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Role of Diffusion Weighted Magnetic Resonance Imaging in the Assessment of Intracranial Meningiomas

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Abstract: Objective: To determine the diagnostic value of mean apparent diffusion coefficient (ADC) measures to distinguish between benign (grade I) and atypical (grade II) cranial meningiomas. **Patients and Methods:** eighty patients (22 men and 58 women) with cranial meningiomas were included in the study and underwent MRI examination including diffusion-weighted imaging (DWI). Signal characteristics on conventional MR and diffusion-weighted images were evaluated. The intratumoral mean ADC values were obtained and correlated with the final histopathological findings of the excised tumors. The optimum cutoff value of mean ADC measurements to differentiate between grade I and II was determined using the generated receiver operating characteristic (ROC) **Results:** sixty four (80%) meningiomas were benign (WHO grade I), while sixteen (20%) were atypical (grade II). No grade III meningiomas were encountered during the study period. At conventional MRI sequences, some of the features as enhancement pattern, tumor margin, tumor invasion to surrounding had produced a significant statistical correlation with the tumoural grade (p=0.002, 0.001and 0.001 respectively) however there were overlap in the result value. Intratumoral mean ADC values were significantly lower in grade II meningiomas ($p < 0.001$). The mean ADC value was $0.97 \pm 0.15\times10^{-3}$mm2/s for grade I meningiomas and $0.65 \pm 0.13\times10^{-3}$mm2/s−1 for grade II. According to the generated receiver operating curve (ROC), we determined a threshold of 0.75×10^{-3}mm2/s−1 to produce the best diagnostic performance to distinguish between grade I and II meningiomas (sensitivity 93.75%, specificity 87.5%). The positive and negative predictive values were 96.8% and 77.8%. **Conclusion:** The intratumoral mean ADC measurement provides a discriminative feature to discriminate between benign (grade I) and atypical (Grade II) cranial meningiomas.

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1. Introduction

Meningiomas are the most common primary brain tumor as well as the most common intradural spinal tumor. **(1)** Meningiomas are the third most common intracranial tumors in adults following gliomas and metastases. **(2-3)**

Based on the WHO classification they are classified as benign (WHO type I, 80% cases), atypical (WHO type II, 15–20%) and malignant (WHO type III, 1–3%) **(2).**

Although meningiomas are easily diagnosed by conventional MRI, differentiation of histological types is usually not possible **(2-4)**

Type II and III meningiomas are more aggressive and have a higher recurrence rate. The recurrence rate of atypical and malignant meningiomas is about 40% and 50–80%, respectively at 5 years of follow up **(4)**.

Distinguishing atypical from benign meningioma preoperatively could affect surgical planning and improve treatment outcomes. **(1)**

Diffusion-weighted MR imaging has been profitably applied to explore primary brain tumors and the apparent diffusion coefficient (ADC) calculation had proven usefulness to discriminate between malignant and benign lesions **(5)**

Diffusion weighted imaging of brain tumors reveals that tumors with higher grades have lower ADC values when compared with low grade tumors. **(6)**

We aimed by the present study to evaluate whether measurement of intra-tumoural mean ADC value would be useful to distinguish between the grade I and grade II/III meningiomas and to choose cutoff value to offer an objective differentiation between both groups.

2. Patients and methods

We included all patients sent to the MRI unit o for imaging of the brain and who showed imaging characteristics of primary (non-recurring) meningiomas.

Exclusion criteria: were pediatric groups, head trauma. Patients with impaired renal functions (<30 ml/mn createnine clearance) they couldn't be subjected to contrast enhanced study.

We excluded all lesions showing artifacts in the DW images, small in size (less than 1 cm) or totally calcific as this would cause the apparent diffusion coefficient (ADC) value measurement unreliable. We ended with 80 patients that were enrolled in the study.

MRI imaging

Eighty patients were examined through 1.5 Tesla closed MRI scanners: Avanto Siemens - Philips (Gyroscan NT). The head coil was used as the receiver coil. Conventional MRI examination included axial plane, T1- weighted spin-echo (SE) (TR/TE 350–600 ms/ 10–15 ms), T2- weighted spin echo (TR/TE 4000–8000 ms/ 100–135 ms) and for fluid attenuated inversion recovery (FLAIR): TI=2200; TR=5000–11000 ms; TE=90–140 ms. Post contrast administration of Go-DTPA [Bayer] in a dosage of 0.2 ml/kg) was obtained in Axial, coronal and sagittal T1- weighted spin echo (SE). The field of view (FOV) was 230 or 240mm2, the slice thickness was 5 mm, and the interslice gap was 1 mm. This was succeeded by a diffusion-weighted sequence with a single shot, gradient-echo, echo-planar pulse sequences with diffusion gradient b values of 0 and 1000 s/mm2, over 22 axial slices.

