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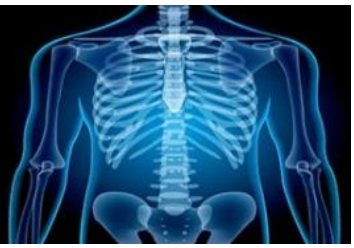

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Role of computed tomography and magnetic resonance imaging in evaluation of gliomas

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Abstract
Purpose: In cases of gliomas (intracranial and spinal), fewer studies have attempted the histopathological and imaging grade correlation. We thus aim to assess the sensitivity and specificity of conventional imaging techniques for the same.
Materials and Methods: The study comprised of 40 patients referred to the department of Radio-diagnosis at a tertiary care hospital in Ahmedabad, India, for a period of 24 monts, with a clinical suspicion of Neuraxial tumour. Computed Tomography and Magnetic Resonance Imaging of the neuraxis was performed.
Results: The mean age of patients was 33 ± 5.68 years with a male predominance (M:F ratio-1.5:1). The major presenting complaint was headache (82.5%). Dorsal spine (10%) was the most commonly affected in spinal gliomas, whereas Parietal lobe was the most common site affected (40%) intracranially. Major imaging findings included soft tissue with variable contrast enhancement and cystic components in 95% of the patients, with the most common ancillary finding being edema (65%) followed by mass effect (60%) depending on the type of tumour. MRI was found to have a better overall sensitivity and specificity in grading of gliomas as compared to CT and was highest for grade IV tumours in both modalities (90.00% and 96.88% for CT and 90.00% and 96.67% for MRI in grade IV). Edema (52.94%), contrast enhancement (47.06%) and multifocality (47.06%) were poor prognostic indicators.
Conclusion: In conclusion, MRI is a better imaging modality than CT in terms of grading, prognostication as well as tumour delineation in both intracranial as well as spinal gliomas.

Keywords: Gliomas, spinal glioma, MRI, CT

Introduction
Gliomas are a wide spectrum of tumours, occurring predominantly in the cerebrospinal axis and the most common primary malignant brain tumors arising from glial cells and second most common intracranial tumors (second to meningiomas) [1]. Gliomas show an annual incidence rate of 5-6 cases per 100,000 population worldwide, thus contributing to morbidity and mortality associated with malignancies [2].
Radiological imaging is integral for diagnosis, characterisation, surveillance and therapeutic monitoring of intracranial tumours. Computed Tomography (CT), both plain and contrast are done for the diagnosis as well as follow up of the same. However, MRI is considered better for the clinical imaging of the tumour as compared to CT [3].
Histopathological diagnosis is considered to be the gold standard for diagnosing gliomas but heterogeneity of the tumor, morphologic overlap, and tumor sampling errors may give rise to a diagnostic difficulty [4].
Therefore, imaging as well as histopathological findings can be correlated for a better diagnostic result.
Fewer studies have attempted the histopathological and imaging grade correlation. The aim of the current study is to assess the sensitivity and specificity of conventional imaging techniques for the same.

Materials and Methods
1. Patient selection
The study comprised of 40 patients referred to the department of Radio-diagnosis at a tertiary care hospital in Ahmedabad with a clinical suspicion of Neuraxial tumour, over a period of 24 months from January 2023 to December 2024. Patients with Implanted electric and electronic devices, (heart pacemakers (especially older types), insulin pumps, implanted

hearing aids, neurostimulators, intracranial metal clips, metallic bodies in the eye, Metallic hip replacements, sutures or foreign bodies) were excluded from the study.

