Section: Radiology

Original Research Article

ROLE OF MR SPECTROSCOPY, PERFUSION AND DIFFUSION FOR DIFFERENT BRAIN TUMOURS

Lakshmi Sindhura Nadella[1], Rakesh Bayyavarapu[2]

[1]Associate Professor, Department of Radiology, Mediciti Institute of Medical Sciences, Ghanpur, Medchal, Telangana, India.
[2]Associate Professor, Department of Radiology, Mediciti Institute of Medical Sciences, Ghanpur, Medchal, Telangana, India.

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Corresponding Author:
Dr. Rakesh Bayyavarapu,
Email: bayyavarapurakesh@gmail.com

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ABSTRACT

Background: An MRI study does not provide complete information about infiltration and grading of tumors; hence, a biopsy study was the tool for finalization of the type of tumor, but the invention of DWI, DTI, and DSCI provides significant structural and functional information at a cellular level, highlighting aspects of brain pathophysiology. **Materials and Methods:** 50 patients suspected of having a tumor were subjected to DWI. Diffusion MRI, perfusion MRI, MR spectroscopy, and evaluation of brain tumors were ruled out. **Result:** Out of 50 patients, 42 had benign tumors and 8 had malignant tumors. In benign tumors, 20 (47.6%) were peripherally enhancing, and 6 (14.2%) were non-enhancing. In malignant tumors, 5 (62.5%) were peripherally enhancing, and 3 (37.5%) were non-enhancing. In a comparative study of various parameters like ADC, NAA, choline, creatinine, and NAA/Cr, there was a significant p-value ($p<0.001$). **Conclusion:** Present significant findings will help the radiologist to study the grading and infiltration of tumoral margins, and easy surgical resection can remove the tumors.

INTRODUCTION

Magnetic Resonance Imaging (MRI) has evolved into the most important non-invasive diagnostic tool for the detection, pre-surgical planning, and evaluation of treatment response of cerebral tumors. Despite its excellent soft tissue visualisation and variety of imaging sequences conventional MRI presents limitations regarding certain tumour properties, such as infiltrations and grading.[1] The inability to detect infiltrating cells beyond the tumoral margin and to accurately define the grade of the tumor impedes surgical resection and post-surgical treatment procedures.[2] Hence, biopsy remains the gold standard, although it might provide histopathological information about the limited portion of the lesion only, not about the whole neoplastic tissue.[3] Therefore advanced MRI techniques using different contrast principles, have been incorporated into clinical routine in order to avoid to aid tumour diagnosis. Diffusion weighed Imaging (DWI) Diffusion Tensor Iamging (DTI) imaging (DSCI) provide non-invasively significant structural and functional information in a cellular level, high lighting aspects of the brain patho-physiology.[4] Hence, an attempt is made to evaluate the brain tumors by MR spectroscopy perfusion and diffusion of different brain tumors.

MATERIALS AND METHODS

50 (fifty) adult patients who visited the Radiology department of Mediciti Institute of Medical Sciences, Ghanpur, Medchal (Mandal), Telangana-501401 were studied.

Inclusion Criteria: Patient suspected of having a brain tumor. Patients more than 18 years of age who gave their consent for the study in writing were selected.

Exclusion Criteria: Patients already operated for brain tumours, pregnant, patients having cardiac pace markers, prosthatic heart valves, cochlear implants, or any metallic implants. Dearranged renal function test, patients having history of claustrophobia, patient already on chemotherapy known allergy to gadolinium based contrast media patients who refused to give their consent for study in writing were excluded.

A renal profile (urea and creatinine value) was carried out for every patient prior to exposure to MRI. Imaging was done on a Siemens Avanto Magnetic Resonance Imaging 1.5 Tesla machine using dedicated brain coils. T_1W_1: T_1-weighted image (also referred to as T_1W_1 or "spin lattice" relaxation time) is one of the basic pulse sequences in MRI and demonstrates differences in the T_1 relaxation times of tissues. T_2 Flair in axial, coronal and sagital: T_2 weighed image (also referred to as T_2 W_1 T_2 Weighted image) is one of the basic pulse sequences

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in MRI. The sequence weighting highlights differences in the T_2 relaxation time of tissues.

