

Role of MR Spectroscopy, Perfusion and Diffusion for Different Brain Tumours in Maharashtra Population

Nitin Appasaheb Raje¹, Michelle Pereira (Raje)²

¹Associate Professor, Department of Radiology, Vedanta Institute of Medical Sciences, Dahanu, Palghar (Dist), Maharashtra-401602.

²Associate Professor, Department of Radiology, Vedanta Institute of Medical Sciences, Dahanu, Palghar (Dist), Maharashtra-401602.

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Corresponding author: Dr. Michelle Pereira

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Abstract

Background: Apart from conventional sequences of MRI, physiological MRI, such as diffusion-weighted (DW) imaging, perfusion MRI (PMRI), and proton MR spectroscopy provides additional information for accurate diagnosis of grades, types, vascularity, and composition of tumors.

Method: 90 patients suspected of having a tumor were subjected to DWI. Diffusion MRI, perfusion MRI, MR spectroscopy on Siemens 1.5T MRI machine.

Results: Out of 90 patients, 75 had benign tumors and 15 had malignant tumors. In benign tumors, 35 (46.6%) were heterogenous, 20 (26.6%) were homogenous, 8 (10.6%) were peripherally enhancing, and 12 (16%) were non-enhancing. In malignant tumors, 9 (60%) were peripherally enhancing, and 6 (40%) 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: The significant findings will help the radiologist to study the differential diagnosis, grading and infiltration of tumoral margins.

Keywords: Benign, malignant, Choline/cr-ratio, Brain tumors, MR Spectroscopy.

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Introduction

Imaging plays a vital role in the management of a brain tumor study. Magnetic resonance imaging is more significant than any imaging technique for visualizing and diagnosing types of brain tumors [1]. MRI has delivered remarkable advances regarding localization, characterization and pathological diagnoses of tumor. [2].

Apart from conventional sequences, physiological MRI such as diffusion-weighted (DW) imaging, perfusion MRI (PMRI), and proton MR spectroscopy [3] provides additional information regarding grades, type of tumor, vascularity, and composition [4] which will enable the radiologist, neurophysician, and neurosurgeon to predict the severity and differentiate the benign and malignant and prognosis of the patient with its histopathological correlations. Hence, an attempt is made to evaluate such patients with spectroscopy, perfusion, and diffusion studies.

Material and Method

90 (ninety) adult patients who visited the Radiology department of Vedanta Institute of

Medical Sciences, Dahanu, Palghar (dist), Maharashtra-401602 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 on for brain tumors, pregnant patients, and patients having cardiac pacemakers, prosthetic heart valves, cochlear implants, or any metallic implants, dearranged renal function test results, patients with a history of claustrophobia, patients already on chemotherapy, patients with a known allergy to gadolinium-based contrast media, and patients who refused to give their consent for the 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. T1W1: T1-weighted image (also referred to as T1W1 or "spin lattice"

relaxation time) is one of the basic pulse sequences in MRI and demonstrates differences in the T1 relaxation times of tissues. T2 Flair in axial, coronal and sagittal: T2-weighted image (also referred to as T2 W1 or T2-weighted image) is one of the basic pulse sequences in MRI. The sequence weighting highlights differences in the T2 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 (voxel size 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 (m²)) 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 (m³)) 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 cm³. 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 edema (vasogenic and infiltrative), non-enhancing tumor
T2 susceptibility sequence (SWI)	Blood products calcification, radiations, induced chronic micro-hemorrhage
DWI/ADC	Reduced 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 January 2022 to June 2025.

Statistical Analysis: Comparison between contrasts 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.

Observation and Results

Table 1: comparison between contrast enhancement and type of tumour:

Out of 90 patients, 75 (83.3%) had benign tumours and 15 (16.6%) had malignant tumours

Table 2: Comparative study of between contrast enhancing and types of tumours

- Heterogenous: 35 (46.6%) and 10 in malignant and total 35 (38.8%)
- Homogenous: 20 (26.6%) and 0 in malignant.
- Pheripheral enhancing 8 (10.6%) benign and 9 (60%) malignant tumour, total 17 (18.8%).

