ASIAN JOURNAL OF PHARMACEUTICAL AND CLINICAL RESEARCH

INNOVARE ACADEMIC SCIENCES
Knowledge to Innovation

Vol 16, Issue 11, 2023

Online - 2455-3891
Print - 0974-2441

Research Article

ROLE OF DIFFUSION-WEIGHTED MAGNETIC RESONANCE IMAGING FOR BRAIN TUMOR CHARACTERIZATION

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Received: 22 April 2023, Revised and Accepted: 05 June 2023

ABSTRACT

Objectives: This study was conducted with the objective to link the results of diffusion-weighted magnetic resonance imaging (MRI) with the tumor's histopathological grade. The current study aims to evaluate this and determine the accuracy of diffusion-weighted MRI to determine grade of glioma.

Methods: The present study was a hospital-based cross-sectional purposive study. A total of 50 patients undergoing the MR evaluation of the brain with evidence of clinically suspected cerebral mass were enrolled in study based on inclusion and exclusion criteria. Statistical analysis was performed.

Results: In our study, the minimum apparent diffusion coefficient (ADC) was significantly lower for high-grade than for low-grade gliomas (1119.68±138.33 vs. 717.18±154.38, p<0.001).

Conclusions: By examining diffusion-weighted images and comparing the ADC of gliomas with the World Health Organization grade, we analyze the potential of ADC in predicting tumor grade through this study.

Keywords: Brain tumors, Apparent diffusion coefficient, Diffusion-weighted imaging.

 DOI: http://dx.doi.org/10.22159/ajpcr.2023v16i11.48158. Journal homepage: https://innovareacademics.in/journals/index.php/ajpcr

INTRODUCTION

The most frequently occurring brain tumors are the neuroepithelial tumors and gliomas. In most cases, morphological imaging is able to differentiate low grade from diffusely invasive or frankly malignant lesions, which tend to show significant perilesional edema and intense contrast enhancement. Dean *et al.* demonstrated that the two most important predictors of the degree of malignancy of a tumor are mass effect and necrosis [1]. Nevertheless, not all high-grade glial tumors exhibit necrosis or mass effect and approximately 40% of them are not enhancing. The issue becomes more complex if we consider two other factors: first, the high frequency of cerebral metastases occurring in around 15–25% of all patients with malignancies and second, the rising incidence over the past two decades of primary cerebral lymphomas as a result of the increasing number of immunocompromised subjects due to organ transplantations and AIDS. The World Health Organization (WHO) classifies high-grade gliomas as the most dangerous primary intra-axial brain tumors in adults, with glioblastoma multiforme constituting the majority of cases (GBM, WHO Grade IV astrocytoma). The majority of WHO Grade II gliomas are much less common and low-grade gliomas [1]. The majority of primary extra-axial brain tumors, or meningiomas, account for 20% of all cases of brain tumors [2,3].

The incidence of gliomas, which make up about 51% of all tumors of the central nervous system, is rising, especially in older patients [4]. In particular, magnetic resonance imaging (MRI) has become the imaging technique most frequently used to assess gliomas, and it continues to play an increasingly diverse role in the identification, characterization, and treatment of gliomas. The standard MRI with contrast study is still the go-to method for glioma imaging both before and after surgery. In addition to traditional MRI methods, a number of novel methods have established themselves in clinical practice. The anatomical information offered by traditional MRI sequences is not the only benefit of these new techniques. Diffusion-weighted imaging is one of the new MRI techniques. At present, DWI is mainly used to diagnose epidermoid cysts, infarcts, and intracranial abscesses. There are not many studies that try to link the results of diffusion-weighted MRI with the tumor's histopathological grade. The present study aims to evaluate this and determine whether diffusion-weighted MRI can be used to determine the glioma grade more accurately. The accurate differentiation between high-grade and low-grade gliomas is crucial for therapeutic management and prognosis [5].

The technique can be performed as a complement to conventional MR using the same contrast material and with only a minimal increase in examination times. Should DWI prove superior to conventional imaging, they could be used to monitor patients undergoing treatment to obtain an earlier evaluation of response to chemo- or radiotherapy and guide the clinician's treatment choices.

