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DIFFUSION WEIGHTED IMAGING – GRADING OF MENINGIOMAS USING ADC AND NADC VALUES FOSTERED WITH HISTOPATHOLOGICAL CORRELATION

Radiodiagnosis

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ABSTRACT

Meningiomas are one of the commonest and very frequently encountered tumours with more female predilection. They are easily diagnosed but yet, differentiating them on imaging alone is cumbersome. So, recent imaging techniques - diffusion weighted imaging helps by delivering ADC, NADC values with help of which grading meningiomas can be materialised on imaging with an increased degree of confidence. In this original article, we present a study of 40 cases of meningioma and attempt to grade them as benign and malignant using the ADC and NADC values on imaging as against histopathological correlation.

KEYWORDS

meningioma, grading, diffusion weighted imaging, apparent diffusion coefficient, normalised apparent diffusion coefficient

Introduction :-

Meningiomas are one of the most commonly encountered intracranial tumours, approximately 14-20% of all intracranial tumours[1]. Being an easy task to diagnose, they are extremely difficult to grade into benign or malignant grade on imaging alone[2]. The gold standard for grading them is histopathological examination. Therefore, it will be interesting to observe if imaging can serve as an adjunct to this purpose. Among the numerous studies carried out in this direction, Hakyemez B et al and Filippi CG et al inferred that the less the value of apparent diffusion coefficient, more the degree of malignancy and vice vera for degree of benignity[3,4]. On the other hand, Yamasaki F et al have no such conclusion[5]. In this study, we compared the respective ADC and NADC values in between benign and malignant meningiomas in order to determine specific cutoff value for meningioma grading on DWI.

Material and methods :-

A prospective study was carried out in the Department of Radiodiagnosis, Acharya Vinoba Bhave Rural Hospital, Sawangi (Meghe), Wardha over a period of 2 years. All cases with cranial meningioma were included irrespective of their age, sex and occupation, and those cases who were claustrophobic, having post operative history or any metallic implants, stents, coils or pacemakers were excluded. The study approval was obtained from Institutional Ethics Committee and all patients were asked to go through informed consent. 40 patients with meningiomas underwent magnetic resonance imaging. MRI was carried out on 1.5 Tesla MRI equipment (GE BRIVO MR 355 make). Cranial meningiomas were examined using routine as well diffusion weighted imaging sequences with ADC and NADC values were obtained from within the tumour and from normal white matter respectively. The values of NADC was obtained using the formula : ADC within tumour/ ADC of normal white matter. All meningiomas were graded according to WHO classification based upon their histopathological examination and correlated with their respective ADC and NADC values.

Statistical tests were incorporated by using SPSS software.

