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RESEARCH ARTICLE

ROLE OF DTI IN DIFFERENTIATING HIGH GRADE GLIOMA AND SOLITARY METASTASIS

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ABSTRACT

Context: Diffusion tensor imaging (DTI) is an advanced MR technique that describes the movement of water molecules by using two metrics, mean diffusivity (MD), and fractional anisotropy (FA), which represent the magnitude and directionality of water diffusion, respectively. We hypothesize that alterations in these values within the tissue surrounding brain tumours reflect combinations of increased water content and tumor infiltration and that these changes can be used to differentiate high-grade gliomas from metastatic lesions.
Aim: To differentiate between vasogenic and infiltrative edema using FA and MD values.
Settings and Design: This is a prospective study, conducted in the Department of Radiodiagnosis and Imaging, Kasturba Medical College, Manipal. Number of study subjects were 30 patients.
Methods and Material:

- Imaging was performed on a 1.5T Philips Achieva MRI machine using a head coil.
- DTI images was then acquired to allow comparison of the results.

Statistical analysis used: Student independent t-test.
Results: For perilesional FA values, p-value is 0.003, statistically significant for differentiating glioma and metastasis. The cut-off value is 0.174, above which is high grade glioma and below is metastasis. Sensitivity is 78.6 % and specificity is 73%. For perilesional MD values, p-value is 0.138, not statistically significant for differentiating glioma and metastasis.
Conclusion: The FA value changes surrounding gliomas, can be attributed not only to increased water content, but also to tumor infiltration.

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INTRODUCTION

Magnetic resonance imaging (MRI) continues to be at the forefront of radiological imaging modalities over the years, and has single handedly revolutionized imaging of the central nervous system (CNS). Newer and highly focused MRI sequences have been developed and standardized that have strengthened our understanding of not just the normal anatomy but also the physiology and varied pathologies of the CNS over the years. The delineation of various WM tracts around a focal lesion and knowledge of the status of infiltration versus displacement are vital pieces of information that help neurologists and neurosurgeons decide on the appropriate management approach (1). Although routine MRI sequences can accurately demonstrate most CNS pathologies, they provide only limited information about the exact degree of involvement and integrity of the white matter (WM) tracts (2). Diffusion tensor imaging (MRI) is an MRI technique that enables measurement of degree and direction of diffusion of water molecules in human tissue and when applied to the CNS, it provides us information from which accurate images of neural tractscan be constructed, thus precisely delineating the anatomy and pathologies of WM tracts. Advanced DTI sequences such as color coded fractional anisotropy (FA) maps and tractography (fiber tracking) are used to evaluate the directionality and morphology of neural tracts (3). Determining tumor grade and evaluation of degree of involvement of WM tracts in the vicinity of focal brain pathologies has been the most important initial applications of DTI and has been well accepted as both a diagnostic and prognostic tool. The purpose of our study is to evaluate whether DTI helps in differentiating vasogenic edema from infiltrative edema.

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Aims and objectives

To differentiate between vasogenic and infiltrative edema using FA and MD values.

MATERIALS AND METHODS

This is a hospital based time bound prospective study, conducted between (September 2013 to august 2015) over a period of 23 months in the Department of Radiodiagnosis and Imaging, Kasturba Medical College, Manipal. The number of study subjects was 30 patients.

Inclusion criteria

Patients with focal brain parenchymal lesions detected on MRI done in Department of Radiodiagnosis, KMC Manipal with confirmation on biopsy/surgery when operated or Known primary malignancy in cases of metastasis.

Exclusion criteria

- No histopathologic proof (in malignancy)
- No e/o primary malignancy (in metastasis)
- No clinical or imaging follow-up (in non-malignant pathologies)
- Medically unstable patients.
- Patients with renal failure.
- Claustrophobic patients.
- Patients with cardiac pacemaker.
- Written informed consent was obtained from all patients after fully explaining to them the nature of the examination.
- All exams were performed in accordance with the rules laid down by the ethical committee of the KMC Manipal.

Image acquisition and data processing

- Imaging was performed on a 1.5T Philips Achieva MRI machine using a circular polarized head coil.
- DTI images was then acquired to allow comparison of the results.