Image evaluation

Assessment was carried out in correlation to the results of the post-operative histopathological analysis. Enhancement pattern, tumoural margins and the presence of pre-tumoural edema were recorded.

DW images were visually classified as hyper, iso, or hypointense as compared to the nearby white matter. ADC maps were made and the intratumoral mean ADC values were measured at the solid part of the tumor while avoiding their calcified, necrotic or cystic portions. Three regions of interest (ROI) ranging from 0.3 to 0.7 cm2 were obtained in various axial images and a mean ADC value was determined.

The definitive diagnosis was established by histopathological analysis of the surgically resected meningiomas according to 2007.

WHO classification of brain neoplasms.

Statistical analysis

Statistical analysis was accomplished utilizing the SPSS (Statistical Package for the Social Sciences) software package, V23 (SPSS Inc., Chicago, USA).

Continuous variables were revealed as mean standard deviations (SD) and categorical variables were expressed as frequencies and percentages.

Cut off value of various ADC measurements that showed the maximum sensitivity and specificity to identify malignant meningiomas were determined from the generated Receiver-operating characteristic (ROC) curve.

3. Results

During the study period, 80 participants with imaging appearances of cranial meningiomas were referred to our MRI unit. The histopathological results of 11 meningiomas were lacking and the grade assessment depend on follow up.

There were 22 men (27.5%) and 58 women (72.5%), mean age ± SD was 57.11 ± 10.83 years (range 28-80 years). sixty four meningiomas (80%) were grade I, 16 (20%) were grade II while no grade III meningiomas were observed during the study period.

Table 1 Different characteristics of conventional MRI features.

	Total (n=80)		Tumor grade				χ^2	^{FE}p
			Grade I (n = 64)		Grade II (n = 16)			
	No.	%	No.	%	No.	%		
Enhancement								
Homogenous	61	76.3	54	84.4	7	43.8	11.665*	0.002*
Heterogeneous	19	23.8	10	15.6	9	56.3		
Margin								
Regular	63	78.8	62	96.9	1	6.3	62.820*	<0.001*
Irregular	17	21.3	2	3.1	15	93.8		
Peritumoral edema	41	51.3	30	46.9	11	68.8	2.452	0.117
Invasion to surrounding	12	15.0	1	1.6	11	68.8	45.319*	<0.001*

On standard MR imaging, homogenous post contrast enhancement was observed in 84.4% [54/64]) of grade I tumors while heterogeneous enhancement was more prevalent among grade II (56.3% [9/16]). The relationship between enhancement type and tumor grade was significant (p=0.002). also there was significant correlation between tumor margin and tumor grade as irregular margin more seen in grade II tumor (1/16 had regular margin while 15/16 had irregular margin) also there was significant correlation between invasion to the surrounding with tumor grade as irregular margin more seen in grade II tumor (11/16 show invasion to the surrounding while 1/64 not show invasion to the surrounding). There was overlap between the two groups.

Nevertheless, no significant correlation was observed between both groups as regards the perilesional edema.

The peri-tumoural edema was observed in 46.9% [30/64] of grade I and 68.8% [11/16] of grade II (p=0.117). (table 1)

On DW imaging (b=1000), the signal intensity of grade I meningiomas was variable, isointense in 39.1% [25/64]), hyperintense in 57.8% [37/64] and hypointense in 1.6% [1/64]. All of grade II meningiomas were hyperintense. The relationship was significant (p=0.004).

The estimated intratumoral mean ADC values of grade I ranged from 0.59 to 1.41×10−3mm2/s−1 (mean; 0.97± 0.15×10−3mm2/s−1).

