The use of ADC parameters to distinguish paediatric brain tumours

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Introduction Accurate preoperative diagnosis is important in paediatric patients with CNS lesions, particularly in those with posterior fossa (PF) lesions. The common tumours in this region, seen in figure 1 (juvenile pilocytic astrocytoma (JPA), (a), ependymoma, (b) and primitive neurectodermal tumours–medulloblastoma (PNET-MB), (c)) require different surgical approaches and have differing natural histories and outcomes.[1] Definitive histological diagnosis remains the gold standard but surgical biopsy carries significant risk of morbidity and mortality and therefore a non-invasive diagnosis could reduce surgical morbidity. Attempts to use diffusion metrics to discriminate between tumour types has shown limited success using average ADC of tumour groups alone,[2] or in combination with age and sex.[3] Our aim was to determine whether it is possible to differentiate the common posterior fossa tumour types on the basis of ADC histogram parameters. In addition we specifically looked at differentiating a rare tumour type (atypical teratoid rhabdoid tumour (ATRT)) from its embryological relative PNET-MB. Given the poorer prognosis and less aggressive management of ATRT.

Methods MRI was performed on patients using a Siemens Symphony or Avanto 1.5T system. Images were obtained as part of a clinical workup pre-operatively with the following parameters: 5mm slice thickness, 3 (Avanto) or 2 averages (Symphony), b-values of 0, 500 and 1000 s/mm^2, 230mm FOV (both scanners), image matrix 128 x 128. Mean ADC of water at identical temperature on the two systems was 2.276 x 10^{-3} (Avanto) and 2.245 x 10^{-3} (Symphony).

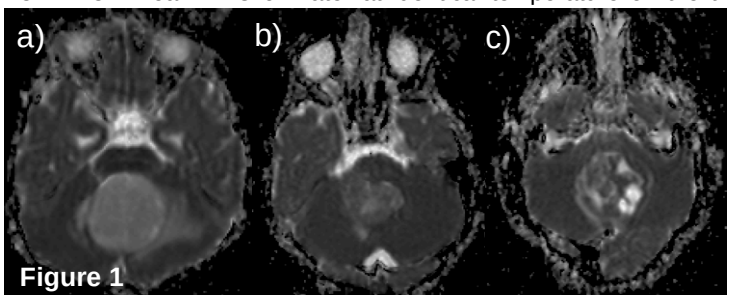

Figure 1

ADC maps and b0 images were transferred to a SunBlade workstation and off-line analysis was performed using DispImage.[5] ROI's were drawn manually, by the author, around the tumour on each slice of the b0 image (areas of large cyst or necrosis were excluded) and then applied to the ADC map. An ADC histogram was generated for the whole tumour volume, which was normalised for tumour volume (bin width 2x10^{-5}). A Matlab (R2007a) script was used to extract parameters; peak height, peak location (mode), mean ADC, 10^{th},25^{th},50^{th},75^{th},90^{th} centile points and skewness.

Patients Data was collected both retrospectively (Sept 2003 to Aug 2006) and prospectively (Sept 2006 to Jul 2007). In total 56 patients were included in the study (23 females and 33 males) with a histopathologically confirmed diagnosis subsequent to their pre-operative imaging). The mean age was 6.1 yrs (0.1-15.8). The study was approved by the local area ethics committee and informed consent was obtained.

Statistical analysis For each patient all the parameters were extracted and individuals were grouped into specific histological tumour types. The data were analyzed using SPSS for Windows (Ver. 14. 2006. Chicago: SPSS Inc.) Differences in mean ADC between tumour types was investigated using one-way ANOVA and using Tamhame's T2 post hoc multiple comparisons correction. Two separate stepwise linear discriminant analyses (LDA) were performed, using all extracted ADC parameters, firstly for all PF tumours and secondly to investigate possible differentiation of ATRT and PNET-MB. In each case a tumour type classification table was generated together with a table of cross-validated classifications (leave one out method).

Table 1. Mean ADC's

Tumour type	N	Mean ADC (x10^{-5})	SE
Ependymoma	5	117.99	2.76
DNET	5	139.23	19.82
Ch Plex Pap	7	154.89	15.19
Ch Plex Ca	2	107.41	14.12
JP Astro	11	183.68	5.10
PNET-MB	22	92.11	3.40
ATRT	4	80.62	10.01
Total	56		

Results Mean ADC's of all tumour groups are shown in Table 1(DNET; Dysembryoplastic neuroepithelial tumour, Ch Plex Pap/Ca; chroid plexus papilloma or carcinoma). There were significant differences between PNET-MB's and astrocytomas confirming previous work,[2,3] and for the first time, using only ADC data, between ependymomas and astrocytomas ($p<0.05$), ependymomas and PNET-MB's ($p<0.05$) and between astrocytomas and ATRT ($p<0.05$). The 25^{th} and 50^{th} ADC centiles were important in discriminating between the PF tumours. The 10^{th} centile was the only variable that discrimated PNET-MB and ATRT. Correct classification of the PF tumours using the stepwise LDA method was as follows; Ependymomas 4/5 (80%), Astrocytomas 11/11 (100%), PNET-MB's 14/16 (88%). PNET-MB was correctly classified in 16/22 (75%) and ATRT was correctly classified in 3/4 (75%).

Discussion These results indicate that ADC histogram parameters can be used to answer focused diagnostic questions. The LDA showed that histogram parameters are useful in discriminating between the common paediatric PF tumours. The technique correctly predicts 91% of PF tumour types in cross validated cases. It is also useful for differentiating PNET-MB and ATRT, which are difficult to separate on radiological and clinical grounds. The technique correctly predicted 73% of cases. ADC histograms therefore have the potential to better predict the diagnosis and potentially reduce the need for invasive surgical biopsy.

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References [1] Becker L., Neuroimaging Clin N Am 1999 ;9 :671-90 [2] Rumboldt Z, et al., AJNR 2006 ; 27 :1362-1369 [3] Yamasaki F, et al., Radiology 2005 ; 235 :985-991 [4] Tozer D, et al., NMR in Biomedicine 2007; 20(1):49-57. [5] Plummer D, Riv. Neuroradiol. 1992 ; 5 :489-495