Image analysis

- Diffusion tensor data were transferred to an independent workstation and processed by using Philips software.
- Three eigen values are used by software to compute FA and MD (ADC) values.

Statistical analysis

- Statistical analysis was done with SPSS version 21.
- Unpaired T-test was used to compare the mean between two groups.

RESULTS

Majority of the patients in the study were in the age group between 46-55 yrs. Minimum age was 19 yrs.; Maximum age was 72 yrs. Mean age was 47.5 yrs.

There were 15 cases of high grade glioma and 15 cases of metastasis.

Variables	Diagnosis	Mean	Standard deviation	Standard error mean
Perilesional edema FA mean	Highgrade Glioma (n=15)	0.234	.085	.022
	Metastasis (n=15)	0.144	.046	.014
Perilesional Edema MD mean	Highgrade glioma (n=15)	1.204	.359	.096
	Metastasis (n=15)	1.472	.514	.155

The FA values were high in the perilesional portions of high grade glioma as compared to metastasis. The difference is statistically significant.p-value is 0.003.

The following is the ROC curve between FA values in perilesional edema portions of high grade glioma and metastasis:

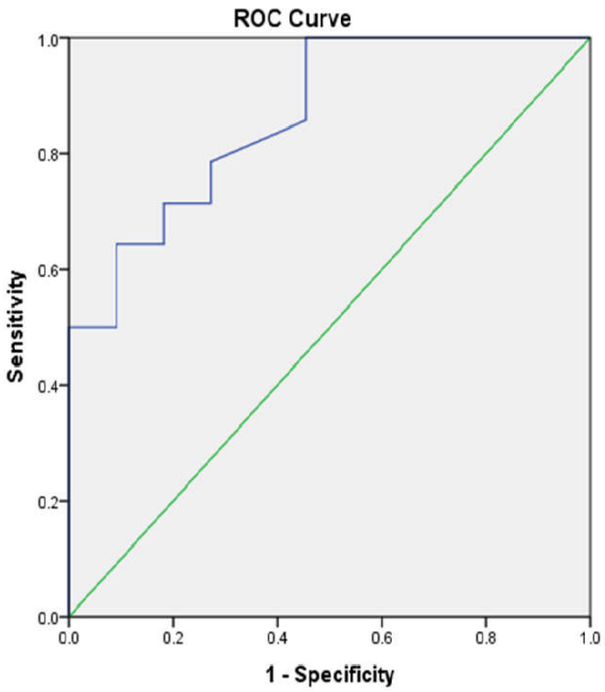

Fig. 1. ROC curve between perilesional edema FA values between high grade glioma and metastasis

The cut-off value is 0.174, above which is high grade glioma and below is metastasis which gave sensitivity of 78.6 % and specificity of 73%.

Fig. 2. Table showing sensitivity and specificity of comparison of FA values between glioma and metastasis

Mean Perilesional FA value	Sensitivity	Specificity
0.174	78.6%	73%

The mean MD values are high in cases of metastasis as compared to high grade glioma, however the difference is not statistically significant. p-value is 0.138.

DISCUSSION

DTI has been used to describe normal brain tissue as well as various disease states. Decreases in diffusivity, thought to be associated with cell swelling and consequent reduction in extracellular space, are seen in acute infarction. Abscesses and epidermoid tumors also display diminished diffusivity, which theoretically occurs through the viscosity of their contents (4). Various intracranial tumors have also been evaluated by using conventional diffusion imaging (5,6).

With DTI, derangement of anisotropy has been described in stroke (7,8), multiple sclerosis (9), and even schizophrenia (10). The anisotropy of various structural abnormalities has also been studied (11,12).

Fig.3. Comparison of our study and Lu et al.

		Peritumoral mean FA	Peritumoral mean MD	P value
Lu et al (AJNR 2003), 1.5T	High grade glioma (n=12)	0.248±0.063	0.622±0.111	Significant for MD p<0.05
	Metastasis(n=12)	0.181±0.041	0.798±0.109	
Our study,1.5T	High grade glioma (n=15)	0.234±0.085	1.204±0.359	Significant for FA p<0.05
	Metastasis(n=15)	0.144±0.046	1.472±0.514	

CASE 1.

