

## ROLE OF DIFFUSION WEIGHTED MRI IN DIFFERENTIAL DIAGNOSIS OF PAEDIATRIC POSTERIOR FOSSA TUMORS

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### Abstract

**Background:** Infratentorial tumors accounts for 65% of all paediatric tumors, and most common infratentorial tumors in children include juvenile pilocytic astrocytoma (JPA), medulloblastoma, ependymoma and brainstem glioma. An accurate diagnosis has important clinical implications related to treatment and prognosis. DWI and ADC maps provide information regarding the cellularity of tumors and have an important role in the preoperative differentiation of different tumor types.

**Aim:** To evaluate the role of DWI and ADC measurement in distinguishing between the most common pediatric posterior fossa tumors.

**Methods:** In this study, we evaluated 25 paediatric patients aged between 1 to 15 years suspected to have posterior fossa mass on the CT referred from neurosurgery department to our department for MRI brain. All these patients subjected to conventional MRI followed by diffusion MR imaging and calculation of the ADC values. Written consent was taken from the guardians.

**Results:** In juvenile pilocytic astrocytoma ( $n = 10$ ), ADC values ranged between 1.3 and  $1.9 \times 10^{-3} \text{ mm}^2/\text{s}$ , ependymoma ( $n = 8$ ), ADC values ranged between 1.1 and  $1.5 \times 10^{-3} \text{ mm}^2/\text{s}$  and medulloblastoma ( $n = 7$ ), ADC values ranged between 0.45 and  $0.9 \times 10^{-3} \text{ mm}^2/\text{s}$ . Statistically significant difference in ADC value was detected between JPA, ependymomas and medulloblastomas, while no statistically significant difference was detected between JPA and ependymomas.

**Conclusion:** Diffusion Imaging plays an important role in demonstrating the features of posterior fossa brain tumours for appropriate diagnosis of medulloblastomas, ependymomas, and pilocytic astrocytoma.

**Keywords:** DWI, MRI, Posterior fossa

### Introduction:

- Intraaxial infratentorial tumors that occur in the posterior fossa are markedly different in the pediatric and adult population. Approximately 65% of all pediatric masses arise in the posterior fossa. The most common tumors in children are pilocytic astrocytoma, medulloblastoma, and ependymoma. [1]
- Although MRI is essential for the diagnosis and evaluation of brain tumors, it offers limited information on the type and grade of the tumor. DWI allowed us to obtain additional information derived from the microscopic movement of the water proton, which is not available by conventional MRI.
- Diffusion imaging was applied for tumor grade assignment or tumor type differentiation, as well as for the diagnosis of other brain masses. [2]
- Recent studies have evaluated the role of diffusion weighted imaging (DWI) in differentiating the grade and type of pediatric brain tumors in the posterior fossa. [3]
- ADC measurement should be useful in tumor evaluation because changes in water content and diffusivity, which can be found in tumors for various

reasons (eg. cytotoxic edema & cellularity), probably provide information that is not readily available in conventional MRI.[4]

### Aim and objective

- To evaluate the role of DWI and ADC measurement in distinguishing between the most common pediatric posterior fossa tumors.

### Methods

- In this study, we evaluated 25 paediatric patients aged between 1 to 15 years suspected to have posterior fossa mass on the CT referred from neurosurgery department to our department for MRI brain. All these patients subjected to conventional MRI followed by diffusion MR imaging and calculation of the ADC values (using a 3-T magnetic resonance scanner Philips Ingenia).
- Written consent was taken from the guardians.
- Histological diagnosis was provided by analysis of postoperative specimens.

### Results

- 14 males and 11 females children (total-25) with posterior fossa brain tumors were enrolled in this study.