Results :-

Our study included total of 40 cases of intracranial meningioma of which, 9 were males and 31 were females. Thus, there was 1:3 male to female ratio, suggesting high female predilection. There were 8 cases each in age groups of 31 to 40 years and 41 to 50 years respectively. A maximum of 12 cases were in the age group of 51 to 60 years, followed by 10 cases in age group of 61 to 70 years. The least number of cases , 2 , were in age group of 71 to 80 years. The different intracranial locations recorded were parafalcine (11 cases), parietal (9 cases), temporal (7 cases), frontal convexities(5 cases), olfactory groove(2 cases), sphenoid wing(1 case) and cerebellopontine angle (5 cases). According to histopathological typing, we recorded maximum number of 15 cases of meningothelial meningioma, followed by 3 cases each of syncytial, fibroblastic and transitional types and 2 cases each of angiomatous and psammomatous meningiomas with 7 cases of rhabdoid meningioma followed by 5 cases of anaplastic meningioma. Thus, there were 28 meningiomas with benign and 12 meningiomas with malignant nature as proven on histopathological examination. On application of diffusion weighted imaging sequences, restricted diffusion, presence of hyperintense area) was observed in all 12 of the malignant meningiomas, while 4 of 28 benign meningiomas showed restriction as well. The remaining 24 cases did not show any restricted diffusion and were isointense to surrounding white matter. Thus, higher the degree of malignancy, more the degree of restricted diffusion. Intratumoral apparent diffusion coefficient values along with normalised apparent diffusion coefficient values were recorded in all cases. The minimum, maximum and mean values of intratumoral apparent diffusion coefficient values for benign meningiomas were 0.921×10^{-3} , 1.473×10^{-3} and 1.012×10^{-3} respectively. The minimum, maximum and mean values of intratumoral apparent diffusion coefficient values for malignant meningiomas were 0.631×10^{-3} , 0.843×10^{-3} and 0.761×10^{-3} respectively. The minimum, maximum and mean values of normalised intratumoral apparent diffusion coefficient values for benign meningiomas were 0.891×10^{-3} , 1.274×10^{-3} and 1.017×10^{-3} respectively. The minimum, maximum and mean values of normalised intratumoral apparent diffusion coefficient values for malignant meningiomas were 0.579×10^{-3}, 0.938×10^{-3} and 0.849×10^{-3} respectively. Therefore, the ADC and NADC values were significantly lower in malignant meningiomas than benign meningiomas. Using ROC curves, optimal cutoff value obtained for ADC and NADC were 0.83×10^{-3} and 0.97×10^{-3} respectively with sensitivity of 94.41%, specificity of 81.27% for ADC and sensitivity of 95.68%, specificity of 90.17% for NADC. Thus, the said values were statistically significant in grading meningiomas as benign or malignant therein.

Discussion :-

Our study showed that ADC and NADC values were were significantly lower in malignant meningiomas than benign meningioma and were crucial in contributing towards grading of meningiomas. This inference is in consistency with Hakyemez et al, Filippi CG et al and Nagar et al [3,4,6]. The use of NADC values proved to be of slightly higher diagnostic accuracy, as it showed higher sensitivity and specificity than ADC values. This result is consistent with Nagar et al[6]. Our study had a sample size of 40 cases close to Nagar et al (n=48), which was larger than Filippi CG et al[4,6]. It is widely accepted that degree of diffusion of water molecules depends upon the ratio of intracellular to extracellular space[7,8].

Higher the grade of a tumour, higher the intratumoral cellularity. This is coupled with presence of intratumoral necrosis, haemorrhage as well as increased mitotic activity, recorded on histopathological examination. These factors can be considered to decrease water diffusion across tissue owing to discordance in intracellular to extracellular ratio therein[7,8,9].

Limitation :-

A study with a larger sample size with double blinding will help validate and standardize the obtained results. Also, not being limited to a single imaging technique such as diffusion weighted imaging, incorporating other imaging modalities like perfusion imaging, PET CT, magnetic resonance spectroscopy will increase the ability of clinching diagnosis in future[10-15].

Conclusion :-

Though the gold standard for grading menigiomas is histopathological examination, our aim in this study was to observe the role of diffusion weighted imaging sequences involving obtaining respective ADC and NADC values in grading meningiomas as benign or malignant tumours. It was observed that using these values increased both sensitivity and specificity of diagnosing meningioma as benign or malignant upon imaging. Thus, diffusion weighted imaging can be very helpful in pointing out the nature of a meningioma, whether benign or malignant and direct the treatment progression as situationally suitable.

1. Sexwise distribution of cases

Males	Females
9	31

2. Agewise distribution of cases

Age group in years	Number of cases
31-40	8
41-50	8
51-60	12
61-70	10
71-80	2

3. Sitewise distribution of cases

Site of tumour	Number of cases
Parafalcine	11
Parietal	9
Temporal	7
Frontal	5
Olfactory	2
Sphenoid	1
Cerebellopontine	5

4. Distribution of cases based on histopathological grading – benign or malignant

Histopathological type	WHO grade	Number of cases	Nature
Syncytial	I/II	3	Benign
Psammomatous	I/II	2	Benign
Angiomatous	I/II	2	Benign
Meningothelial	I/II	15	Benign
Fibroblastic	I/II	3	Benign
Transitional	I/II	3	Benign
Anaplastic	III/IV	5	Malignant
Rhabdoid	III/IV	7	Malignant