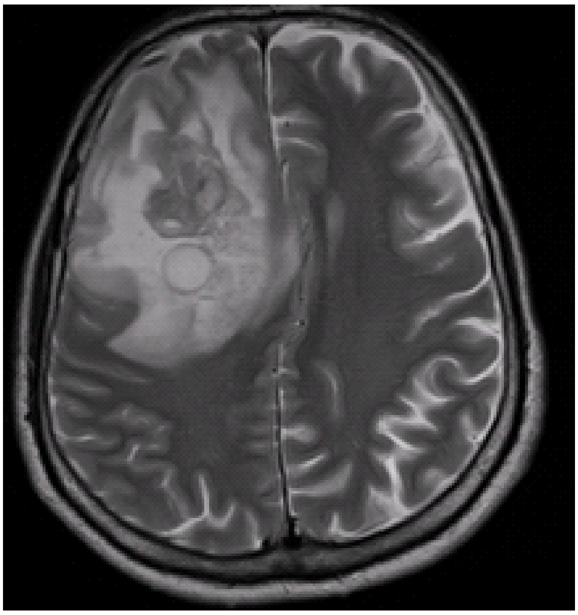

Fig.4A.

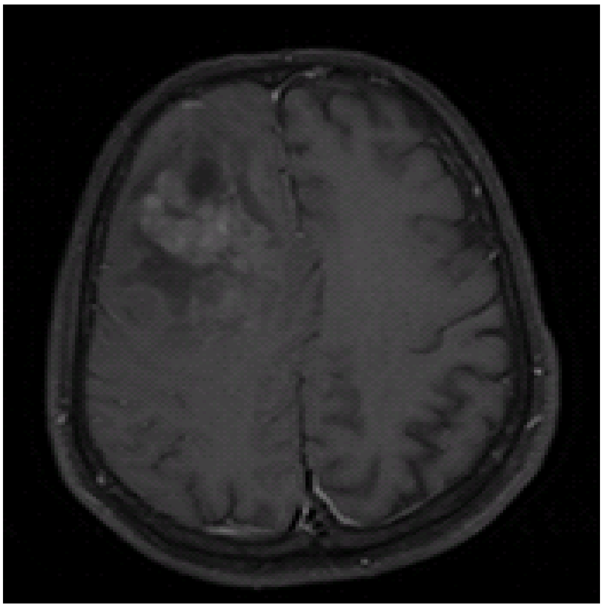

Fig.4B

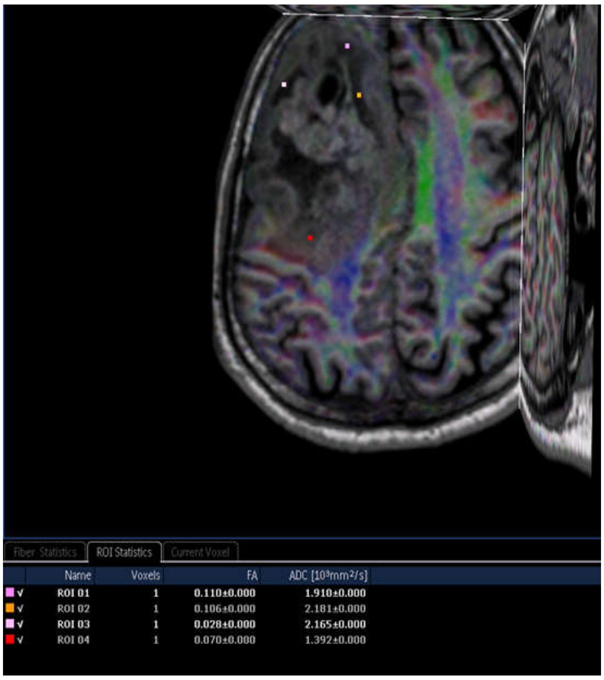

Fig.4C

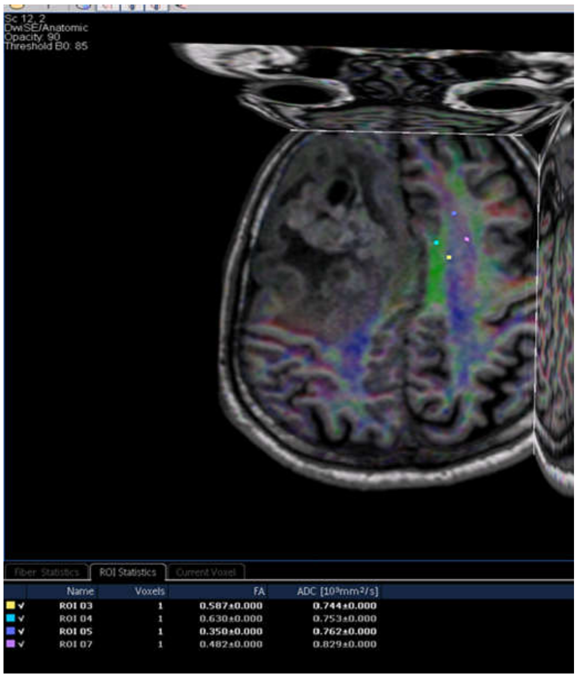

Fig.4D

Case of Anaplastic oligoastrocytoma. Fig.4A-Axial T2WI, showing hyperintense lesion, Fig.4B-heterogeneously enhancing lesion in right frontal lobe. Fig.4C-FA and MD values in perilesional edema.Fig. 4D-FA and MD values in normal contralateral white matter

CASE 2.