Diffusion MRI: DWI used a single-shot echo planar sequence (TR/TE 1/4 4/1 mm, number of excitations 1/4 1, matrix 1/4 112 X 89, slice number 1/4 30) using b values of 0 and 1000 S/m².

Perfusion MRI: DSC perfusion imaging was performed during the first pass of a bolus of gadobenate dimeglumine (Multi-Hance, Bracco Diagnostics, Princeton, NJ) using a 3D principle of echo shifting with a train of observation (PRESTO) sequence, effective TR/TE 1/4–16/24 ms, flip angle 1/4 7, FOV 1/4 230 X 187 X 120 mm, and matrix 128 X 180 X 40 (voxelsize 1/4 1.8 X 1.8 X 3.0 mm).

MR Spectroscopy: Proton 2D (TR/TE 1/4 2000 14Y ms, FOV 1/4 24 cm, voxel size 1/4 1.0 X 1.0 X 1.2 (m^2)) or 33D (TR/TE 1/4 2000/288 ms, FOV 1/4 2.4 cm, Voxel size 1/4 1.0 X 1.0 X 1.2 (m^3)) multi-voxel chemical shift imaging (CSI) was performed after administration of gadolinium contrast. In most cases single-voxel PRESS (TR/TE 1/4 2000/35-acquired and in some cases voxel) PRESS was technically successful where multi-voxel CSI was not. Automated second-order shimming and water suppression were used. For all MRS acquisitions, the volume of interest was manually placed on co-registered axial FLAIR images or contrast-enhanced axial T1-weighted images. For single-voxel MRS, the VOI was adapted to the size and extent of the lesion, resulting in voxel sizes ranging from 1.1 X 1.1 X 1.3 to 2.0 X 2.0 cm^3. Slice thickness-4 mm.

Table 1: Imaging methods and the major utility in brain tumour

Imaging technique	Major utility in tumour imaging
CT	Mass effect herniation, hemorrhage, calcification
Pre and post contrast T1	Enhancement characteristics, necrosis extent of enhancing portion of the tumour
T2/T2 Flair	Peri-tumour aldema (vasogenic and infiltrative), non-enhancing tumor
T2 susceptibility sequence (SW1)	Blood products calcification, radiations, induced chronic micro-hemorrhage
DW1/ADC	Rediced in highly cellular portions of tumour, post operative injury
DTI	Tractography for surgical planning / navigation
Perfusion (generally DSC)	Tumour/tissue vascularity
MR spectroscopy	Metabolic profile
FMRI	Pre-operative functional mapping, research into treatment effects
Pet/MR	Potential new radio tracers

Duration of study was from April 2024 to May 2025.

Statistical Analysis: Comparison between contrast was classified with percentage. Comparative study of various parameters studied with t test. The statistical analysis was carried out SPSS software. The ratio of male and female was 2:1.

RESULTS

Table 1: Comparison between contrast enhancement and type of tumour

- 20 (47.6%) Benign, (0%) Malignant, Total 20 (40%) Homogenous
- 11 (26.1%) and zero – heterogeneous
- 5 (11%) benign, 5 (62.5%) Malignant, Total 10 (20%) peripheral enhancement
- 6 (14.2%) benign, 3 (37.5%) malignant, total 9 (18%) non-enhancing

Table 2: Comparative study of –

- ADC: 1.18 (± 0.28) benign, 0.83 (± 0.5) malignant, t test was 2.82 and p<0.001 (p value is highly significant).
- NAA: 14.80 (± 2.20) benign, 9.12 (± 1.22) malignant, t test was 7.05 and p<0.001 (p value is highly significant).
- Choline: 33.55 (± 2.15) in benign, 35.75 (± 3.20) in malignant, t test was 2.44 and p<0.001.
- Creatinine: 19.70 (± 2.80) benign, 9.90 (± 1.90) malignant, t test was 2.44 and p<0.001.