At grade II meningiomas this value ranged from 0.35 to 0.76×10−3mm2/s−1 (mean; 0.65 ± 0.13×10−3mm2/s−1)

At the generated ROC curve, we selected a Cut off value of 0.75×10−3mm2/s−1 to achieve highest sensitivity (93.75%), specificity (87.5%) and accuracy (89.3%) (Area under the curve: 0.962, 95%CI: 0.923–1.001), to discriminate between Grade I and II. The positive the negative predictive values were 96.8% and 77.8%. The relationship between both groups was statistically significant ($p < 0.001$). (fig. 1)

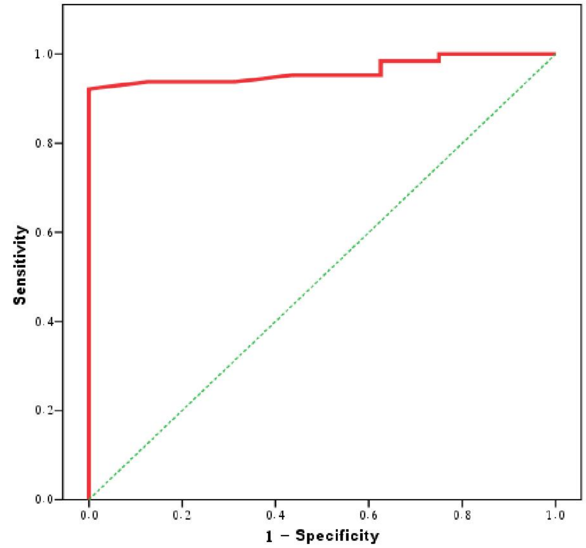
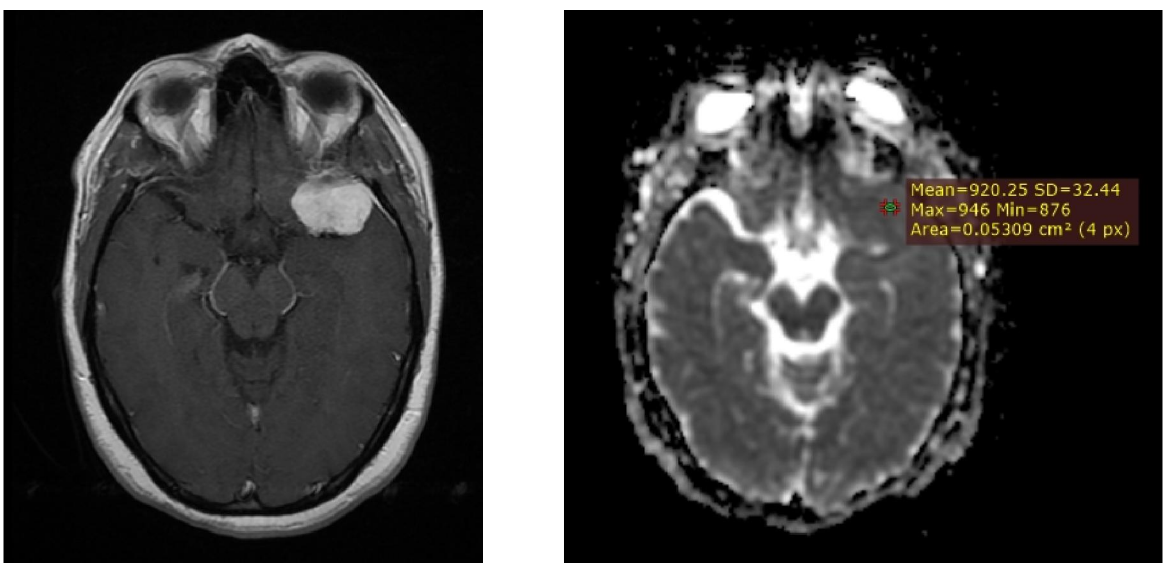
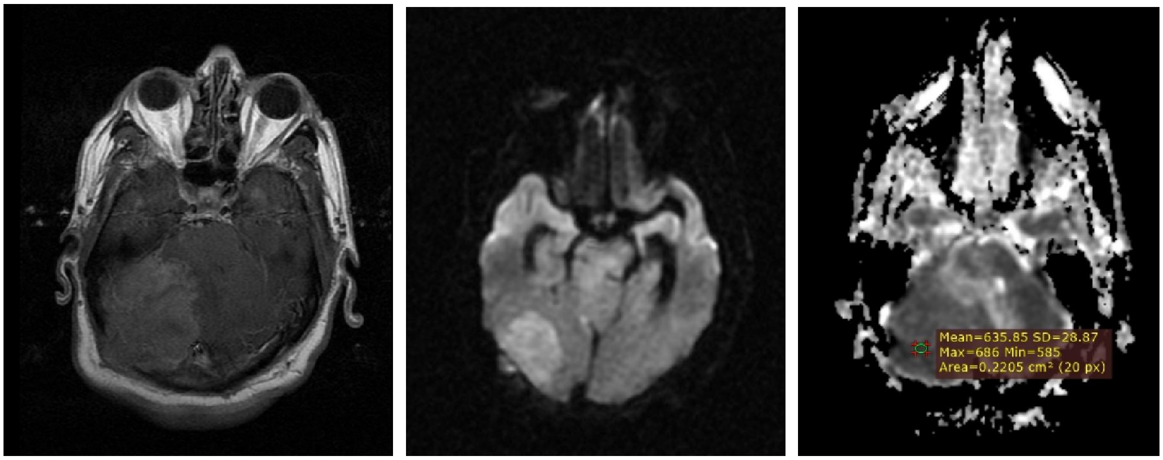


