioma	0	2
Medulloblastoma	1	0



Table/Fig 6: Extra axial tumours

Extra axial tumours	Restriction	No restriction
Meningioma	2	7
Hemangiopericytoma	1	0
Arachnoid cyst	0	1
Epidermoid	1	0
Dermoid	0	2
Schwannoma	0	4
Pituitary macroadenoma	0	7
Craniopharyngioma	0	1
Colloid cyst	0	1



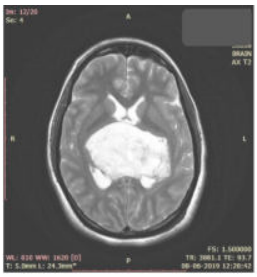
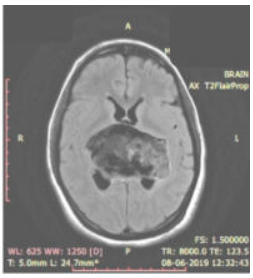
Table/Fig 7: ADC values of Low- and High-grade glioma

Grades	N	Min	Max	Mean	Mean
Low	8	.001	.00012	.001536	1.536 x 10 -3
High	5	.0013	.0025	.001106	1.106 x 10 -3

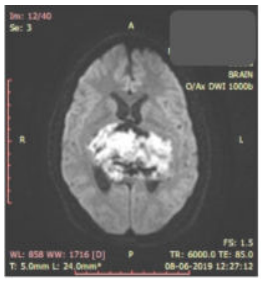
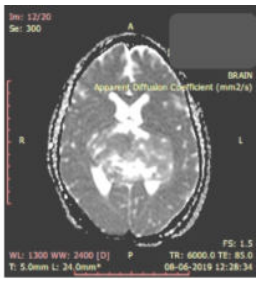
Table/Fig 8: ADC values of all lesions

	No. of cases	Minimum	Maximum	Mean	Mean
GBM	3	.0010	.0012	.001093	1.093 x 10-3
Anaplastic astrocytoma	2	.0010	.0012	.001126	1.126 x 10-3
Oligodendroglioma	3	.0014	.0015	.001407	1.407 x 10-3
Pituitary macroadenoma	7	.0007	.0008	.000766	0.766 x 10-3
Ganglioglioma	2	.0014	.0015	.001450	1.450 x 10-3
Epidermoid	1	.0013	.0013	.001260	1.260 x 10-3
Medulloblastoma	1	.0008	.0008	.000810	0.810 x 10-3
Arachnoid cyst	1	.0033	.0033	.003300	3.3 x 10-3
Dermoid	2	.0010	.0011	.001035	1.035 x 10-3
Hemangiopericytoma	1	.0013	.0013	.001300	1.3 x 10-3
Meningioma	9	.0006	.0014	.001172	1.3 x 10-3
Tuberculoma	2	.0010	.0010	.000960	0.96 x 10-3
Schwannoma	5	.00104	.0015	.001115	1.115 x 10-3
Metastases	5	.0010	.0015	.001316	1.316 x 10-3
NCC granuloma	1	.0013	.0025	.001915	1.915 x 10-3
Colloid cyst	1	.0015	.0015	.001530	1.53 x 10-3
Diffuse astrocytoma	3	.0013	.0015	.001377	1.377 x 10-3
Total	50	.0006	.0033	.001224	1.224 x 10-3

Table/Fig 9: Epidermoid.

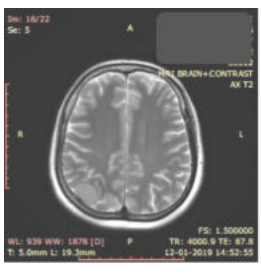
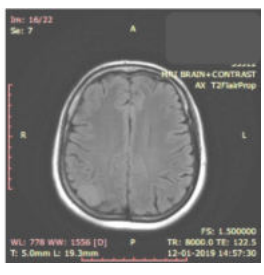
T2 image **FLAIR image**

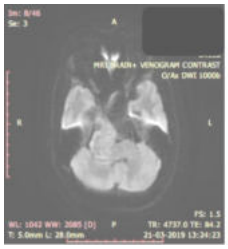
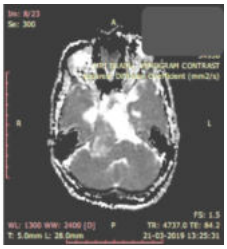
DW image **ADC image**

Findings: Well-defined extra axial T2 hyperintense lesion noted in the Third Ventricular Region. On FLAIR image the lesion appears isointense and on DW image the lesion appears hyperintense and corresponding areas appears hypointense on ADC depicting true restriction. Mean ADC - 1.26 x 10^{-3}.

Table/Fig 10: Meningioma

T2 image **FLAIR image**

DW image **ADC image**

Findings: Well defined extra axial T2 hyperintense and FLAIR Hyperintense lesion noted in the right cerebellopontine angle. On ADC images the lesion appears iso and the corresponding area on DWI appears iso. Mean ADC - 1.04 x 10^{-3}.

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