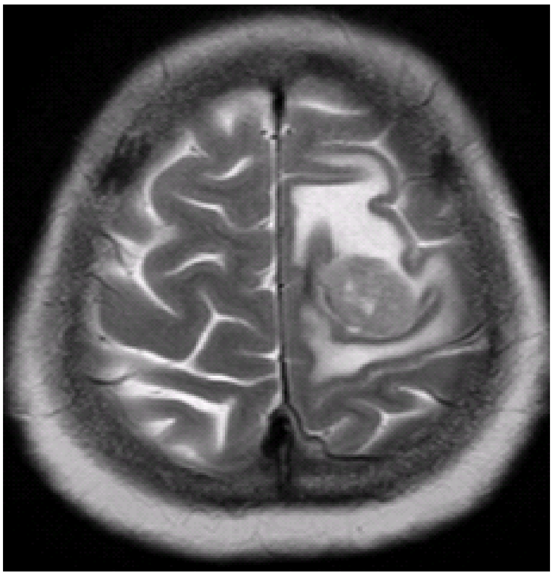

Fig.5A

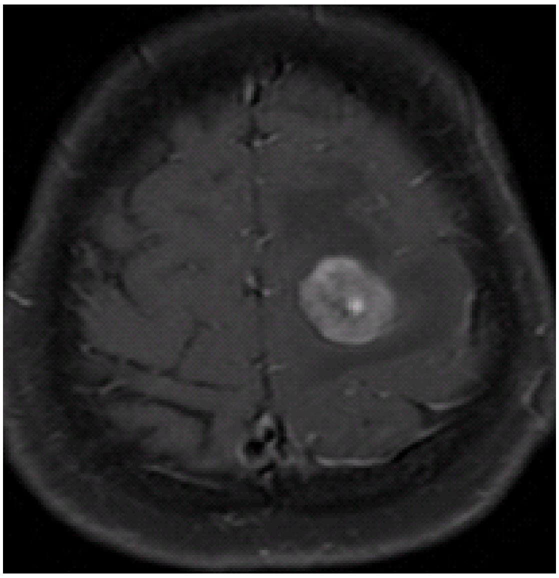

Fig.5B

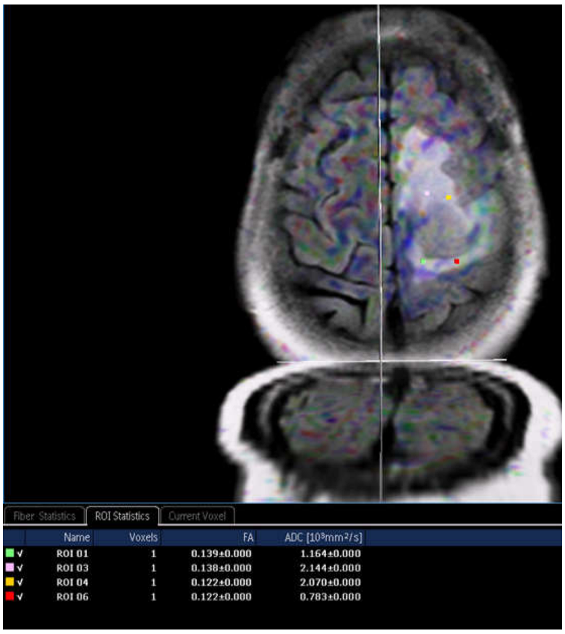

Fig.5C

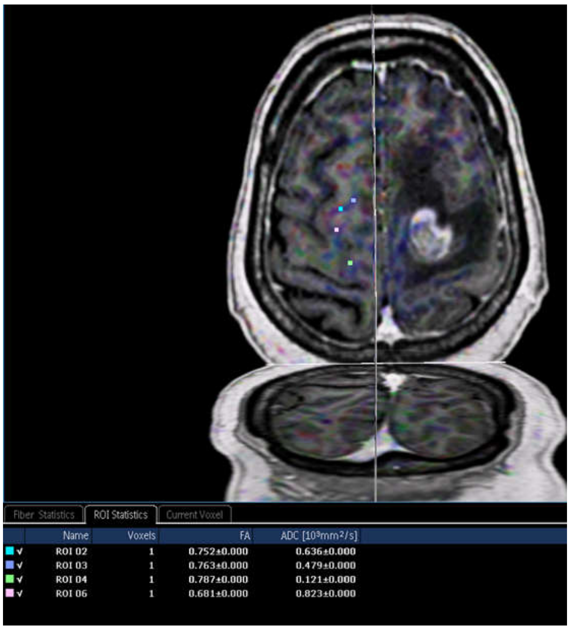

Fig.5D

Case of Metastasis from breast. Fig.5A-Axial T2WI showing hyperintense lesion, Fig.5B-Enhancing lesion in left frontal lobe. Fig.5C -FA and MD values in perilesional edema. Fig. 5D-FA and MD values in contralateral white matter

On conventional MR images, high-grade gliomas and solitary metastatic brain tumors often display similar signal intensity characteristics and contrast enhancement patterns. Most of these tumors are surrounded by a T2 signal intensity abnormality that has traditionally been termed vasogenic edema. By appearance alone, these peritumoral changes generally cannot be used to differentiate glioma from metastatic disease; however, because the vasogenic edema involves an increased water component (13), we used peritumoral DTI to study the molecular motion of the water. In the study done by Lu et al, they studied the role of DTI in differentiating metastasis and high grade glioma. They used peritumoral DTI to study the molecular motion of the water. In their study, they confirmed first hypothesis by showing statistically significant changes between the MD and FA values of normal-appearing white matter and those of the peritumoral T2 signal intensity abnormality. Surrounding both gliomas and metastatic lesions, there was an increase in MD and a decrease in FA, which were best explained by increased extracellular water. The addition of free water to any tissue increases the amount of diffusion (i.e., increases the MD) and causes more disorganized diffusion (i.e., decreases the FA), similar to the values seen in