METHODS

Study design

The present study was a duration-based cross-sectional study, done at the department of Radiodiagnosis, Geetanjali Medical College and Hospital, Udaipur, during the term February 2021–July 2022.

Inclusion criteria

1. Adults (≥18 years)
2. Both sexes
3. All patients with incidentally diagnosed cerebral masses by any other modality.

Exclusion criteria

1. MRI contraindicated patients (cardiac pacemaker, cochlear implant, claustrophobic patients etc.)
2. All patients who had allergy to previous contrast study.
3. Non-neoplastic lesions.
4. Previous treatments on the tumors (surgery, chemotherapy, and radiotherapy).
5. Incorrect examination technique.

Procedure

Each subject was worked up and investigated according to the set protocol as follows:

- Well-informed written consent was taken.
- History of patients presenting with cerebral masses was noted.

A complete clinical history of the patient with reference to the motor and sensory symptoms was noted. Scanning was done with MRI 3 tesla (SIGNA ARCHITECT) machine in the supine position with proper positioning and immobilization of the body. Pre-contrast scanning was done using T1WI, T2WI, FLAIR sagittal, STIR sagittal, T1WI, and T2WI axial. Contrast was given as and when required, post-contrast T1WIsag and axial and coronal images were obtained. Whenever required, thinner sections were obtained in the region of interest. Special MRI sequences such as FLAIR and STIR were routinely obtained.

Statistical analysis

The data were entered in MS Excel Software version 20 and analyzed using SPSS, IBM Comp, version 21. Descriptive analysis of the data was performed presenting the results as frequency and percent for qualitative variables and as mean and standard deviation for age. The relation between qualitative variables was evaluated by Chi-square test and Fisher's exact test if needed. The descriptive data were expressed in proportions, mean, and frequency tables. The categorical data were analyzed using Chi-square test. The quantitative data were analyzed using independent student's *t*-test. p<0.05 was considered statistically significant.

RESULTS

This cross-sectional study was conducted on patients who underwent MRI evaluation of the brain presenting with headache, seizures, personality changes, memory loss, sensory loss at Geetanjali Medical College and Hospital, Udaipur. In our study, maximum 8 cases were seen of RTF region and LTF region, 6 cases of RTP region, and 5 cases of right temporal RTT region. On MRI, we observed 17 cases of glioma; 11 cases of meningioma; 6 cases of GBM; and 3 cases each of astrocytoma, lymphoma, and oligodendroglioma (Fig. 1 and Table 1). 6 cases of GBM and 5 cases of gliomatosis cerebri had MRI grading of 4, and 8 cases of glioma and 5 cases of meningioma had MRI grading 3 (Table 2). Extensive and moderate contrast was given in 37 (74%) of cases. (Fig. 2) Maximum 28 (56%) patients had Grade III-IV gliomas. Moderate mass effect was seen in 11 (22%) of cases. The minimum ADC was significantly lower for high-grade than for low-grade gliomas (1119.68±138.33 vs. 717.18±154.38, p<0.001) and the minimum ADC for tumors.

Maximum 8 cases were seen of RTF region and LTF region, 6 cases of RTP region, and 5 cases of RTT region.

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6 cases of GBM and 5 cases of gliomatosis cerebri had MRI grading of 4, and 8 cases of glioma and 5 cases of meningioma had MRI grading 3.

Extensive and moderate contrast was given in 37 (74%) of cases.

The mean lowest ADC of the tumor region was significantly higher for Grade I than for Grade IV lesions (1132.0±91.34 vs. 665.15±88.08, p=0.001) (Table 3). Patients were dichotomized into those with high-