2. Image acquisition protocols

a) Computed tomography of the brain

The patients were positioned supine on the gantry, with head first. Tube voltage was set at 120 kVp. Scout images in AP and Lateral Projections were obtained first, following which the scan extent was set from C2 to vertex in caudocranial direction with slice thickness <1 mm and slice increment 0.5 mm. Positive non-ionic iodinated contrast agent (Iohexol) was injected in the dose of 1 cc/s pressure injection with saline chaser following a non-contrast scan. Finally, Multiplanar reconstructions (MPR) were obtained in 3 mm axial, sagittal and coronal brain as well as bone reformats.

b) Computed tomography of the spine

The patients were positioned supine on the gantry, with head first. Tube voltage was set at 120 kVp. Scout images in Lateral Projections were obtained first, following which the scan extent was set depending on the part of spine to be screened in caudocranial direction with Field of View (FOV) 120-200 mm, slice thickness ~0.625 mm, interval ≤0.5 mm and reconstruction algorithm of bone, soft tissue. Positive non-ionic iodinated contrast agent (Iohexol) was injected in the dose of 1 cc/s pressure injection with saline chaser following a non-contrast scan. Finally, Multiplanar Reconstructions (MPR) were obtained in 3 mm axial, sagittal and coronal spine as well as bone reformats.

c) Magnetic resonance imaging of the brain

The patients were made to undergo a standard conventional contrast-enhanced MRI brain on Siemens 1.5 T MRI. Brain MRI was performed using the following protocols: Plain sequences included Sagittal T1 (Tse), Axial T1 (Tse), Axial T2 (Tse), Axial FLAIR, T2 Coronal, Diffusion weighted Imaging (DWI) with high b-values (2000-3000), Apparent diffusion coefficient (ADC), Susceptibility Weighted Imaged (SWI). After Gadolinium (Magnevist) administered intravenously (0.2 mL/kg, 0.1 mmol/kg) by hand injection: Axial 3D T1.

d) Magnetic resonance imaging of the spine

The patients were made to undergo a standard conventional contrast-enhanced MRI spine on Siemens 1.5 T MRI using a spine / body coil with in-plane spatial resolution ~0.7 x 0.7 mm, field of view (FOV) 300-380 (sagittal/coronal), 150-250 (axial), slice thickness (3 mm) with following protocols: T1-weighted fast spin echo (sagittal), T2-weighted fast spin echo (sagittal, axial), T2-weighted (fat-saturated - coronal, sagittal) sequences.

After the conventional imaging and additional workup, a tumour biopsy was done to achieve a histopathological diagnosis.

3. Image processing

Two radiologists with 10 and 5 years of experience, respectively, who were blinded to the clinical information, retrospectively read the MRI images. For qualitative analysis, the following imaging parameters were evaluated:

a) Location
b) Soft tissue
c) Edema
d) Mass effect
e) Cyst formation
f) Necrosis
g) Haemorrhage
h) Calcification
i) Multifocality
j) Contrast enhancement

Based on these findings, various types of gliomas were graded as well as prognosis was evaluated.

Results

1) Sociodemographics and symptomatology

A total of 40 cases (Table 1) were included in the study in which the predominant age group involved was the 3rd decade (33 ± 5.68 years) with a male to female ratio of 1.5:1. The major presenting complaint was headache (82.5%) followed by seizures (47.5%).

Table 1: Sociodemographics and symptomatology

Variable	Distribution	Number	Percentage
Age distribution	<18	1	2.5
	18-30	8	20
	31-40	11	27.5
	41-50	8	20
	51-60	7	17.5
	>60	5	12.5
Sex distribution	Males	24	
	Females	16	
	M:F	1.5:1	
Complaints	Headache	33	82.5
	Seizures	19	47.5
	Memory loss	16	40
	Backpain	6	15
	Paresthesias	6	15
	Blurring of vision	5	12.5
	Inability to bend down	4	10
	Gait disturbances	3	7.5
	Visual disturbances	2	5
	Inability to focus	1	2.5

2) Imaging features

a) Location

In terms of location of the tumour (Table 2), the parietal lobe was the most common site affected (40%) followed by frontal lobe (32.5%).