ventricles. They did the study with 12 high grade gliomas and 12 solitary metastasis. Their main hypothesis was to prove that differentiation of high-grade gliomas and metastatic tumors can be done by using FA values. But they disproved their hypothesis by showing that the changes in peritumoral FA do not differ significantly between high-grade gliomas and metastatic tumors. According to our study there is significant difference in FA values in the peritumoral portion of high grade glioma and metastasis. MD values are not statistically significant between glioma and metastasis in our study.

According to Lu et al, the peritumoral MD surrounding metastatic lesions proved to be significantly greater than that of surrounding high-grade gliomas. Whereas FA values are not significant in differentiating high grade glioma and metastasis. MD is determined by increased extracellular water, and therefore, metastasis-related vasogenic edema reflects greater increased water content of the surrounding tissue. The high grade gliomas had both increased water content and tumor infiltration in the peritumoral edema which contributes to more disorganized diffusion which leads to decreased FA. The glioma-related FA changes induced by both increased water content and tumor infiltration are comparable to the metastasis-related changes caused by the increased water content alone.

Conclusion

High-grade gliomas may be distinguished from brain metastases by comparing the peritumoral FA values. DTI appears to be a promising tool in diagnosing solitary intracranial lesions. The FA changes surrounding gliomas, can be attributed not only to increased water content, but also to tumor infiltration.

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