- Non-Enhancing: 12 (16%) benign and 4 (40%) malignant, total 18 (20%)

Table 3: In the comparison of various parameters

- ADC (Apparent Diffusion coefficient): 1.20 (±0.30%) in benign tumours, 0.85 (± 0.4) in malignant tumours, t test was 3.89 and p<0.001.
- NAA (Neutron Activation Analysis): 16.40 (± 2.28) in benign, 9.15 (± 1.20) in malignant cases, t test was 11.9 and p<0.001.
- In choline analysis study: 34.60 (± 2.18) in benign, 36.45 (±3.30) in malignant patients, t test was 2.88 and p<0.001.
- In creatinine analysis: 20.30 (± 2.60) in benign tumour patients, 9.98 (± 1.80) in malignant cases, t test value is 14.6 and p<0.001.

Table 4: Comparative study of NAA/creatinine according to type of tumour: 0.80 (± 0.04) in benign, 1.02 (± 0.02) in malignant cases, t test was 20.7 and p<0.001.

Table 5: Comparative study of choline/Cr. according to type of tumours: 1.58 (± 0.4) in

benign, 4.40 ($\pm$ 1.3) in malignant, t test value 15.6 and $p < 0.001$.

Table 2: Comparison study between contrast enhancing and type of tumour

Contrast Enhancing details	Type of tumour		Total (90)
	Benign Tumour (75)	Malignant Tumour (15)	
Heterogenous	35 (46.6%)	0	35 (46.6%)
Homogenous	20 (26.6%)	0	20 (22%)
Peripheral Enhancing	8 (10.6%)	9 (60%)	17 (18.8%)
Non-Enhancing	12 (16%)	6 (40%)	18 (20%)
Total	75 (100%)	15 (100%)	90 (100%)

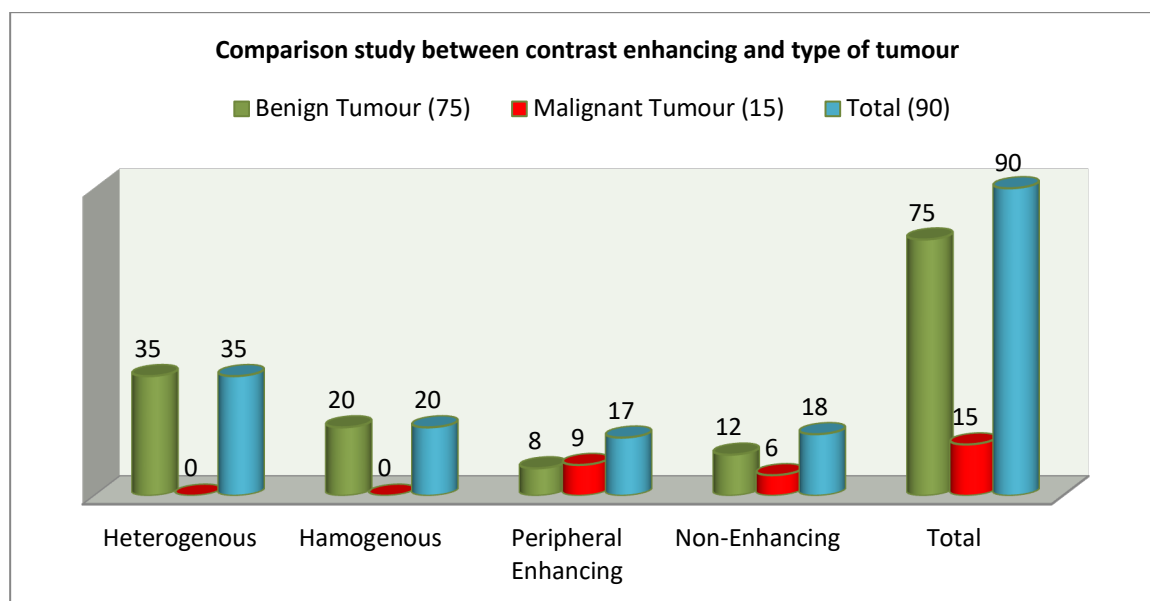


Figure 1: Comparison study between contrast enhancing and type of tumour

Table 3: Comparative study of various parameters

Parameter	Benign Tumour (75) Mean ($\pm$ SD)	Malignant Tumour (15) Mean ($\pm$ SD)	t test	p value
ADC	1.20 ($\pm$ 0.30)	0.85 ($\pm$ 0.4)	3.89	$P < 0.001$
NAA	16.40 ($\pm$ 2.28)	9.15 ($\pm$ 1.20)	11.9	$P < 0.001$
Choline	34.50 ($\pm$ 2.18)	36.45 ($\pm$ 3.30)	2.88	$P < 0.001$
Creatinine	20.30 ($\pm$ 2.60)	9.98 ($\pm$ 1.80)	14.6	$P < 0.001$