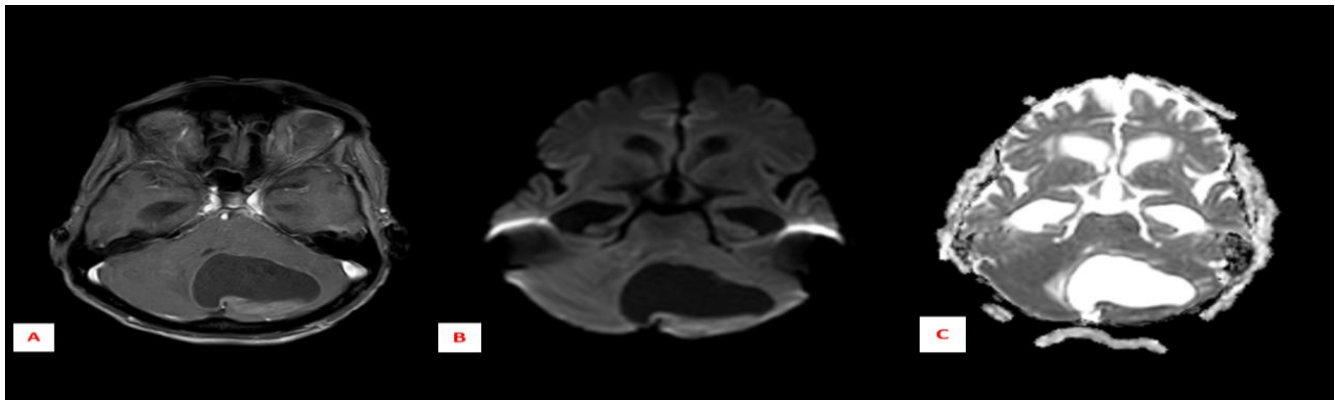
• Most common pediatric posterior fossa tumors encountered in our study were pilocytic astrocytoma in 10 cases, ependymoma in 8 cases and medulloblastoma in 7 cases.

**Table 1:** DWI findings and ADC values in the three examined posterior fossa tumors groups.

	Pilocytic Astrocytoma	Ependymoma	Medulloblastoma
No. of patients	10(40%)	8(32%)	7(28%)
Signal Intensity on DWI	Low(cystic) SI, Iso-slightly high SI (solid mural nodule)	Heterogeneous SI	Predominantly high SI
Range of ADC( $10^{-3}$ mm <sup>2</sup> /s)	2.5-3.1(Cystic) 1.3-1.9(solid part)	1.1-1.5	0.45-0.9
Avg ADC value	1.6(solid part)	1.3	0.79

In the pilocytic astrocytomas examined 10 cases, the cystic component in all cases of juvenile pilocytic astrocytomas appeared hypointense in DWI (b1000) (Table-1) compared to the normal-appearing brain parenchyma, denoting free diffusion. Their ADC values ranged from 2.5 to  $3.1 \times 10^{-3}$  mm<sup>2</sup>/s.

The solid mural nodule of the tumor showed an iso to hyperintense signal in DWI and an iso to hypointense signal in the ADC map denoting minimal diffusion restriction in the solid mural nodule in pilocytic astrocytoma, the ADC value was between  $1.3$  and  $1.9 \times 10^{-3}$  mm<sup>2</sup>/s (Figure 1).



**Figure 1:**

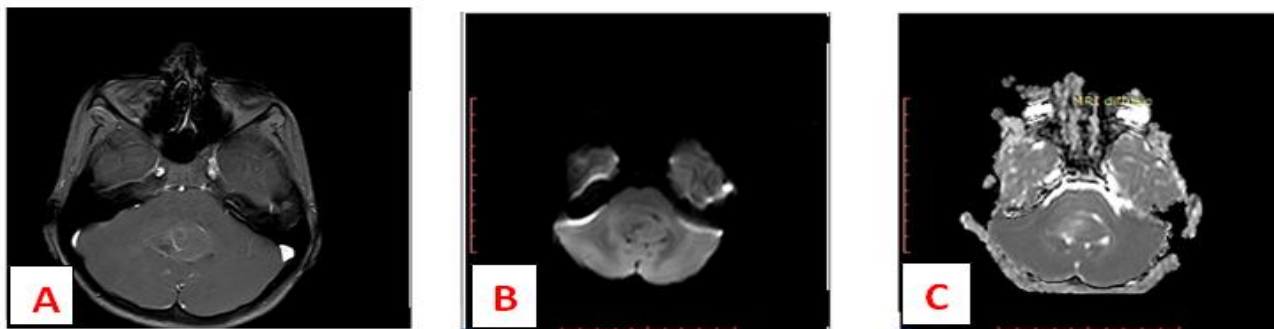
**A-Axial** T1 post contrast image shows midline infra-tentorial cystic lesion with enhanced peripheral solid mural nodule.