Table 3: Comparative study of NAA Cr. according to type of tumour:

- NAA/Cr.: 0.77 (± 0.03) in benign, 1.01 (±0.02) malignant, t test was 21.6 and p<0.001 (p value is highly significant).

Table 4: Comparative study of Choline/Cr. according to type of tumours:

Choline/Cr.: 1.55 (± 0.03) in benign, 4.36 (±1.2) malignant, t test was 13.6 and p<0.001 (p value is highly significant).

Table 1: Comparison between contrast enhancing and type of tumour

Contrast Enhancing	Type of tumour		Total (50)
	Benign Tumour (42)	Malignant Tumour (8)	
Heterogenous	20 (47.1%)	0	20 (40%)
Homogenous	11 (26%)	0	11 (22%)
Peripheral Enhancing	5 (11%)	5 (62.5%)	10 (20%)
Non-Enhancing	6 (14.2%)	3 (37.5%)	9 (18%)
Total	42 (100%)	8 (100%)	50 (100%)

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Table 2: Comparative study of various parameters

Parameter	Benign Tumour (42) Mean (±SD)	Malignant Tumour (8) Mean (±SD)	t test	p value
ADC	1.18 (±0.28)	0.83 (±0.5)	2.82	P<0.001
NAA	14.80 (±2.20)	9.12 (±1.22)	7.05	P<0.001
Choline	33.55 (± 2.15)	35.75 (±3.20)	2.44	P<0.001
Creatinine	19.70 (±2.80)	9.90 (±1.90)	9.45	P<0.001

Table 3: Comparative study of NAA /cr (Nucleic Acid Amplification creatinine) accoutring to type of tumour

Parameter	Benign Tumour (42) Mean (±SD)	Malignant Tumour (8) Mean (±SD)	t test	p value
NAA/Cr	0.77 (±0.03)	1.01 (±0.02)	21.6	P<0.001

Table 4: Comparative study of choline/cr accoutring to type of tumours

Parameter	Benign (42) Mean (±SD)	Malignant (8) Mean (±SD)	t test	p value
Choline/cr	1.55 (±0.3)	4.36 (±1.2)	13.6	P<0.001