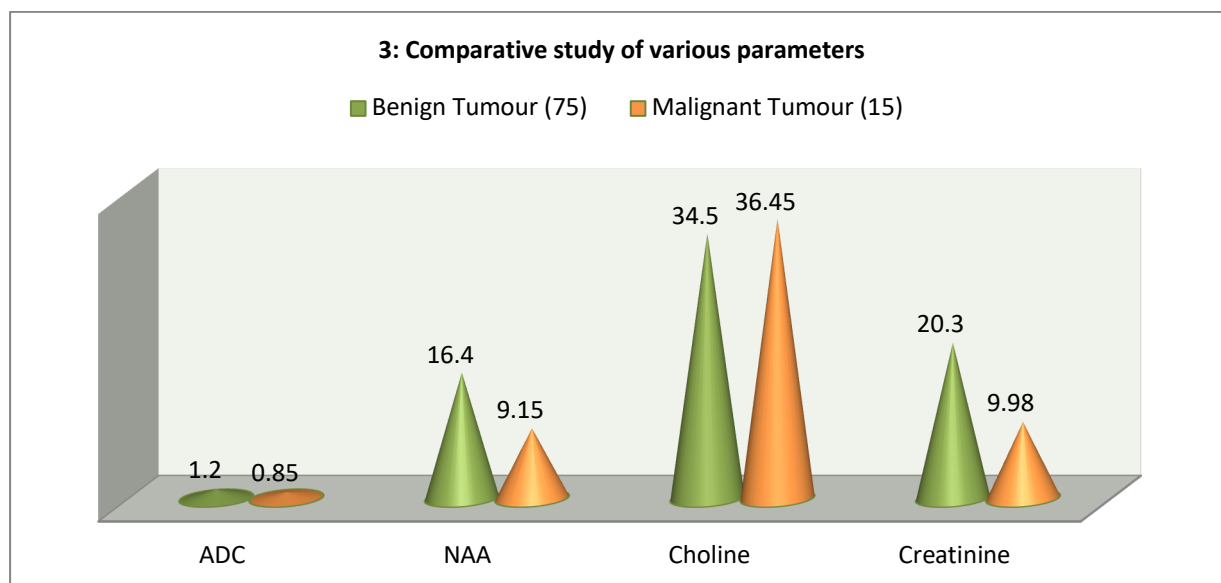
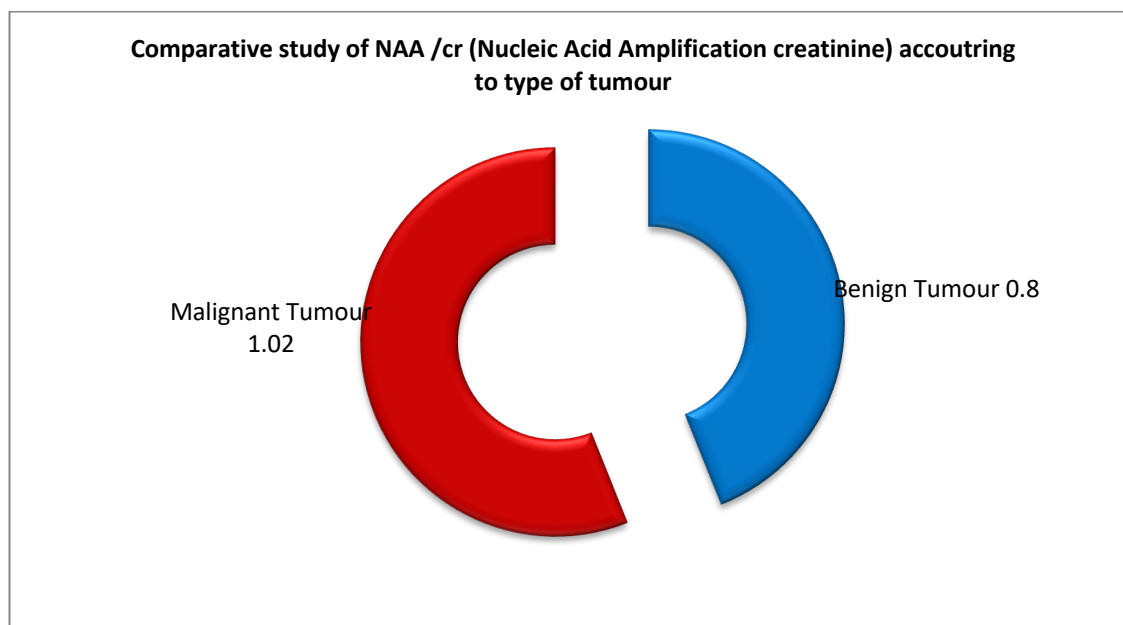