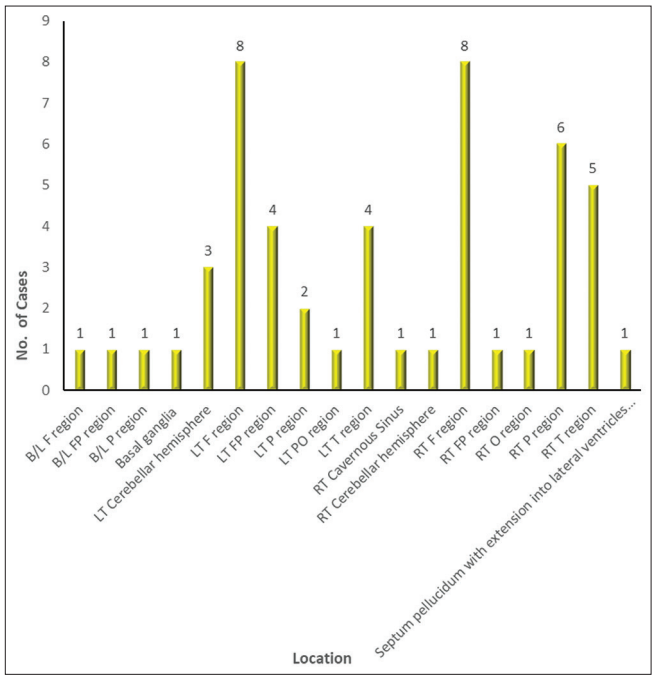

Fig. 1: Magnetic resonance imaging diagnosis-wise distribution of cases

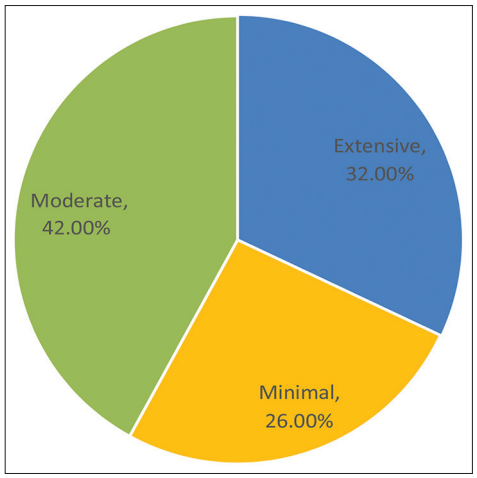

Fig. 2: Contrast enhancement

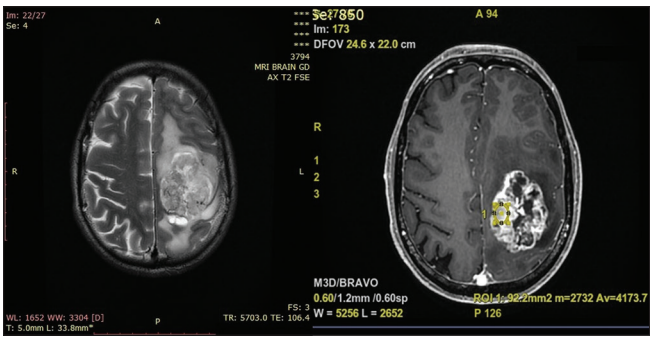

Fig. 3: Diagnosis: Aggressive meningioma

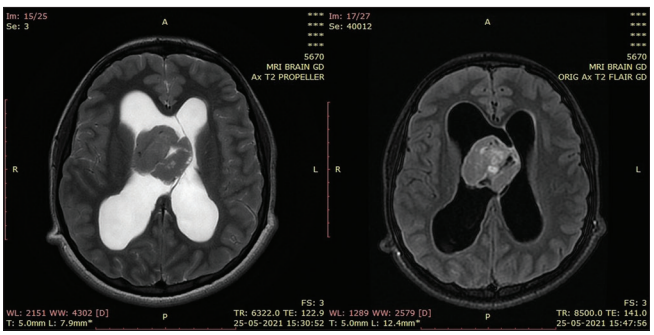

Fig. 4: Diagnosis: Central neurocytoma

Table 1: Location-wise distribution of cases

Location	No. of cases
B/L F region	1
B/L FP region	1
B/L P region	1
Basal ganglia	1
LT Cerebellar hemisphere	3
LT F region	8
LT FP region	4
LT P region	2
LT PO region	1
LT T region	4
RT Cavernous sinus	1
RT Cerebellar hemisphere	1
RT F region	8
RT FP region	1
RT O region	1
RT P region	6
RT T region	5
Septum pellucidum with extension into lateral ventricles and foramen of Monro	1
Total	50