Figure (1): ROC curve for ADC value to differentiate between grade I and II



A B

Case 1. 46 years old female patient presented by persistent headache. left sphenoid well defined mass lesion **(A) Axial post contrast enhanced T1 MR image** shows avid homogeneous enhancement. **(B) ADC map** with ADC value 0.92 x $10^{-3}mm^2/sec$. **Histopathological examination** confirmed the diagnosis as WHO grade I meningioma.



A B C

Case 2. 59 years old male patient presented by neurological deficits, right occipital mass and persistent headache. Right tentorium mass lesion **(A) Axial post contrast enhanced T1 MR image** shows heterogeneous enhancement. **(B) DWI s**hows hyper intense signals **(C) ADC map** with ADC value 0.63 x $10^{-3}mm^2$/sec. The lesion shows infiltration of the related right cerebellum as well as the related occipital bone with extra calvarial extension. **Histopathological examination** confirmed the diagnosis as WHO grade II meningioma.

4. Discussion

Management of grade II meningiomas is usually accompanied with bad prognosis and considerable morbidity and requires further postoperative gamma knife stereotactic radiosurgery. Preoperative diagnosis of this entity has, thus, an important clinical value **(7)**.

In the present study, we had 69 operated meningiomas and we have correlated their conventional and diffusion MRI features with the histopathological data.

As regard the tumor enhancement pattern, heterogeneous enhancement was seen more in grade II meningiomas as in our study 56.3% of grade II show heterogeneous enhancement while 15.6% of grade I show heterogeneous enhancement. This is matched with **Naseruddin et al (8)** who reported that heterogeneous enhancement is more presented in atypical meningioma as 4 patient out of 5 show heterogeneous lesion enhancement.

As regard the tumor margin, irregular margin was seen more in grade II meningiomas as In our study 93.8 % of grade II show irregular margin while 3.1 % of grade I show irregular margin. This is matched with **Shawkey et al. (9)** Who reported that irregular tumor margin seen with atypical meningioma as 5 out of 9 patient show irregular margin and 2 out of 15 patient of typical meningioma presented with irregular margin.

As regard the peritumoral edema, it was seen more in grade II meningiomas as In our study 68.8 % of grade II show peritumoral edema while 46.9 % of grade I show peri tumoral edema, which was statistically insignificant. **Abdel-kerim et al. (10)** Also noticed that there is no significant correlation between tumor grade and peri lesion edema. The peri-tumoural edema was observed in 36.1% [13/36] of grade I and 63.6% [7/11] of grade II (p=0.11).

As regard the tumor invasion to the surrounding parenchyma, it was seen more in grade II meningiomas which presented by 68.8 % while its was presented by 1.6 % in grade I. This is matched with **Ranabhat et al. (11)** Who reported that tumor invasion to surrounding tissue seen more with atypical meningioma as 71.4 of atypical type show tumor invasion while 22.6 % of grade I show tumor invasion.

So, Conventional MRI finding help in the diagnosis of cranial meningioma however it is inconclusive as there is signs overlap between the two tumor groups.

At DWI, we noticed variable signal intensities in DW images in both groups, with grade I lesions showed isointense signal in 39.1 % of lesions, hyperintense in 59.4 % and hypointense in 1.6 % of lesions. While grade II lesions showed hyperintense signal in all the cases 100% of lesions. Therefore, hyperintense signal is not exclusive for grade II tumor and there is overlap between both groups in DW image signal was noted. **Bano S et al. (12)** also reported that the appearance of meningiomas on the DW images was variable.