**B-Axial** DWI shows a low signal intensity of the cystic lesion and hypo to isointense mural nodule.

**C-Axial** ADC map shows a hypo-isointense signal of mural nodule with ADC value =  $1.6 \times 10^{-3}$  mm<sup>2</sup>/s raising the diagnosis of pilocytic astrocytoma.

In the 8 ependymoma cases examined, the intensity of the signal was heterogeneous both in the DWI and in the ADC map due to the presence of solid and cystic components (Table 1).

The enhanced solid component exhibited an isointense to slightly hyperintense signal on diffusion images, a hypointense signal on the ADC map, and had an ADC value between  $1.1$  and  $1.5 \times 10^{-3}$  mm<sup>2</sup>/s (Fig. 2) suggesting a restriction diffusion greater than that observed in the pilocytic astrocytoma cases.



**Figure 2:**

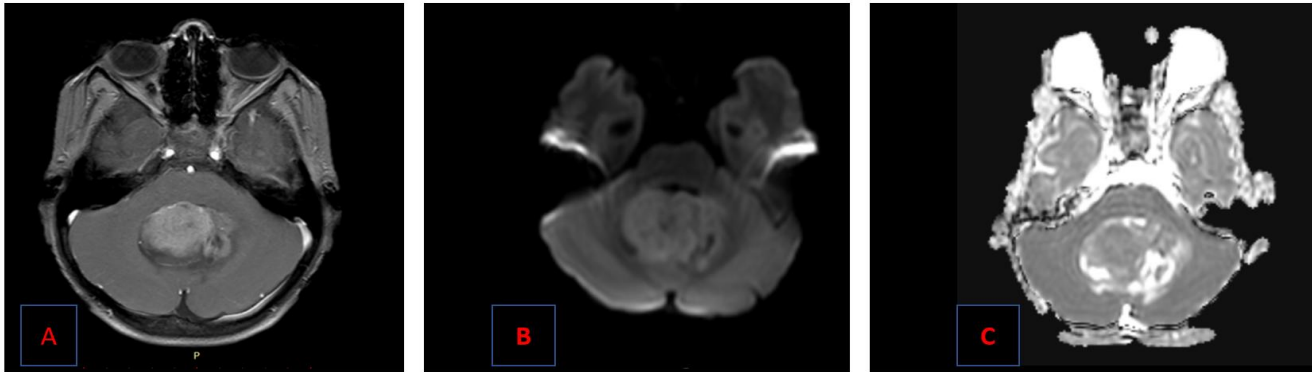
**A-Axial** T1 contrast image shows heterogeneously enhanced posterior fossa mass( solid-cystic in IV ventricle).

**B-Axial** DWI shows an intermediate signal intensity of solid component denoting restricted diffusion with hypointense cystic area.

**C-Axial** ADC map revealed a low signal intensity of the lesion denoting diffusion restriction with ADC value =  $1.2 \times 10^{-3}$  mm<sup>2</sup>/s which is in the ADC range of ependymoma.

In cases of medulloblastoma (n = 7), the diffusion was significantly restricted compared with pilocytic astrocytoma and ependymoma due to the densely packed characteristics of the cells.

All cases of medulloblastoma appeared predominantly hyperintense on diffusion images in relation to normal brain parenchyma, hypointense on the ADC map, and the ADC value ranged between  $0.45$  and  $0.9 \times 10^{-3} \text{ mm}^2/\text{s}$ , which is consistent with a marked restriction of diffusion (Fig. 3).



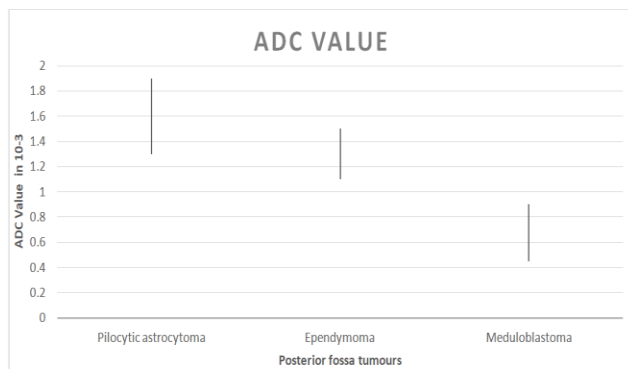
**Figure 3:**

**A-Axial** T1 post contrast image showing a heterogeneously enhanced midline posterior fossa mass, into the 4th ventricle. The diagnostic possibilities were medulloblastoma versus ependymoma.