Table 2: MRI diagnosis wise and grading

MRI diagnosis	Grading			
MRI diagnosis	1	2	3	4
Astrocytoma		2	1	
Central neurocytoma		1		
DNET		1		
GBM				6
Glioma		4	8	5
Gliomatosis cerebri			1	
Hemangioblastoma	2			
Lymphoma		3		
Medulloblastoma				2
Meningioma	5	1	5	
Oligodendroglioma		3		
Total	7	15	15	13

MRI: Magnetic resource imaging

Table 3: Grading-wise distribution of ADC count

Grading	ADC count		p value
	Mean	SD	
1	1132.00	91.34	<0.001 (HS)
2	1113.93	158.16	
3	762.27	186.07	
4	665.15	88.08	
Low-grade glioma	1119.68	138.33	<0.001 (HS)
High-grade glioma	717.18	154.38	
Total	894.28	249.13	

ADC: Apparent diffusion coefficient

grade (III and IV) and low-grade (I and II) gliomas. The mean lowest ADC of the tumor region was significantly higher for low-grade than high-grade gliomas (1119.68±138.33 vs. 717.18±154.38, p<0.001).

In figure 3 there is Extra-axial T2 heterogeneous lesion in left high frontoparietal region. There is significant heterogeneous intense enhancement post-contrast.

In figure 4 there is enhancing T2W isointense mass lesion with significant DW restriction and enhancement post-gadolinium administration involving region of septum pellucidum, right-sided foramen of Monro, body of right lateral ventricle, and inferiorly extending into third ventricle.

DISCUSSION

Previous studies assessing the role of ADC in predicting tumor pathology (Bihan *et al*., Kono *et al.*) had several limitations, including small sample size and heterogeneous pathology [6,7]. The study by Yamasaki *et al*. with the largest sample size involved 275 patients, including subgroups with intra-axial lesions and showed that ADC had good discriminatory value in predicting grades of astrocytoma's [8]. ADCs have also been used to distinguish GBMs from lymphomas and to reliably distinguish pilocytic astrocytoma's from ependymomas and medulloblastomas in pediatric patients. Toh *et al*. showed the lowest ADCs for Grade I pilocytic astrocytoma ranged from 800 to 2400, similar to our results [9].

A study by Darbar *et al*. reported that Grade I lesions had a significantly higher mean lowest ADC of the tumor region than did Grade IV lesions (653.20±145.07 vs. 333.83±295.47, p=0.001) [10]. Patients with high-grade (III and IV) and low-grade (I and II) gliomas were dichotomized. For low-grade gliomas compared to high-grade gliomas, the mean lowest ADC of the tumor region was higher (678.73±208.52 vs. 373.75±257.06, p<0.001).

According to Zhang *et al.*, on the one hand, one-third of non-enhancing gliomas turn out to be high-grade gliomas, while on the other hand, partial contrast enhancement is seen in around 20% of low-grade gliomas [11].

These results, which were based on the ADC map of tumors, show that ADC maps can be useful for directing the sampling of tumor regions and enhancing the accuracy and representativeness of these samples. These results can be further supported by a prospective study demonstrating the relationship between histologic features and ADCs. ADC can accurately distinguish between low- and high-grade tumors, making it a suitable imaging modality for tumor-grade prediction. High-grade gliomas have lower ADC values because of the tissue's higher cellularity, whereas low-grade gliomas have higher ADC values because of their lower cellularity and likely higher water content in the interstitial spaces (Zhang *et al*.) [11]. Tumor pathology and grade have been assessed using mean and minimum ADCs of the entire tumor as well as the lowest mean ADC within a tumor. It might not be able to distinguish between diagnostic grades because many gliomas exhibited enhancement on contrast sequences.

According to Hakyemez *et al*., many high-grade gliomas exhibited moderate to extensive contrast enhancement, but three cases exhibited only slight enhancement. In 2 of 11 cases, low-grade gliomas showed moderate or extensive contrast enhancement, whereas in 9 cases, there were minimal or no contrast enhancements [12].