Table 2: Location of the neoplasm

Location	Number of patients	Percentage of patients
Parietal lobe	16	40
Frontal lobe	13	32.5
Temporal lobe	12	30
Dorsal spine	3	7.5
Gangliocapsular region	3	7.5
Lateral ventricle	3	7.5
Hippocampus	2	5
Occipital lobe	2	5
Cerebellar vermis	1	2.5
Cervical spine	1	2.5
Dorso-lumbar spine	1	2.5
Sacral spine - S2 level	1	2.5
Floor of fourth ventricle	1	2.5
Hypothalamus	1	2.5
Insular cortex	1	2.5
Septum pellucidum	1	2.5
Splenium of corpus callosum	1	2.5
Thalamus	1	2.5

b) Tumours with histological proof

In our study, all the patients that were included had undergone a histopathological correlation, which indicated that the most common type of glioma in our study was low grade glioma (40%) followed by Glioblastoma multiforme (22.5%), Astrocytoma (15%), Ependymoma (7.5%), and NOS, High grade glioma and Oligodendroglioma (5%).

c) Imaging findings

In our study, presence of soft tissue with variable contrast enhancement was noted in 95% of the patients. The most common ancillary finding associated with the neoplasms was found to be edema (65%) followed by mass effect and cystic component (60%), necrosis in 30%, haemorrhage in 17.5% and calcification in 12.5% patients.

d) Tumour characterisation

1) Glioma grading

Glioma grading is an integral part of the diagnostic work up and in our study, MRI was found to have a better sensitivity and specificity (Sn: 98.7%, Sp: 99.2%) in grading of gliomas as compared to CT.

Conventional imaging methods (CT and MRI) help in tumour characterization by contrast enhancement, vasogenic edema, mass effect, haemorrhage, necrosis, and hence help in tumor grading. Presence and degree of the aforementioned components indicates a higher tumour grade.

2) Prognostic measures

In our study, we compared the imaging features namely edema (52.94%), contrast enhancement (47.06%) and multifocality (48%) vs patient survival, which were poor prognostic indicators in high-grade gliomas, while non-contrast enhancing tumours (81.82%) was associated with longer survival. However, contrast enhancement along could not predict the prognostic out come as 2 out of 10 patients in our study showed contrast enhancement despite being diagnosed as low-grade glioma.

3) Tumour delineation

In our study, the more heterogeneous appearing lesions with ill-defined margins (98%) were associated with a higher grade. Degree of enhancement (42%) and the associated vasogenic edema (72%) surrounding the lesion also indicated a higher grade.

3. Comparison of CT versus MRI

Mass effects: MRI was slightly better (Sn: 97%, Sp: 98.2%) than CT (Sn: 91.3%, Sp: 93%) in terms of delineation of mass effects in our patients.

Necrosis: MRI was better (Sn: 93.4%, Sp: 94.5%) than CT (Sn: 80.6%, Sp: 81.2%) in demonstration of necrotic areas (10 out of 12 patients) within the lesion in our study.

Calcification: CT was better (Sn: 98.6%, Sp: 98.8%) in demonstrating calcification in the patients with Pilocytic astrocytoma (1 patient) and GBM (2 patients out of 3 showing calcification) in which the foci of calcification were relatively smaller and were missed on SWAN images on MRI.

Soft tissue: Soft tissue within the tumour was better seen on MRI (Sn: 98.8%, Sp: 96.2%) than on CT (Sn: 79.8%, Sp: 83.2%) especially in the patients with spinal tumours.

Grading: MRI was proven to be better in terms of sensitivity and specificity in grading of gliomas than CT when compared with Histopathological evaluation of the same.

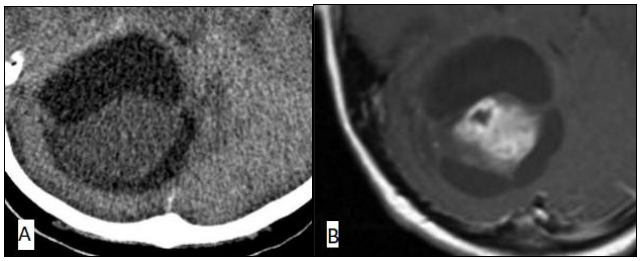

Fig 1: Pilocytic astrocytoma A. CT image showing cystic density tumour with a mural nodule (Solid isodense area) B. MRI showing contrast enhancement in the mural nodule with surrounding non-enhancing cystic area