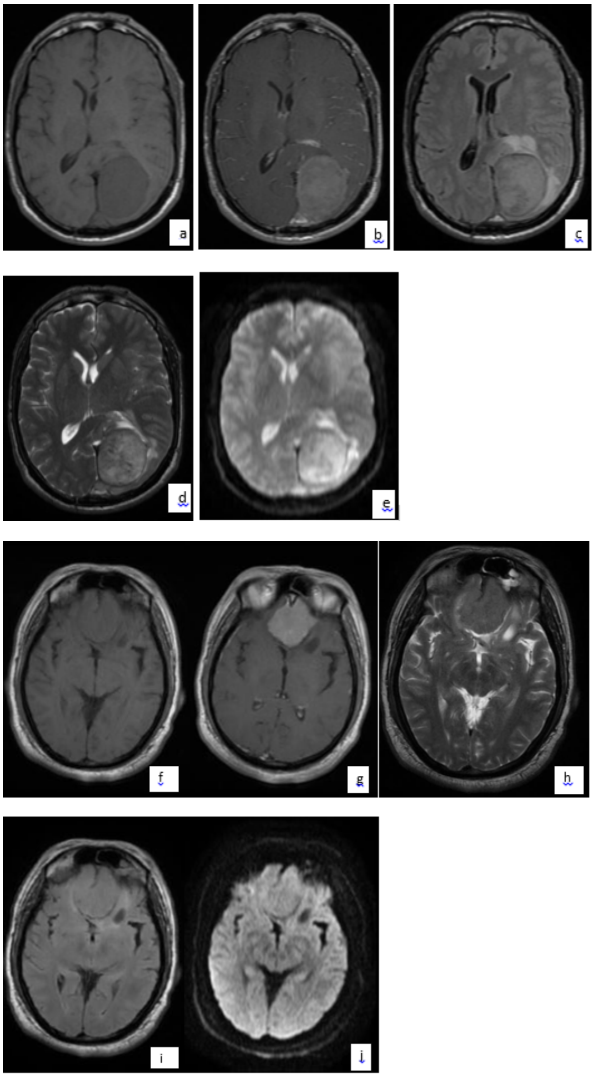
5. Restriction on Diffusion weighted imaging

	Restriction present	Restriction absent
Benign	4	24
Malignant	12	0

6. ADC and NADC values in benign and malignant cases on ADC mapping

Benign	ADC_{min}	ADCmax	ADCmean
	0.921×10^{-3}	1.473×10^{-3}	1.012×10^{-3}
	$NADC_{min}$	**NADCmax**	**NADCmean**
	0.891×10^{-3}	1.274×10^{-3}	1.017×10^{-3}
Malignant	**ADC_{min}**	**ADCmax**	**ADCmean**
	0.631×10^{-3}	0.843×10^{-3}	0.761×10^{-3}
	$NADC_{min}$	**NADCmax**	**NADCmean**
	0.579×10^{-3}	0.938×10^{-3}	0.849×10^{-3}

Images :-



Legends :-

A well defined extraaxial round to oval mass seen hypointense on T1(figure a), showing intense post contrast enhancement (figure b), hyperintense on T2 and FLAIR showing cerebrospinal fluid cleft (figure c and d) with restricted diffusion on diffusion weighted imaging sequences. This mass was diagnosed malignant rhabdoid meningioma on histoapathological examination.

A well defined extraaxial round to oval mass seen isointense on T1 (figure f), showing intense post contrast enhancement (figure g), mildly hyperintense on T2 and FLAIR showing cerebrospinal fluid cleft (figure h and i) showing no restricted iffusion on diffusion imaging sequences. This mass was diagnosed benign meningothelial meningioma on histoapathological examination.

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