On the other hand, we have noticed an appreciable difference between intratumoral ADC values in both groups (mean intratumoral ADC value was 0.97 x $10^{-3}mm^2$/sec. and 0.65 x $10^{-3}mm^2$/sec. for grade I and II lesions respectively). Therefore, we think that intratumoral ADC value could be a predictor differentiating factor between both groups.

This could be explained by their higher cellularity and mitotic activity, high nucleo-cytoplasmic ratio and steady growth pattern; resulting in reduced diffusion and lower ADC values.

Shawkey et al. (9) Reported that mean ADC values of atypical /malignant meningiomas were significantly lower compared with benign meningiomas.

In contrary, **Santelli L et al. (4)** who concluded that DWI and ADC measurements, even when performed under the best conditions, do not seem reliable in grading meningiomas or identifying histological sub-types.

Conclusion

Conventional MRI features are not always reliable to differentiate between grade I and II meningiomas. ADC measurements produce a valuable addition to the information obtained from conventional MR imaging, improving the capability of the radiologist to distinguish between grade I and II.

References

1. Hale AT, Wang L, Strother MK, Chambless LB. Differentiating meningioma grade by imaging features on magnetic resonance imaging. J Clin Neurosci. 2018 Feb;48:71-75.
2. Sanverdi SE, Ozgen B, Oguz KK et al. (2012). Is diffusion-weighted imaging useful in grading and differentiating histopathological subtypes of meningiomas? Eur J Radiol 81: 2389–2395.
3. Muhammad Azeemuddin, Waseem Mehmood Nizamani, Muhammad Usman Tariq, Mohammad Wasay. Role of ADC values and ratios of MRI scan in differentiating typical from atypical/anaplastic meningiomas. J Pak Med Assoc Vol.68, No.9, September2018.
4. Santelli L, Ramondo G, Della Puppa Aet al. (2010). Diffusion-weighted imaging does not predict histological grading in meningiomas. Acta Neurochir (Wien) 152: 1315–1319. discussion 1319.
5. Kinoshita M, Goto T, Okita Y, Kagawa N, Kishima H, Hashimoto N, et al. Diffusion tensor-based tumor infiltration index cannot discriminate vasogenic edema from tumor-infiltrated edema. J Neurooncol 2010;96(3):409–15.
6. Hanft S, Canoll P, Bruce JN. A review of malignant meningiomas: diagnosis, characteristics, and treatment. J Neurooncol 2010;99(3):433–43.
7. Aboukais R, Zairi F, Lejeune JP, Le Rhun E, Vermandel M, Blond S, et al. Grade 2 meningioma and radiosurgery. J Neurosurg 2015;122(5):1157–62.
8. V.S. Khaja Naseruddin, B. Vijayalakshmi Devi, B.C.M. Prasad, N. Rukmangada, A.Y. Lakshmi. Differentiation of typical from atypical and malignant meningiomas using diffusion weighted magnetic resonance imaging. J Clin Sci Res 2017;6:80-8.
9. Shawky MK, Teama MI, MD, Tantawy HI, and EL Samak DA. Role of Magnetic Resonance Imaging in Evaluating Typical and Atypical Meningiomas. ZUMJ 2019; 25(1); 171-186.
10. Amr Abdel-Kerima, Mohamed Shehataa, Basma El Sabaab et al. Difffferentiation between benign and atypical cranial Meningiomas. Can ADC measurement help? MRI fifindings with hystopathologial correlation. The Egyptian Journal of Radiology and Nuclear Medicine 49 (2018) 172–175.
11. Kajan Ranabhat, Suresh Bishokarma, Prity Agrawal, Pratyush Shrestha, Ram Kumar Ghimire, Rajesh Panth. Role of MR Morphology and Diffusion-Weighted Imaging in the Evaluation of Meningiomas: Radio-Pathologic Correlation. J Nepal Med Assoc 2019;57(215):37-44.
12. Bano S, Waraich MM, Khan MA, Buzdar SA, Manzur S. Diagnostic value of apparent diffusion coefficient for the accurate assessment and differentiation of intracranial meningiomas. Acta Radiol Short Rep 2013;2(7):2047981613512484.

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