Original Research Article

Pre and Post-operative evaluation of brain neoplasms on Diffusion Tensor Imaging

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Abstract

Context: Complex neural networks are formed by the communication of billions of neurons with each other through their axons. Limitation to the understanding of brain function, due to the lack of non-invasive methods makes it essential to recognize such networks by structural mapping. **Aims:** We conducted this study with the aim of evaluating various brain neoplasms pre and post operatively and help guide the neurosurgeon for better resection of the tumor.**Settings and Design:** The study was conducted in Department of Radio-diagnosis, Dr. D. Y. Patil medical college, hospital and research center by using 3T MR scanner (Siemens Magnetom Vida) on 30 histopathologically proven cases of intracerebral neoplasms. The study design was Cross sectional observational study. **Statistical analysis used:** The data was entered in MS EXCEL spreadsheet and analysis done using licensed Statistical Package for Social Sciences (SPSS) version 21.0. Descriptive statistics (means and SDs) for each parameter were computed for the different tumor groups. The tumor groups were compared by using student or non-parametric sample tests. A 'p' value of <0.05 was considered statistically significant.**Results**: Or study showed that DTI can be helpful in differentiating low from high grade neoplasms. Various white matter tracts adjacent to the neoplasm were visualized and classified into displaced, edematous, infiltrated and destroyed depending upon the type of involvement by the neoplasm. Post operative KPS score showed improvement as compared to the pre-operative KPS score, highlighting value of DTI. **Conclusions:** Tract visualization can be extremely helpful for neurosurgeons in differentiating salvageable from lost tracts, thus DTI is an important tool in the arsenal of a neurosurgeon.

Keywords: DTI, MRI, intracerebral, neoplasm, edema

Introduction

For a neurosurgeon it is a matter of grave importance to achieve highest complete surgical removal while preserving the adjacent lying white matter tracts so as to minimize the functional deficits post-operatively.Achieving near total resection helps in preventing relapse and recurrence which allows further management through non-invasive ways like chemotherapy and radiotherapy[1-4]. However, economical resection keeping in mind the functionally significant areas improve the quality of life of patients remarkably, by sparing the language, visual and motor functions[5,6]. Multiple modalities in imaging including functional MRI, Positron Emission tomography have been found useful in assessing tumors[7]. However, it is prudent to understand the structural anatomy and integrity of such white matter tracts in relation to the location of the tumor for careful planning and approach[8].Diffusion tensor imaging provides knowledge in locating white matter tract pathways in brain. It is based on the phenomenon of anisotropic and isotropic diffusion. White matter tracts covered by myelin sheath allow highest diffusion of molecules parallel to it along the direction of the white matter tract. It gives us idea about the tissue integrity and the location, structure and architectural organization[9]. Additionally, it provides as a supplement to understand the connections amongst white matter fibers and determine their orientation and interconnectivity.CNS tumors accounts for less than 2% of all malignancies, the association of brain tumors with a high morbidity and mortality makes these neoplasms the most dreaded.DTI enabling the visualization of corticospinal tracts provides to complement in intraoperative fiber stimulation[1-3]. In the field of diagnostic imaging, DTI is an eloquent tool and the only possible way to exhibit WM tracts in vivo and provides to be a useful preoperative aid to the neurosurgeon[10,11].