CONCLUSION

By examining diffusion-weighted images and comparing the ADC of gliomas with the WHO grade, we analyze the potential of ADC in predicting tumor grade through this study. Low-grade gliomas have significantly higher mean lowest ADCs than high-grade gliomas, and ADCs of tumor regions on pre-operative MRI can distinguish between low and high-grade gliomas. We believe that ADCs should be routinely assessed when planning surgery for glioma, and we hope that these findings provide more information on the potential for a larger role for ADC in the representative sampling of tumor tissue.

ACKNOWLEDGMENT

I thank Dr. Ravinder Kundu for his expertise and assistance throughout all aspects of our study and Dr. Sabina Shams who provided a factual review and helped edit the manuscript.

CONFLICTS OF INTEREST

There are no conflicts of interest.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

REFERENCES

1. Zonari P, Baraldi P, Crisi G. Multimodal MRI in the characterization of glial neoplasms: The combined role of single-voxel MR spectroscopy, diffusion imaging and echo-planar perfusion imaging. Neuroradiology 2007;49:795-803. doi: 10.1007/s00234-007-0253-x, PMID 17619871
2. Provenzale JM, Mukundan S, Barboriak DP. Diffusion-weighted and perfusion MR imaging for brain tumor characterization and assessment of treatment response. Radiology 2006;239:632-49. doi: 10.1148/radiol.2393042031, PMID 16714455
3. Bulakbasi N, Kocaoglu M, Farzaliyev A, Tayfun C, Ucoz T, Somuncu I. Assessment of diagnostic accuracy of perfusion MR imaging in primary and metastatic solitary malignant brain tumors. AJNR Am J Neuroradiol 2005;26:2187-99. PMID 16219821
4. Hess KR, Broglio KR, Bondy ML. Adult glioma incidence trends in the United States, 1977-2000. Cancer 2004;101:2293-9. doi: 10.1002/cncr.20621, PMID 15476282
5. Cha S. Update on brain tumor imaging: from anatomy to physiology. AJNR Am J Neuroradiol 2006;27:475-87. PMID 16551981
6. Le Bihan D, Douek PM, Argyropoulou M, Turner R, Patronas N, Fulham M. Diffusion and perfusion magnetic resonance imaging in brain tumors. Top Magn Reson Imaging 1993;5:25-31. doi: 10.1097/00002142-199300520-00005, PMID 8416686
7. Kono K, Inoue Y, Nakayama K, Shakudo M, Morino M, Ohata K, *et al*. The role of diffusion-weighted imaging in patients with brain tumors. AJNR Am J Neuroradiol 2001;22:1081-8. PMID 11415902
8. Yamasaki F, Kurisu K, Satoh K, Arita K, Sugiyama K, Ohtaki M, *et al*. Apparent diffusion coefficient of human brain tumors at MR imaging. Radiology 2005;235:985-91. doi: 10.1148/radiol.2353031338, PMID 15833979
9. Toh CH, Castillo M, Wei KC, Chen PY. MRS as an aid to diagnose malignant transformation in Low-grade gliomas with increasing contrast enhancement. AJNR Am J Neuroradiol 2020;41:1592-8. doi: 10.3174/ajnr.A6688, PMID 32732270
10. Darbar A, Waqas M, Enam SF, Mahmood SD. Use of preoperative apparent diffusion coefficients to predict brain tumor grade. Cureus 2018;10:e2284. doi: 10.7759/cureus.2284, PMID 29740523
11. Zhang J, Tehrani YM, Wang L, Ishill NM, Schwartz LH, Hricak H. Renal masses: Characterization with diffusion-weighted MR imaging--a preliminary experience. Radiology 2008;247:458-64. doi: 10.1148/radiol.2472070823, PMID 18430878
12. Hakyemez BA, Erdogan C, Ercan I, Ergin N, Uysal S, Atahan S. High-grade and low-grade gliomas: Differentiation by using perfusion MR imaging. Clin Radiol 2005;60:493-502. doi: 10.1016/j.crad.2004.09.009, PMID 15767107