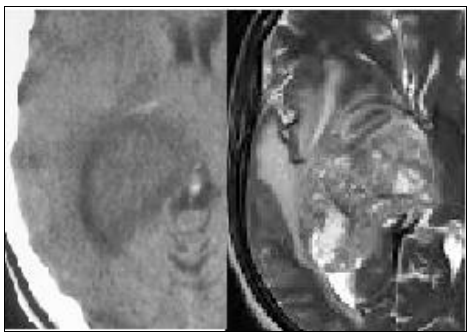

Fig 2: Glioblastoma multiforme

a) CT image showing heterogenous lesion with effacement of sulci and gyri and surrounding hypodense edema with minimal midline shift.
b) MRI image showing the same lesion with more marked edema, midline shift as well as lesion crossing the midline.

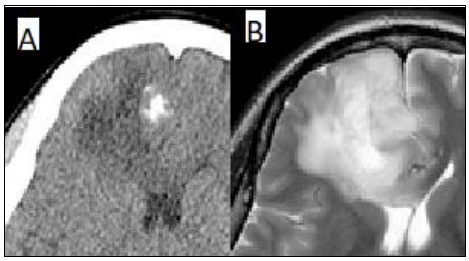

Fig 3: Oligodendroglioma

a) CT image showing heterogenous lesion with internal coarse calcifications
b) MRI image showing heterogenous hyperintense lesion on T2W image with internal solid areas showing focal signal loss corresponding to the area of calcification

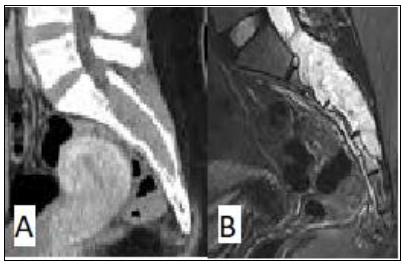

Fig 4: Myxopapillary ependymoma

a) CT image showing a lesion in the filum terminale region of the spinal cord without significant bone destruction or invasion of the surrounding structures.
b) MRI image of the same lesion showing hyperintense signal on T2W images.

Discussion

Astrocytomas are the most common type of intramedullary spinal tumour in pediatric age group whereas ependymomas rank second. According to WHO grading, spinal ependymomas are grade 2 lesions while myxopapillary ependymomas are grade 1 lesions at the conus / cauda equina. Our study showed a similar pattern of sociodemographics as well as tumour prevalence [5, 6].

In our study, heterogeneity of the lesions, tumour margins, contrast enhancement and edema were used for differentiation of gliomas as the contrast enhancement alone cannot reliably distinguish between high-grade gliomas and low grade gliomas in an individual patient. This is in concordance with a study by Scott JN *et al*. [7].

In our study, we concluded that the grading of the tumour is directly dependent on the contrast enhancement, edema, mass effect and necrosis, which is similar to a study by Asari S *et al*. [8].

Tumour subtyping is important according to the new WHO 2021 guidelines in terms of detecting 1p/19q translocation mutation in cases of Oligodendrogliomas and astrocytomas for treatment response and prognosis. However, in our study, tumour subtyping could not be done as it would require higher modality. This is in accordance to a study by Upadhyay N *et al*. [3, 9, 10, 11].

Tumour delineation is integral for both biopsy and resection. In our study, the more heterogeneous appearing lesions, higher degree of enhancement and vasogenic edema were associated with a higher grade. Both CT as well as MRI were helpful in the same, however, MRI was better than CT for the same. This is similar to a conclusion by Pope WB *et al* and Pronin IN *et al*. [11, 12].

In our study, we concluded that calcification was better delineated on CT as compared to MRI. MRI was however found to be better in demonstration of mass effects, soft tissue enhancement within the tumour as well as necrosis, tumor enlargement and abnormal signals. This is in agreement with a similar study done by Peterman SB *et al*. and Lee BC *et al*. [13, 14].

Conclusion

We have concluded that MRI is a better imaging modality than CT in terms of tumour delineation in both intracranial as well as spinal gliomas. However, CT was better in terms of detecting calcifications within the tumour. It was also noted that conventional imaging can help in grading and prognostication as well. Thus it can help in deciding the further line of management in a relatively non-invasive way.

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