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Methodology

We conducted the study in 30 cases of primary brain space occupying lesions detected on routine MRI brain for whom tumor resection was planned. Patients included 19 males and 11 females age groups (figure 1) between 18 to 62 years of median age group 40 years (Figure 2).Only those tumors were included which were singular, involving one cerebral hemisphere and occupied functional brain areas like the motor cortex (located in the precentral gyrus) and speech areas.The imaging protocols included axial T1 weighted, T2 weighted, FLAIR sequences, diffusion weighted imaging, and diffusion tensor imaging (DTI) and contrast enhanced T1W sequences. DTI sequence in our study was "ep2d_diff _mddw _20 _ (DTI)" which is based on Multidirectional Diffusion weighted Imaging in which multiple diffusion gradients are applied in 24 different directions on Echo Planar Imaging (EPI) Sequence. Diffusion tensor imaging was performed on 3T scanner in the axial plane with echo- planar imaging: repetition time (TR) = 3800 milli seconds (ms); echo time (TE) =75 ms; diffusion gradient encoding in 20 directions; b = 0; b = 1000 seconds/mm^2; voxel size= 1.7x1.7x4 mm; 128; slice thickness= 4 mm with distance factor of 30. Total of 25 slices without gap were used to include the cerebral hemispheres, upper brain stem, and cerebellum without gaps. Acquisition time on the 3-T scanner for the Diffusion Tensor Imaging sequences was 4 minutes 39 seconds.Color coded maps were analysed that were obtained from DTI.

Tracts were categorized based on following features –

1) Displaced – White matter tract maintained their structural integrity but were either oriented in a different axis or shifted

from their normal location as compared to the white matter tracts on the contralateral side.

2) Edematous – White matter tracts showed normal orientation and location and colour coding as compared to the opposite side, but showed hyperintensity on T2 images.
3) Infiltrated/invaded – White matter tracts on the side of the affected hemisphere adjacent to tumor showed change in color hue, however the tracts could be visualized to some extent.
4) Destroyed – White matter tracts could not be visualized with marked decrease in colour hue or complete non-visualization of tracts on color coded maps. The preoperative and postoperative evaluation of these patients based on improvement in symptoms and neurological deficits based on Karnofsky performance scale (KPS) performed.

Results

Out of the 30 patients included, the median age of patients was between 40-50 years. The location of lesion was frontal in 6 patients, parietal in 16 patients, temporal in 6 patients, 2 in posterior fossa (Figure 3). Patients presented with headache as predominant complaint in about 60% (18 patients) followed by seizures in 9 patients (30%) with other complaints like sensory and motor neurological deficits and slurring of speech and visual complaints.

On evaluating 2D and 3D diffusion tensor color coded maps they were categorized as according to the following criteria as; displaced, edematous, infiltrated and destroyed and found white matter tracts displaced in 18 patients(60% of study population),in 6 patients appeared edematous (20% of patients), infiltrated in 4 patients (13% population) and in 7% destroyed, which were 2 patients (Figure 4 and 5).Figure 5 shows disruption of white matter tracts adjacent to a GBM.Anisotropy was reduced in patients whose white matter tracts were infiltrated on color coded maps.On histopathology, glioblastoma was found to be the most common neoplasm, followed by astrocytoma and oligodendroglioma. Posterior fossa tumors were found to be medulloblastoma and hemangioblastoma.The results of DTI study were then used for preoperative assessment and planning, involvement of various functional areas of brain like language and motor areas and thereby correlated with postoperative functions and neurological status.The assessment was done using Karnofsky performance scale (KPS) (Figure 6)It was found that marked improvement was seen in majority of cases in which predominant tract involvement was categorized as displaced and/or edematous. On the other hand, slight or poor improvement in KPS score was noted in white matter tracts that were categorized as infilitrated and/or destroyed. It was correlated using Mann Whitney test with a significant p value < 0.05.These results could further be correlated with the histopathological diagnosis of the tumors done pre, intra or postoperatively and suggested that low grade tumors such as diffuse astrocytoma, pilocytic astrocytoma primarily caused displacement of adjacent white matter tracts whereas high grade neoplasms like glioblastoma multiforme and anaplastic astrocytoma caused disruption and infiltration in a higher number of patients.