**B-Axial** DWI shows high signal intensity of the lesion relative to brain parenchyma, which is consistent with diffusion restriction.

**C-Axial** ADC map shows a low signal intensity of the lesion with ADC value =  $0.65 \times 10^{-3} \text{ mm}^2/\text{s}$  denoting marked diffusion restriction and supporting the diagnosis of medulloblastoma.

There were significant differences in ADC values between pilocytic astrocytoma and medulloblastoma and between ependymoma and medulloblastoma. However, no statistically significant differences were found between pilocytic astrocytoma and ependymoma.



**Figure 4:** Scatter diagram showing the ADC value in the three tumor types is included in this study.

### Discussion

Diffusion MRI was performed using echo-planer units and, due to its sensitivity to alterations in the movement of water molecules in the studied brain region, had a significant impact on the clinical image.

The cellularity and grade of the tumor were related to the ADC values from the ADC maps (the ADC value is inversely proportional to the cellularity of the tumor). [3]

In our study, pilocytic astrocytoma and medulloblastoma could be differentiated on the basis of the ADC value in all patients, and there was no overlap in the measurements obtained between the two types of tumors.

The ADC value was higher than  $1.3 \times 10^{-3} \text{ mm}^2/\text{s}$  in pilocytic astrocytoma cases while in medulloblastoma cases the ADC values were lower than  $0.9 \times 10^{-3} \text{ mm}^2/\text{s}$ , indicating a significant difference in the ADC values between the two tumor types.

Our results were consistent with the study done by *Rumboldt et al.*[4], as they concluded that significant differences in cellularity of pediatric cerebellar neoplasms, particularly between juvenile pilocytic astrocytomas and medulloblastomas indicate that these lesions could potentially be distinguished by their ADC values. They used cut off values of more than  $1.4 \times 10^{-3} \text{ mm}^2/\text{s}$  for juvenile pilocytic astrocytomas and less than  $0.9 \times 10^{-3} \text{ mm}^2/\text{s}$  for medulloblastoma which seem to reliably provide the diagnosis which may affect the treatment plan and prognosis.

Ependymomas are heterogenous, moderately cellular tumors. Therefore ependymoma is somewhere between that of pilocytic astrocytomas and medulloblastomas.[5]

In this study, the ADC values also clearly distinguished medulloblastoma from ependymoma in all patients without any overlap, as ependymoma cases showed ADC values  $1.1$ – $1.5 \times 10^{-3} \text{ mm}^2/\text{s}$  which are higher than that

seen in medulloblastoma, in consistency with study of *Yamasaki et al.*[6], as they found that ADC values were retrospectively 100% accurate in the differentiation between ependymomas and medulloblastomas.

The ADC values of pilocytic astrocytomas were also higher from ependymomas in our study and this difference was not statistically significant because of ADC value overlap between the two tumor types in disagreement with few authors [4], they found that ependymomas were also significantly different from other tumor types and in most of cases show ADC values  $1.00\text{--}1.30 \times 10^{-3} \text{ mm}^2/\text{s}$ .

### Conclusion

Based on our study, we suggest that ADC values play an important role in the pre-operative diagnosis of posterior fossa tumors in children.

If high ADC value ( $>1.5 \times 10^{-3} \text{ mm}^2/\text{s}$ ) is detected, a patient may go directly to surgery without additional imaging as pilocytic astrocytoma is unlikely to metastasize via CSF seeding.

On the other hand, very low ADC value ( $<0.9 \times 10^{-3} \text{ mm}^2/\text{s}$ ) suggests that the tumor is medulloblastoma, so further imaging of the spine is essential to exclude metastases and appropriately manage the patient.

Ependymoma is also significantly differentiated from medulloblastoma, but no statistically significant difference between ependymoma and pilocytic astrocytoma was detected on ADC.

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