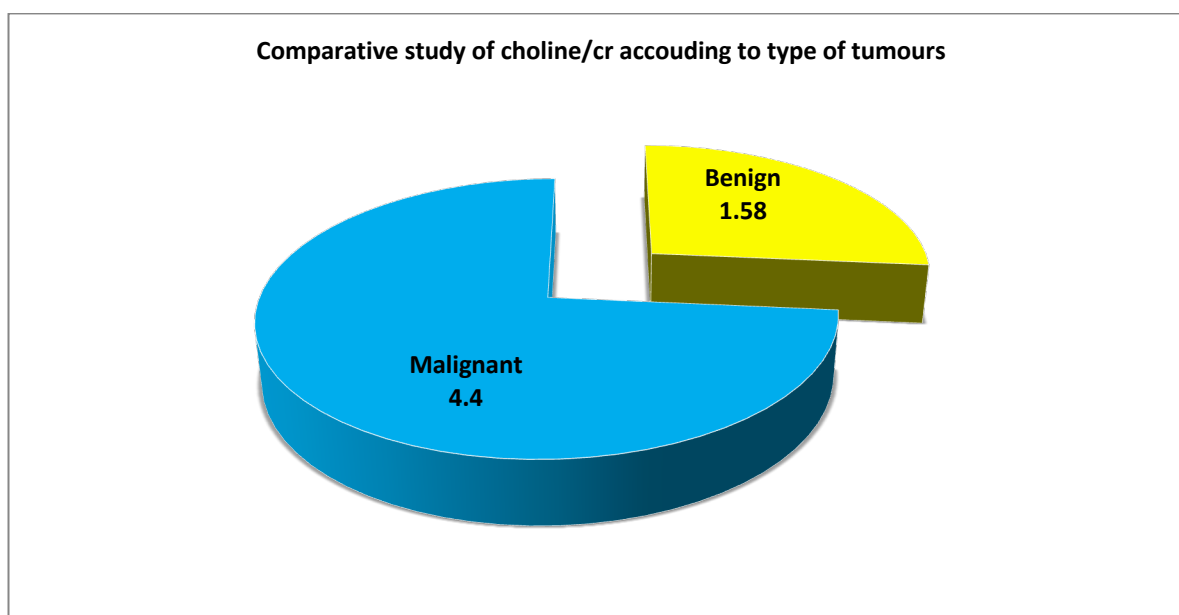
Figure 2: 3: Comparative study of various parameters

Table 4: Comparative study of NAA /cr (Nucleic Acid Amplification creatinine) accoutring to type of tumour

Parameter	Benign Tumour (75) Mean ($\pm$ SD)	Malignant Tumour (15) Mean ($\pm$ SD)	t test	p value
NAA/Cr	0.80 ($\pm$ 0.04)	1.02 ($\pm$ 0.02)	20.7	P<0.001

**Figure 3: Comparative study of NAA /cr (Nucleic Acid Amplification creatinine) accoutring to type of tumour****Table 5: Comparative study of choline/cr according to type of tumours**

Parameter	Benign (75) Mean ($\pm$ SD)	Malignant (15) Mean ($\pm$ SD)	t test	p value
Choline/cr	1.58 ($\pm$ 0.4)	4.40 ($\pm$ 1.2)	15.6	P<0.001

**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. Out of 90 patients, 75 were benign and 15 were malignant. In a comparison between contrast

enhancing and type of tumor in benign 35 (46%) were heterogeneous, 20 (26%) were homogenous, 8 (10.6%) were peripheral enhancing, and 12 (16%) were non-enhancing.

In Malignant 9 (60%) had peripheral enhancement and 6 (40%) were non-enhancing (Table 1). A comparative study of various parameters of ADC, NAA, choline, creatinine, and 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].

Summary and Conclusion

The characterization of tumoral and peritumoral tissue microstructure, based on diffusion, perfusion and spectroscopy 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 Vedanta Institute of Medical Sciences, Dahanu, Palghar (Dist), Maharashtra-401602.

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