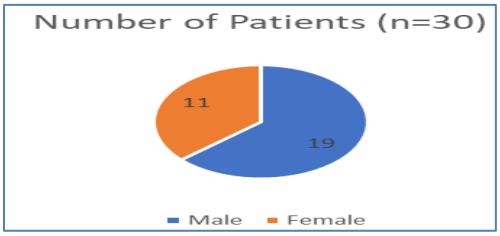

Fig 1: Gender distribution

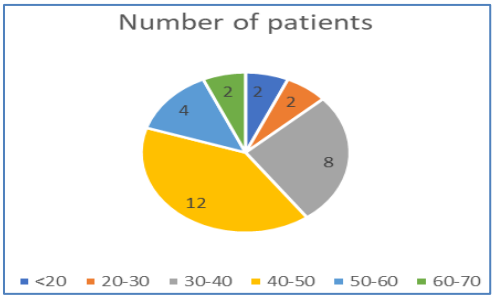

Fig 2: Age Distribution

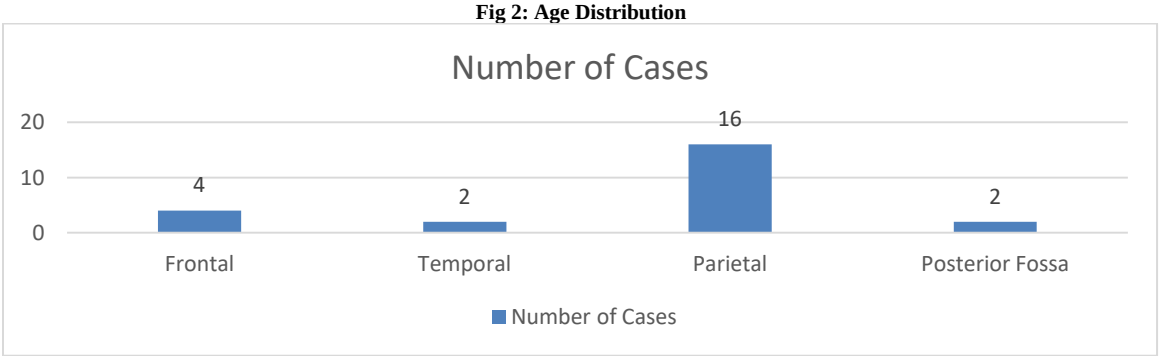

Fig 3: Lobe involvement by various neoplasms

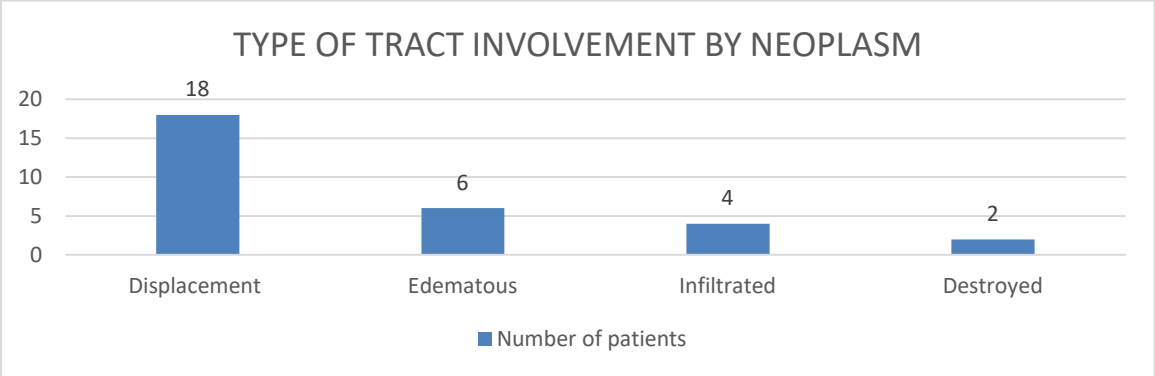

Fig 4:Type of white matter tract involvement by various neoplasms

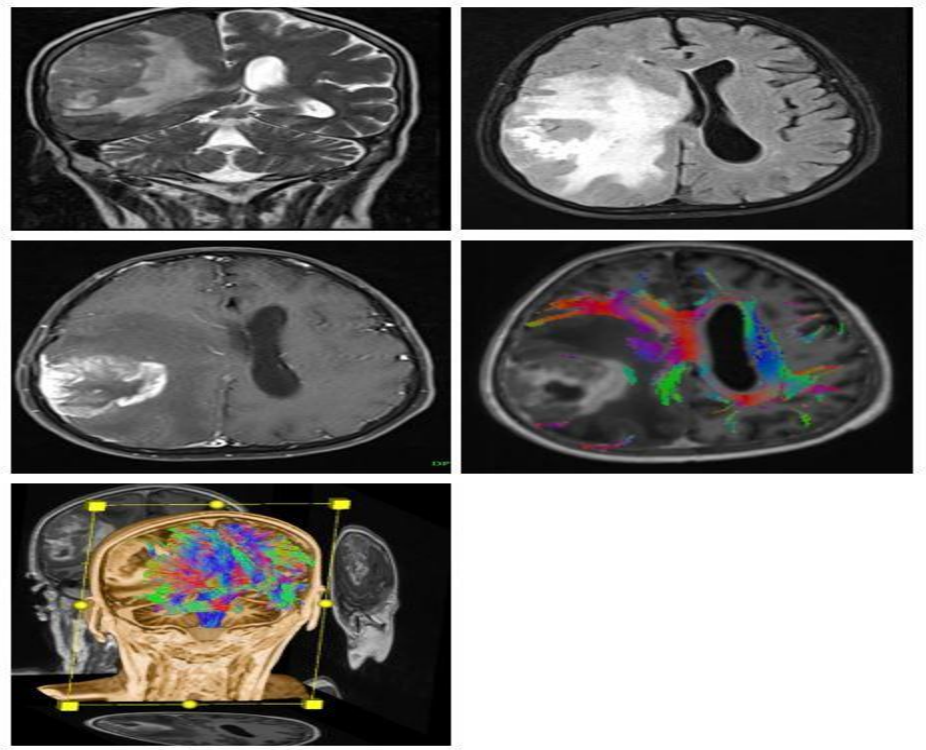

Fig 5: A, B) Coronal T2 weighted image and axial FLAIR in patient shows a fairly well defined lesion in the right frontoparietal region involving the cortical and subcortical matter with extensive edema surrounding it. C)The lesion shows heterogenous peripheral enhancement with non-enhancing center. D, E) Tractography and fused images show tracts infiltration and disruption in the adjacent tracts with normal appearance seen in the contralateral lobe. On histopathological diagnosis, the lesion was found to be a glioblastoma.