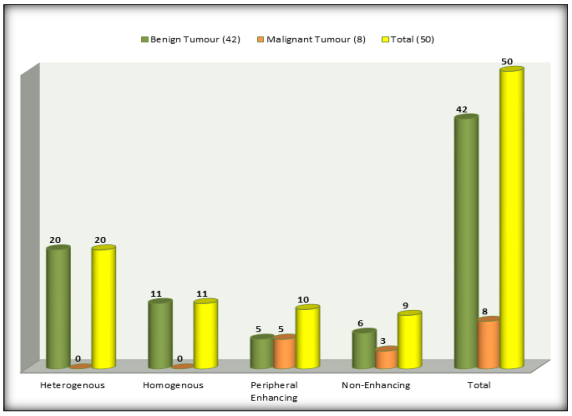

Figure 1: Comparison between contrast enhancing and type of tumour

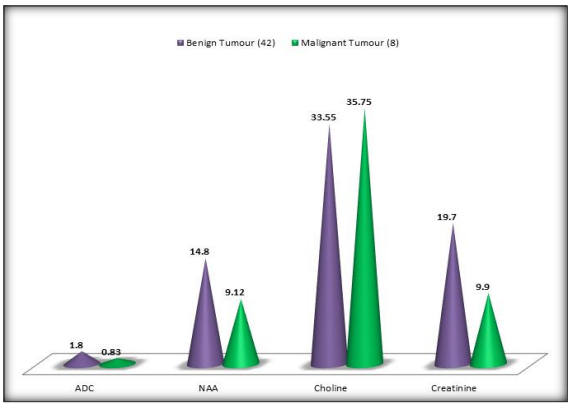

Figure 2: Comparative study of various parameters

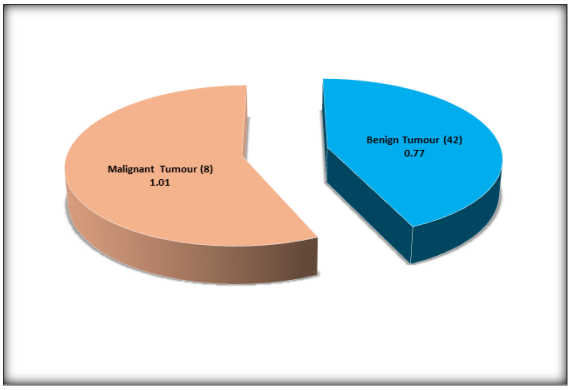

Figure 3: Comparative study of NAA /cr (Nucleic Acid Amplification creatinine) accoutring to type of tumour

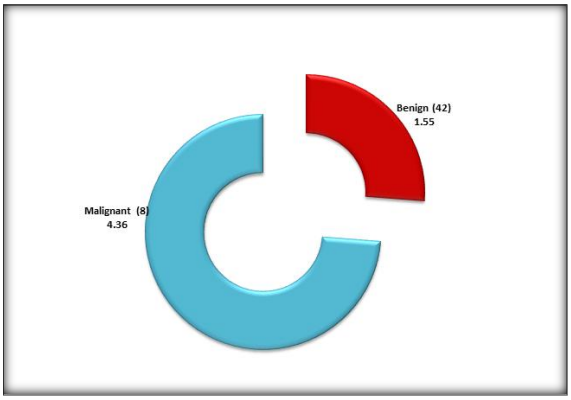

Figure 4: Comparative study of choline/cr accoutring to type of tumours

DISCUSSION

Present study of the role of MR spectrometry, perfusion, and diffusion for different tumours. In a comparison between contrast enhancing and type of tumor in benign (42) tumors, 20 (47.6%) were heterogeneous, 11 (26%) were homogenous, 5 (11%) were peripheral enhancing, and 6 (14.2%) were non-enhancing. In Malignant (8), 5 (62.5%) had peripheral enhancement and 3 (37.5%) were non-enhancing (Table 1). A comparative study of various parameters of ADC, NAA, choline, creatinine, and

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NAA/Cr and choline/Cr had significant p-values (Tables 2, 3, and 4). These findings are more or less in agreement with previous studies.[5,6,7]

In diffusion-weighted imaging, water molecules diffuse mainly along the direction of white matter axons, rather than perpendicular to them. Under these circumstances diffusion becomes highly directional along the length of the tract and is called anisotropic. DTI is a further development of DWI, taking advantage of this preferential water diffusion inside the brain tissue. DTI measures both the magnitude and the direction of proton movement within the voxel for multiple dimensions of movement using a mathematical model to represent this information called diffuse tensor.[8]

The differentiation of the metastases from primary high-grade gliomas has been extensively investigated, as the differential diagnosis DSCI (dynamic susceptibility contrast image) has been a useful technique in discriminating the two tumor groups based on differences in the underlying pathophysiology of their peritumoral area.[9]

It is reported that the efficiency of combined textural MRI features and MRSI metabolite ratios employing the support vector machine (SVM) algorithm for the discrimination of metastatic tumors from meningiomas. This combination resulted in 92.5% overall accuracy between two groups and 100% correctly classified meningiomas and metastases cases derived from an independent test set.[10] They asserted that perfusion and diffusion parameters made a much greater contribution to the discrimination than conventional MRI. Accuracy, sensitivity, and specificity were 94.4%, 88.9%, and 93.7%, respectively.[11]

CONCLUSION

The characterization of tumoral and peritumoral tissue microstructure, based on diffusion and perfusion findings, resulted in increased diagnostic values. Without any biopsy studies, neurosurgeons and neurophysicians can take proper decisions and prognoses of cerebral tumors.

Limitation of study: Owing to remote location of research centre, small number of patients, lack of latest techniques, we have limited findings and results.

- This research work was approved by the ethical committee of Mediciti Institute of Medical Sciences, Ghanpur, Medchal (Mandal), Telangana-501401.
- No Conflict of Interest
- Self-Funding

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