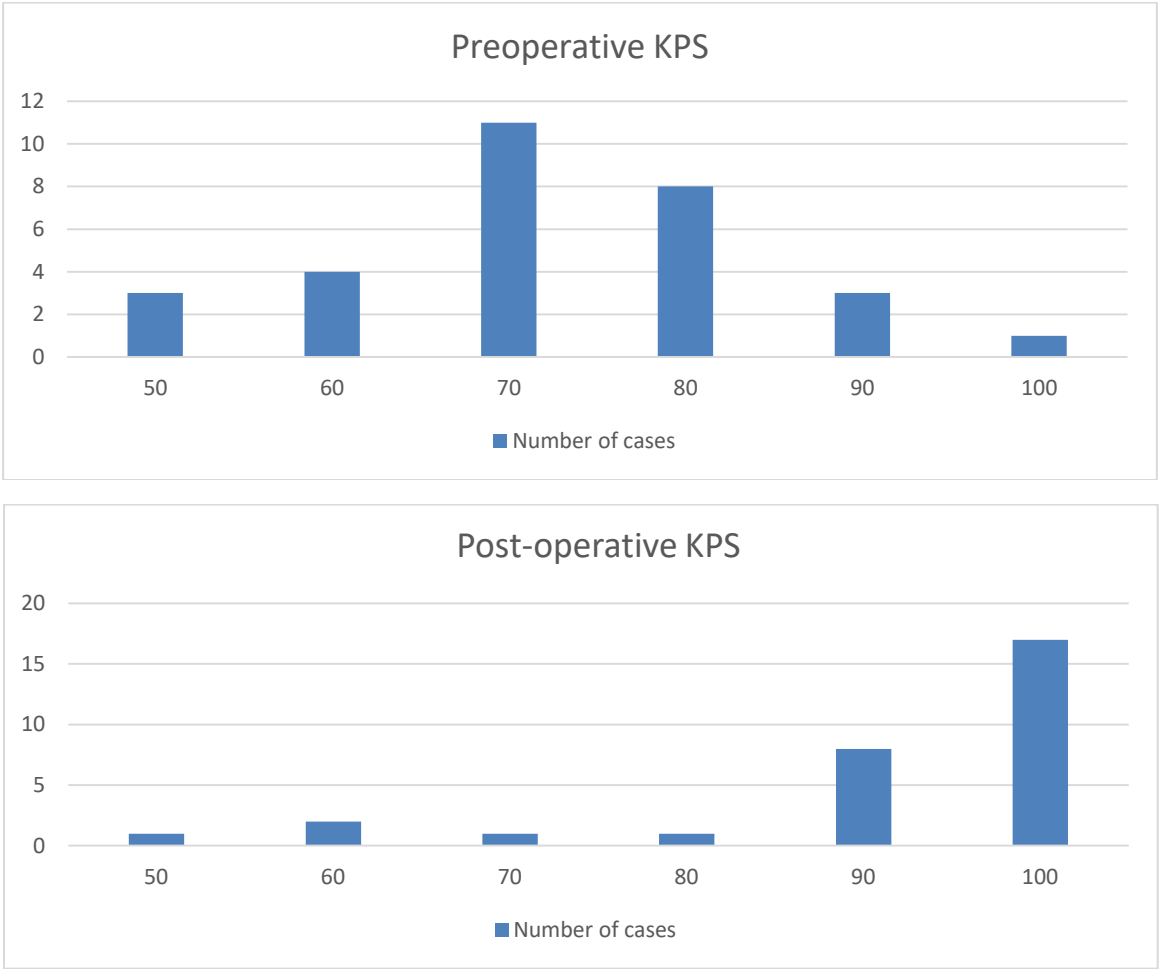

Fig 6:Changes in Karnofsky performance scale (KPS) pre and post operatively

Discussion

Intracerebral neoplasms by deteriorating the neurological status, affects the patients physically and psychologically. Diffusion tensor imaging in addition to routing MRI brain imaging helps in accurately locating the tumors and in better understanding of the involvement of white matter tracts. It provides as a useful supplement in preoperative planning as a guide for better surgical approach and delineating the functional white matter tracts that can be preserved. It assesses the degree of involvement of white matter tracts and further provides the surgeon the knowledge of functional areas that can be preserved.

In cases with complete destruction of white matter tracts as seen in aggressive tumors, tumor margins while resection can also be increased as to avoid recurrence despite loss of function in those patients[12]. Such knowledge also provides better patient counselling about the poor status of prognosis for better guidance to the patient and their family.Thirty cases were assessed to identify the relationship between tumor and adjacent white matter tracts. Displacement of tracts were seen in eighteen patients while they appeared edematous in six patients.Neurological status postoperatively based on KPS scale showed good improvement as compared to the four patients with infiltrated and 2 patients with destroyed tracts. Poorer neurological outcome was noted in the latter two categories and could be further communicated with the patients. Histopathological diagnosis of tumors also gave as a clue that high grade tumors like glioblastoma multiforme and anaplastic astrocytoma frequently caused destruction and infiltration in comparison to low grade tumors which mainly caused edema or displaced the white matter tracts. This provides us with clues about the aggressiveness and likely grade of a tumor.Diffusion tensor imaging with its capability in localizing white matter tracts, assessing their involvement and the severity of involvement helps in effective preoperative assessment, planning appropriate surgical approach, intraoperative preservation of functionally paramount areas, better knowledge of clinical outcome and patient counselling and hence becomes indispensable for evaluation of brain neoplasms.

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